

# **Sokoine University of Agriculture**



## **PhD Thesis**

**Development of Value-Added  
Pigeon Peas-Based Products  
for Recipe Diversification in  
Lindi Region: A Consumer  
and Market-Driven Approach**

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**Development of Value-Added Pigeon Peas-Based  
Products for Recipe Diversification in Lindi Region: A  
Consumer and Market-Driven Approach**

**A Thesis Submitted in Fulfilment of the Requirements  
for the Degree of Doctor of Philosophy of Sokoine  
University of Agriculture, Morogoro, Tanzania**

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## EXTENDED ABSTRACT

**Background:** Pigeon peas is among legume rich in protein, minerals, and vitamins. Despite the nutritional importance of pigeon peas, in Tanzania, the crop has not been fully utilized for human consumption in different types of recipes. Among the documented reasons for the lack of diversification of pigeon peas recipes include inadequate processing skills and technologies, low storage capacities, knowledge, and experience. Hence, this study aimed to develop value-added pigeon peas-based products to diversify recipes for nutrition improvement. Specifically, the study aimed at (i) characterize the existing pigeon peas recipes and their consumption pattern (ii) develop value-added pigeon peas-based products and test their sensory attributes (iii) assess the preferences and acceptability of the developed products and (iv) assess willingness to pay for the newly developed pigeon peas-based product.

**Methods:** The study was conducted in Mitumbati and Mibure villages in Nachingwea and Ruangwa Districts in Lindi region. A cross-sectional study was conducted to collect both quantitative and qualitative information using a structured questionnaire and checklist with guiding questions, respectively. Information about crops grown, foods, legumes, pigeon peas consumption patterns and the existing pigeon peas recipes was collected. Optimal formulation of the product was done using Linear Programming simplex methods for minimizing costs while maximizing nutrients. Tanzania and Kenya Food Composition Tables were used to get nutrient contents of the ingredients used for formulating the products. Laboratory based experiments was conducted during product development whereas formulation and production of products' samples were done. The experiments involved developing pigeon peas-based



noodles and porridge flour. Quantitative Descriptive Analysis (QDA) of the developed pigeon peas-based products was also done. Complete and Incomplete Randomized Block Designs were used to assess the preference of pigeon peas-based instant porridge and noodles, respectively. Stated Preference Method was used to assess willingness to pay for developed products.

Statistical Product for Service Solution, R, Consumer checker, Excel and XLSTAT were used for data analysis. Deductive thematic content analysis was used for qualitative data to summarize themes and factors which drive their preferences. For quantitative data, descriptive and inferential statistics were computed. Mean and standard deviation were used to summarize the continuous variables and frequencies were used to summarize categorical variables. The median and interquartile ranges were used to summarize continuous variables that were not normally distributed. Pairwise comparison counts and Garrett mean rank scores were used to summarize the ranked data. Significance tests for non-parametric data were determined using Kruskal Wallis, Mann–Whitney U and Wilcoxon signed-rank test. Spearman correlation was computed to determine the associations among variables. For the ordered dependent variables, ordinal regression was used to analyse the effect between groups' overall levels and the outcome variables. The Analysis of Variance was used to compare mean difference between samples. Tukey test was used for mean separation of the samples. Multivariate analysis was used to determine the multidimensional and possible relations of the samples against sensory attributes, and map individual preferences. The logistic regression analysis model was used to determine predictors for willingness to pay for the developed noodles. A p-value of  $< 0.05$  was considered statistically significant.



**Results:** The mean pigeon peas consumption during the harvesting and lean seasons was 80 and 18 g/person/day, respectively. Five major recipes existed in the study area. The majority (84%) of farmers consumed pigeon peas as a stew (green, dried or dehulled). Other recipes consumed in the area included pigeon peas mixed with other foods and consumed as snack (boiled green pigeon peas). Twelve pigeon peas-based products were identified and prioritized. The highest ranked scores for pigeon peas-based noodles (70.6), flour (61.4) and chapati (60.4) was observed. Results also indicated that 70% of variation on preference ranking scores among prioritized pigeon peas-based food types and consumer categories.

Eight and four samples of pigeon peas-based noodles (PPBN) and instant porridge (PPIP) respectively, were formulated and developed. The main ingredient for PPBN was pigeon peas, wheat flour and orange fleshed sweet potatoes. Based on linear programming formulation the protein content for PPBN ranged from 41 to 58.2 g/100 g of dry matter. The highest amount of computed iron content per developed sample was as follows; observed in sample PPNB193 (26.4 mg/100 g), PPNB136 (21 mg/100 g) and PPNB718 (19.3 mg/100 g). The highest value of zinc and pro-vitamin A was observed in sample PPNB136. The highest mean intensity score for colour, aroma and mouthfeel was observed in samples PPNB718, PPNB193 and PPNB136. The average mean of overall liking was higher for samples PPNB718 ( $4.5 \pm 1.25$  (SD)), PPNB136 ( $4.5 \pm 1.08$  (SD)) and PPNB193 ( $4.5 \pm 1.02$  (SD)). The correlation loadings indicated that the samples were preferred due to their colour and aroma.

For instant porridge, the main ingredients used in the formulation were pigeon peas, maize and OFSP (or pumpkin



flour). The highest value of protein (17.5g/100 g), iron (7.9 g/100 g), zinc (5.4 mg/100 g) and pro-vitamin A (308.5 µg/100 g) was observed in sample PPIP<sub>ofsp</sub><sup>r</sup>. Similarly, the highest mean intensity scores for colour (8.7), aroma (7.7), mouthfeel (7.8), sweetness (7.1), viscosity (7.9) and overall liking (4.9 ± 0.29 (SD)) was observed in sample PPIP<sub>ofsp</sub><sup>r</sup>. The correlation loadings indicated that sample PPIP<sub>ofsp</sub><sup>r</sup> was the most preferred sample based to its mouthfeel, sweetness, colour and aroma attributes. The average amount of maize porridge (MP) and PPIP consumed among children was 137.7 g ± 48.4 (SD) and 128.3 g ± 47.1 (SD) with differences among children's age at  $p < 0.05$ . A Wilcoxon signed-rank test showed that there was no significant difference in mean consumption between PPIP and MP ( $Z = -1.402$ ,  $p = 0.161$ ). About 88% of children consumed amount of PPIP more than 50% of the amount of maize porridge consumed. About 90% of children were equally fast in opening their mouth, responsive and satisfied for both MP and PPIP.

Over three quarters (86%) of the consumers were willing to pay for the developed PPBN at the median price of TZS 2000 (IQR =1500, 2200) for a package size of 1000g. Likewise, 85% of consumers were willing to pay for developed instant porridge flour at an average price of TZS 1610.28 ± 546.84 for 1000g. The significant predictors ( $p < 0.05$ ) of willingness to pay included the cost of the product, pack size, and purchasing power for household food.

**Conclusion:** Consumers prioritized pigeon peas-based noodles, flour, chapati and dhal as the food products to be developed due to their perceived value, sensory attributes and convenience. Pigeon peas-based noodles and porridge flour were developed products in this study. Addition of pigeon peas flour into noodles and maize porridge flour improves protein, iron and zinc content of it. The developed



PPBN and PPIP were preferred by majority of consumers due to its colour, aroma and mouthfeel attributes. Consumers were willing to pay for developed PPBN and PPIP due to their taste, colour and estimated selling price. Multiple interrelated factors such as sensory attributes, price per portion size and familiarity about the product should be considered to meet consumers' culinary taste that are adequate, culturally acceptable and consumed sustainably.



## IKISIRI KUU

Mbaazi ni miongoni mwa mazao ya jamii ya mikunde yenye kiwango kikubwa cha protini, madini na vitamini. Licha ya umuhimu wa mbaazi kwa lishe, nchini Tanzania zao hili halijatumika kikamilifu kwa matumizi ya chakula cha binadamu. Miongoni mwa sababu zilizoainishwa juu ya ukosefu wa aina mbalimbali za mapishi ya mbaazi ni teknolojia duni ya usindikaji, uwezo mdogo wa kuhifadhi, ukosefu wa ujuzi na uzoefu wa matumizi mbalimbali ya mbaazi katika kuboresha mlo katika kaya. Hivyo basi, utafiti huu ulilenga kutengeneza bidhaa mbalimbali zitokanazo na mbaazi ili kuboresha hali ya lishe na kipato katika kaya. Mahsus, utafiti huu ulilenga (i) kubainisha vyakula vitokanavyo na mbaazi na ulaji wake katika jamii kwa sasa (ii) kutengeneza vyakula vilivyochanganywa na mbaazi na kutathmini hisia za walaji wa vyakula hivyo (iii) kutathmini ni namna gani vyakula vilivyotengenezwa kwa kuchanganywa na mbaazi vinapendwa na kukubalika na walaji na (iv) kutathmini utayari wa kulipia vyakula vipya vilivyotengenezwa kwa kuchanganywa na mbaazi.

Utafiti huu ulifanyika katika vijiji vya Mitumbati na Mibure katika wilaya za Nachingwea na Ruangwa mkoani Lindi. Utafiti ulifanyika kwa awamu mbalimbali na kila awamu takwimu zilikusanywa mara moja na bila kurudia katika awamu inayofuata. Ukitumia dodoso na orodha ya ukaguzi. Awamu ya kwanza ililenga kujua hali halisi ya uandaji na ulaji wa mbaazi katika vijiji vya utafiti. Awamu ya pili ilihusisha ukokotoaji wa kiasi cha mbaazi, unga wa ngano na/au unga wa viazi lishe unaohitajika kutengeneza tambu zenye virutubishi vya kutosha kukidhi mahitaji ya protini, madini chuma, vitamini A na madini ya zinki kwa watu wazima. Pia ukokotoaji wa kiasi cha mbaazi, unga wa mahindi na viazi lishe au unga wa boga ulifanyika ili kuweza kupata kiwango



sahihi kitachotumika kutengeneza mchanganyiko wa unga wa uji utakaokidhi mahitaji ya lishe bora kwa watoto wa umri wa miezi 7 hadi 36. Ukokotoaji huu ulifanyika kwa kutumia mbinu ya “*linear programming*” ambayo ilizingatia kutengeneza mchanganyiko ambao utakuwa na virutubishi vya kutosha na wakati huohuo kupunguza gharama ya mchanganyiko huo. Majedwali ya muundo wa chakula ya Tanzania na Kenya yalitumika kuainisha kiasi cha virutubisho vilivyomo kwenye kila chakula kilichotumika kutengeneza mchanganyiko wa tambi na unga wa uji.

Awamu ya pili pia ilihusisha utengenezaji wa vyakula vilivyochanganywa na mbaazi kwa kufanya majaribio mbalimbali katika maabara na kupata sampuli za bidhaa hizo. Majaribio hayo yalikusisha kutengeneza tambi zilizochanganywa na unga wa mbaazi, ngano na/au unga wa viazi lishe. Pia yalikusisha utengenezaji wa unga wa uji kwa kuchanganya mbaazi, mahindi na viazi lishe (au unga wa maboga). Bidhaa zilizotengenezwa zilifanyiwa tathimini (*Quantitative Descriptive Analysis*) na wataalamu waliofundishwa namna ya kutambua vigezo vya ubora (*sensory attributes*) vya vyakula vilivyotengenezwa ambavyo vitapelekea vyakula hivyo kukubalika na walaji.

Awamu ya tatu ilihusisha kufanya tathmini ya kutambua ni namna gani vyakula vilivyotengenezwa kwa kuchanganywa na unga wa mbaazi vinakubalika na makundi mbalimbali ya walaji na vigezo vipi vya ubora vimepelekea kukubalika kwa vyakula hivyo. Mbinu ya *Balance Incomplete Block Designs* ulitumika wakati wa kufanya tathmini ya ubora wa tambi zilizotengenezwa na mbinu ya *Complete Randomized Block Design* ilitumika kufanya tathmini ya unga wa uji uliotengenezwa kwa kuchanganywa na mbaazi. Awamu ya nne ilihusisha kutathmini utayari wa walaji kulipia vyakula vilivyotengenezwa na kupendekeza bei ambayo watakuwa tayari kulipia vyakula hivyo.



Takwimu zilizokusanywa zilichambuliwa na kukokotolewa kwa kutumia programu mbalimbali (*Statistical Product for Service Solution, R, Consumer checker, Excel na XLSTAT*). Uchambuzi wa maudhui ya mada (*Deductive thematic content*) ulitumika kufanya muhtasari wa uelewa juu ya maswala ya mbaazi ikiwemo namna ya uandaaji na ulaji wa mbaazi. Wastani ulitumika kuwasilisha *“continuous variable”* na idadi kwa makundi ilitumika kuwasilisha *“categorical variable”* zilizotawanyika kwa usawa wa kati wa wastani na *“interquartile ranges”* zilitumika kuwasilisha takwimu ambazo hazikutawanyika kwa usawa. Mbinu ya *“Garrett Henry”* na chati linganishi (*“Pairwise comparison”*) ilitumika kupanga bidhaa zitokanazo na mbaazi kwa kufuata utaratibu wa upendeleo (*preferences*). Mbinu ya *“Kruskal Wallis, Mann–Whitney U na Wilcoxon signed-rank test”* zilitumika kubaini usawa na utofauti wa takwimu ambazo hazijatawanyika kwa usawa. Uhusiano wa takwimu ulikokotolewa kwa kutumia *“Spearman correlation”*. Takwimu pia zilikokotolewa kuweza kubaini mchango wa takwimu zilizokusanywa kwa matokeo tarajari kulingana na malengo ya uchambuzi wa takwimu husika. Ulinganishi baina ya sampuli pia ulifanyika kuweza kutambua ni sampuli zipi zinafanana na zipi zinatofautiana. Tofauti baina ya sampuli iliweza kubainishwa kwa utumia *Tukey test*. Halikadhalika njia ya *multivariate analysis* ilitumika kutambua uhusiano baina ya sampuli na ubora wa vigezo (*sensory attributes*) vya tamba na unga wa uji uliotengenezwa kwa kutumia mbaazi. Vilevile, kuweza kupata mtawanyiko wa sampuli na zilivyoweza kukubalika baina ya walaji. Pia ukokotoaji wa takwimu (*logistic regression analysis*) ulifanyika kutambua vigezo vilivyochangia katika utayari wa kununua tamba na unga wa uji uliotengenezwa kwa kutumia mbaazi. Thamani ya  $p$  ya chini ya 0.05 ( $P < 0.05$ ) ilizingatiwa kuweza kutofatisha sampuli zilizotengenezwa.



Utafiti huu ulibaini kuwa kiwango cha gramu 80/mtu/siku za mbaazi huliwa kipindi cha mavuno na kiasi cha gramu 18/mtu/siku huliwa kipindi cha kiangazi. Aina tano za uandaaji na mapishi ya mbaazi ziliweza kubainishwa. Takribani asilimia 84 ya wakulima walikula mbaazi mbichi, au kavu au zilizokobolewa na kupikwa kupata mboga ya kulia vyakula vingine kama vile ugali na wali. Mapishi mengine yaliyotumika katika eneo hilo ni pamoja na mbaazi zilizochanganywa na vyakula vingine na mbaazi mbichi zilizochemshwa na kuliwa kama asusa. Bidhaa kumi na mbili zilizotengenezwa kwa kuchanganywa na mbaazi ziliainishwa na kupangwa kwa ubora ili kuweza kubaini bidhaa ambazo walipenda zitengenezwe. Miongoni mwa bidhaa hizo tambizi zinazotokana na mbaazi zilipata alama ya juu (70.6), ikifuatiwa na unga wa uji (61.4) na chapati (60.4). Matokeo pia yalionyesha kuna uhusiano mkubwa ( $R^2 = 0.703$ ) baina ya alama za upendeleo, aina za vyakula vilivyotengenezwa na mbaazi pamoja na sifa za walaji.

Sampuli nane za tambizi za mbaazi (PPBN) na nne za unga wa uji wa mbaazi (PPIP) zilitengenezwa. Kulingana na matokeo ya “*Linear Programming*” kiwango cha protini cha gramu 41 hadi 58.2 katika gramu 100 za mchanganyiko kilibainishwa katika sampuli za tambizi za mbaazi. Sampuli PPBN193 ilionekana kuwa na kiwango cha juu cha madini chuma cha miligramu 26.4/gramu 100 za tambizi za mbaazi, ikifuatiwa na sampuli PPBN136 (21 mg/100 g), na PPBN718 (19.3 mg/100 g). Kiwango cha juu zaidi cha madini ya zinki na *pro-vitamin A* zimebainishwa kwenye sampuli ya PPBN136. Matokeo ya ubora wa vigezo (“*sensory attributes*”) ilibainisha rangi, harufu na ladha ya chakula kuwa moja wapo ya vigezo vya kukubalika kwa sampuli PPBN718, PPBN193 na PPBN136 za tambizi za mbaazi. Kwa ujumla wastani wa ubora ulikuwa sawa na alama  $4.5 \pm 1.25$  (SD) sampuli PPBN718, alama  $4.5 \pm 1.08$  (SD) kwa sampuli



PPBN136 na alama  $4.5 \pm 1.02$  (SD) kwa sampuli PPBN193. Alama hizi zilimaanisha kupendwa kwa sampuli hizo kati ya sampuli nane za tamba za mbaazi zilizotengenezwa.

Matokeo yalionesha sampuli ya unga wa uji uliotengenezwa na mbaazi (PPIP<sub>ofsp</sub><sup>r</sup>) kuwa na kiwango cha juu cha protini (gramu 17.5 katika gramu 100 za mchanganyiko wa unga wa uji. Wakati kiwango cha madini chuma kilikuwa ni gramu 7.9/gramu100 za mchanganyiko wa unga wa uji. Sampuli PPIP<sub>ofsp</sub><sup>r</sup> pia ilikuwa na kiwango cha madini ya zinki cha miligramu 5.4/100 g na “*pro-vitamin A*” ilikuwa ni sawa migrogramu “*retinol equivalent*” 308.5 katika gramu100 za mchanganyiko wa unga wa uji. Vilevile, sampuli PPIP<sub>ofsp</sub><sup>r</sup> ilipendwa na walaji kwa wastani wa alama ya ubora ya  $4.9 \pm 0.29$  (SD) na kuwa miongoni mwa sampuli iliyopendendwa kati ya sampuli nne zilizotengenezwa. Matokeo yalionesha pia, sampuli PPIP<sub>ofsp</sub><sup>r</sup> iliwa na viwango vya juu vya vigezo vya ubora wa rangi (8.7), harufu (7.7), ladha (7.8), utamu (7.1) na “*viscosity*” (7.9).

Kiwango cha wastani cha gramu  $137.7 \pm 48.4$  (SD) za uji wa mahindi (MP) na gramu  $128.3 \pm 47.1$  (SD) za uji wa mbaazi (PPIP) kiliweza kunywewa na watoto wenye miezi 9 hadi 36. Matokeo yalionesha tofauti ya kiwango cha uji ulionywewa miongoni mwa watoto wenye umri wa miezi 7-12 na wale wenye umri zaidi ya miezi 12. Watoto wenye umri zaidi ya miezi 12 walikunywa kiasi kikubwa cha uji ukilinganisha na kiasi kilichonywewa na watoto wa miezi 7-12 ( $p < 0.05$ ). Jaribio la *Wilcoxon* lilionyesha kuwa hapakuwa na tofauti ya kiasi cha uji ulionywewa baina ya uji wa unga wa mahindi (MP) na uji wa mbaazi (PPIP) ( $Z = -1.402$ ,  $p = 0.161$ ). Takriban asilimia 88 ya watoto walikunywa kiasi cha uji uliotengenezwa na mbaazi (PPIP) zaidi ya asilimia 50 ya kiasi cha uji wa mahindi ulionywewa na watoto. Takriban asilimia 90 ya watoto waliweza kunywa uji bila usumbufu wowote kwa kufungua midomo yao bila kizuizi chochote.



Utafiti huu ulibaini pia zaidi ya robo tatu (86%) ya walaji walikuwa tayari kulipia tamba zilizotengenezwa na mbaazi (PPBN) kwa bei ya wastani wa shilingi 2000 (IQR =1500, 2200) kwa gramu 1000 za tamba za mbaazi. Kadhalika, asilimia 85 ya walaji walikuwa tayari kulipia unga wa uji wa papo hapo wa mbaazi kwa bei ya wastani wa shilingi  $1610.28 \pm 546.84$  kwa 1000g. Utafiti huu ulibaini pia gharama ya bidhaa, ujazo, na uwezo wa kununua chakula ni vigezo vya utayari wa kulipia vyakula vilivyotengenezwa kwa kuchanganywa na mbaazi ( $p < 0.05$ ).

Utafiti huu umewezesha kupatikana namna nyingine mbili za uandaaji vyakula ("*recipes*") vya mbaazi kuboresha thamani ya tamba na unga wa uji. Kwa ujumla tamba na unga wa uji uliotengenezwa ulipendwa na walaji kwa sababu ya rangi, ladha na harufu yake ambazo zimefanana na tamba za ngano na aina ya uji unaonywewa na watoto kabla ya utafiti huu. Kiwango cha mbaazi kilichowekwa kwenye mchanganyiko wa unga uliotengenezwa na tamba (PPBN) na uji wa watoto (PPIP) kimeboresha kiwango cha protini, madini chuma, madini ya zinki na "*pro-vitamin A*" ukilinganisha na tamba za ngano na unga wa uji unaotumika kwasasa. Walaji wako tayari kununua tamba na unga wa uji uliotengenezwa na mbaazi endapo bei ya kuuzia itakuwa ndani ya uwezo wao kifedha. Kulingana na matokeo ya utafiti huu, ni muhimu kutafiti vigezo vya ubora wa vyakula vinavyotengenezwa, utayari wa bei ya kununulia, uelewa wa bidhaa iliyotengenezwa ili chakula hicho kikubalike katika jamii husika na hivyo kuweza kuliwa wakati wote kwa lishe endelevu.



## DECLARATION

I, **Zahra Saidi Majili**, do hereby declare to the senate of the Sokoine University of Agriculture that this thesis is my original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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**Zahra Saidi Majili**  
(PhD Candidate)

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**Date**

The above declaration is confirmed by the following;

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**Prof. Cornelio N. Nyaruhucha**  
(supervisors)

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**Date**

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**Dr. Kissa Kulwa (Deceased)**  
(Supervisors)

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**Date**

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**Prof. Khamaldin Mutabazi**  
(supervisors)

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**Date**

*Constance Rybak*

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**Dr. Constance Rybak**  
(supervisors)

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**Date**



**LIST OF PUBLICATIONS**

- Majili, Z., Nyaruhucha, C.N., Kulwa, K., (Deceased), Mutabazi, K., Rybak, C. and Sieber, S. (2020). Preferences and consumption of pigeon peas among rural households as determinants for developing diversified products for sustainable health. *Sustainability*, 12(6130), 1-15. [doi:10.3390/su12156130](https://doi.org/10.3390/su12156130)
- Majili, Z., Nyaruhucha, C.N., Kulwa, K., (Deceased), Mutabazi, K., Rybak, C. and Sieber, S. (2022). Identification and prioritization of pigeon peas-based products tailored to consumer preference perspective. A mixed method assessment approach. *Legume science, Wiley*, 4(3): 1-12. DOI: [10.1002/leg3.137](https://doi.org/10.1002/leg3.137)
- Majili, Z., Nyaruhucha, C.N., Kulwa, K., (Deceased), Mutabazi, K., Rybak, C. and Sieber, S. (2023). Development and profiling of affordable and nutritionally optimal pigeon peas-based products mix for improved recipe diversification in rural communities in Tanzania. *East African Journal of Science, Technology and Innovation*, 4(Special Issue 2): 1-19. <https://doi.org/10.37425/eajsti.v4i13.704>
- Majili, Z., Nyaruhucha, C.N., Kulwa, K., (Deceased), Mutabazi, K., Rybak, C. and Sieber, S. (2022). Preferences and acceptability of developed value-added pigeon peas-based noodles and instant porridge among different consumers. *In manuscript format –to be submitted to Food Research International – Elsevier*



Majili, Z., Nyaruhucha, C.N., Kulwa, K., (Deceased), Mutabazi, K., Rybak, C. and Sieber, S. (2022). Consumer willingness to pay, perceived value and drivers of choice for value - added pigeon peas-based noodles and instant porridge. *In manuscript format – to be submitted to Journal of Food & Agribusiness Marketing.*



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## **DEDICATION**

I dedicate this work to my late father (Saidi Majili) and my late mother (Zubeda Gumbo) for the groundwork of my education and for their encouragement during their life. I would also like to dedicate this to my beloved husband (Juma Mfaume), my daughters (Husna, Aisha, Sharifa and Zainab) and my only son (Ramadhani) for their praise, patience, encouragement and love during my study. Special dedication goes to my beloved sister (Hamida Majili) for her moral support and encouragement as well as to my aunties (Rehema Simba and Halima Majili) for caring my children when I was away and busy with my PhD study.



## TABLE OF CONTENT

|   |               |
|---|---------------|
| <b>EXTENDED ABSTRACT .....</b>  | <b>iii</b>    |
| <b>IKISIRI KUU .....</b>  | <b>xiii</b>   |
| <b>DECLARATION.....</b>   | <b>xxv</b>    |
| <b>LIST OF PUBLICATIONS .....</b>   | <b>xxvii</b>  |
| <b>COPYRIGHT .....</b>  | <b>xxxi</b>   |
| <b>ACKNOWLEDGEMENTS .....</b>   | <b>xxxiii</b> |
| <b>DEDICATION .....</b>   | <b>xxxix</b>  |
| <b>LIST OF TABLES.....</b>  | <b>xlix</b>   |
| <b>LIST OF FIGURES .....</b>  | <b>li</b>     |
| <b>LIST OF APPENDICES .....</b>   | <b>liii</b>   |
| <b>ORGANIZATION OF THE THESIS .....</b>                                       | <b>lv</b>     |
| <b>LIST OF ABBREVIATIONS AND ACRONYMS .....</b>                               | <b>lix</b>    |
| <b>1.0 CHAPTER ONE.....</b>   | <b>1</b>      |
| <b>GENERAL INTRODUCTION .....</b>   | <b>1</b>      |
| 1.1 Background Information .....  | 1             |
| 1.2 Pigeon peas Production .....  | 2             |
| 1.3 Nutrient Composition of Pigeon peas and Consumption<br>Trend.....         | 3             |
| 1.4 Pigeon peas Processing .....  | 4             |
| 1.5 Use of Pigeon peas in Making Different Food Products                      | 5             |
| 1.6 Consumers' Preferences and Willingness to Purchase a<br>food product..... | 6             |
| 1.7 Problem statement and Justification of the Study.....                     | 8             |
| 1.8 Study Objectives.....   | 10            |
| 1.8.1 Overall objective .....   | 10            |
| 1.8.2 Specific objectives .....   | 10            |



|   |    |
|---|----|
| 1.9 Theoretical Framework .....   | 10 |
| 1.10 Conceptual Framework.....  | 13 |
| 1.11 Materials and Methods.....   | 16 |
| 1.11.1 Study design .....   | 16 |
| 1.11.2 Study areas.....   | 16 |
| 1.11.3 Study population .....   | 18 |
| 1.11.4 Data collection .....  | 19 |
| 1.11.4.1 Characterize existing recipes of pigeon peas (PP)<br>and their consumption pattern.....  | 19 |
| 1.11.4.2 Development of value-added pigeon peas-based<br>products and test their sensory attributes.....  | 19 |
| 1.11.4.3 Assessment of consumer preference and<br>acceptability of value-added pigeon peas-based products   | 23 |
| 1.11.4.4 Determine consumer willingness to pay perceived<br>value and drivers of choice for developed value-added<br>pigeon peas-based products.....  | 23 |
| 1.11.5 Ethical clearance.....   | 24 |
| 1.11.6 Data analysis .....  | 24 |
| 1.11.6.1 Characterize existing recipes of pigeon peas (PP)<br>and their consumption pattern.....  | 25 |
| 1.11.6.2 Development of value-added pigeon peas-based<br>products and test their sensory attributes.....  | 26 |
| 1.11.6.3 Assessment of consumer preference and<br>acceptability of value-added pigeon peas-based<br>products.....                                     | 27 |
| 1.11.6.4 Determine consumer willingness to pay, perceived<br>value and drivers of choice for developed value-added<br>pigeon peas-based products..... | 28 |



|   |            |
|---|------------|
| <b>CHAPTER TWO .....</b>  | <b>29</b>  |
| <b>Preferences and Consumption of Pigeon peas among Rural Households as Determinants for Developing Diversified Products for Sustainable Health.....</b>                        | <b>29</b>  |
| <b>3.0 CHAPTER THREE .....</b>  | <b>45</b>  |
| <b>Identification and Prioritization of Pigeon Peas-based Products Tailored to Consumer Preference Perspective. A Mixed Method Assessment Approach .....</b>                    | <b>45</b>  |
| <b>4.0 CHAPTER FOUR .....</b>   | <b>59</b>  |
| <b>Development and Profiling of Affordable and Nutritionally Optimal Pigeon Peas-based Products for Improved Recipes Diversification in Rural Communities in Tanzania .....</b> | <b>59</b>  |
| <b>5.0 CHAPTER FIVE .....</b>   | <b>79</b>  |
| <b>Preferences and Acceptability of Developed Value-Added Pigeon peas-based Noodles and Instant Porridge among Different Consumers in Rural Tanzania.....</b>                   | <b>79</b>  |
| <b>CHAPTER SIX.....</b>   | <b>117</b> |
| <b>Consumer Willingness to Pay, Perceived Value and Drivers of Choice for Value-added Pigeon peas-based Noodles and Instant Porridge .....</b>                                  | <b>117</b> |
| <b>7.0 CHAPTER SEVEN .....</b>  | <b>149</b> |
| <b>GENERAL DISCUSSION .....</b>   | <b>149</b> |
| <b>7.1 Introduction .....</b>   | <b>149</b> |
| <b>7.2 Main Findings .....</b>  | <b>149</b> |
| <b>7.2.1 Preferences and consumption of pigeon peas among rural households .....</b>  | <b>149</b> |
| <b>7.2.2 Identification and prioritization of pigeon peas-based products.....</b>   | <b>150</b> |



|  |            |
|--|------------|
| 7.2.3 Development and profiling of affordable and nutritionally optimal pigeon peas-based products.....                    | 150        |
| 7.2.4 Preferences and acceptability of developed value-added pigeon peas products.....                                     | 151        |
| 7.2.5 Willingness to pay, perceived value and drivers of choice for the developed products .....                           | 152        |
| 7.3 Generalizability to other Settings.....  | <b>153</b> |
| 7.4 Drawbacks/ Limitations of the Study .....  | <b>154</b> |
| 7.5 Methodological Considerations .....  | <b>155</b> |
| 7.5.1 Sample size .....  | 156        |
| 7.5.2 Selection of study participants.....   | 157        |
| 7.5.3 Methods and techniques used in the identification and prioritization of pigeon peas-based food to be developed ..... | 157        |
| 7.5.4 Use of Linear programming in product formulation and development   | 159        |
| 7.5.6 Stated Preference Method to assess willingness to pay .....  | 160        |
| 7.5.7 Proportionate price estimation for the developed products.....   | 161        |
| 7.6 Results in Perspective .....   | <b>161</b> |
| 7.6.1 Public health implications.....  | 161        |
| 7.6.2 Implications for Practice .....  | 163        |
| 7.6.3 Policy Implications .....  | 164        |
| <b>8.0 CHAPTER EIGHT.....</b>  | <b>169</b> |
| <b>GENERAL CONCLUSION AND RECOMMENDATIONS</b>  | <b>169</b> |
| 8.1 General Conclusion .....   | <b>169</b> |
| 8.2 Recommendations .....  | <b>170</b> |
| <b>REFERENCES .....</b>  | <b>171</b> |
| <b>APPENDICES .....</b>  | <b>183</b> |



**LIST OF TABLES**

Table 1.1: Chart of design (PC matrix)..... 21



**LIST OF FIGURES**

Figure 1.1: Contribution of study objectives and papers to  
Theoretical framework ..... 13

Figure 1.2: Conceptual framework showing underlying  
theories and relationships among variables... 15

Figure 1.3: A map of Lindi region showing the study villages  
..... 18



**LIST OF APPENDICES**

Appendix 1: Household questionnaire .....183

Appendix 2: Quantitative Descriptive Analysis (QDA)  
questionnaire .....193

Appendix 3: Hedonic test questionnaire .....194

Appendix 4: Acceptance test questionnaire .....196

Appendix 5: Questionnaire on willingness to pay.....203

Appendix 6: Checklist for Focus group discussion.....215



## **ORGANIZATION OF THE THESIS**

This thesis comprises of eight chapters. The first chapter is an introductory part, which presents the background information on pigeon peas production, nutrient composition of pigeon peas, consumption trends of pigeon peas, processing and use of pigeon peas in making different food products. Also, the chapter describes the consumer preferences and willingness to pay for newly developed value-added food products. Furthermore, the chapter describes justification of the study, objectives, definition of key terms, theoretical and conceptual frameworks as well as materials and methods.

Chapters two to six are paper-based chapters presenting the publications and manuscripts generated from the four specific study objectives. Chapter two presents the first paper on assessment of preferences of pigeon peas and their consumption pattern as the bases for the development of pigeon peas-based products to diversified recipes for nutrition and income improvement. This chapter answers objective one of the thesis. Chapters three and four present papers that were generated from objective two. Chapter three identifies pigeon peas-based products that could be prioritized for development to improve organoleptic preferences and increase the diversification of the recipes. Chapter four presents a paper on the best combinations of the ingredients to formulate pigeon peas-based noodles and instant porridge flour. The chapter also describes how the formulated products have been developed and tested to meet consumers' sensory attributes. Chapter five addresses objective three that assessed the preferences and acceptability of the developed pigeon peas-based noodles (PPBN) and instant porridge (PIIP). Chapter six is on objective four of the study that was intended to determine consumers' willingness to pay, perceived value and drivers



that influence buying decision for the developed value-added pigeon peas-based noodles and instant porridge.

Chapter seven presents general discussion of the research findings. It summarizes the main findings of the investigated objectives, generalizability to other settings, drawbacks and methodological consideration. It also focuses on discussion of the results in perspectives of public health, practice and policy implications. Chapter eight provides the overall conclusion and recommendations and relation to findings generated from the research.



**LIST OF ABBREVIATIONS AND ACRONYMS**

|                                   |  |
|-----------------------------------|--|
| AM                                | Attribute Model  |
| FAO                               | Food and Agriculture Organization  |
| IOM                               | Institute of Medicine  |
| MoHCDGEC                          | Ministry of Health, Community<br>Development, Gender, Elderly and<br>Children                |
| NBS                               | National Bureau of Statistics  |
| NIMR                              | National Institute for Medical<br>Research   |
| PP                                | Pigeon peas  |
| PPBN                              | Pigeon peas-based noodles  |
| PPIP                              | Pigeon peas- based instant porridge  |
| PPIP <sub>ofsp</sub> <sup>b</sup> | Blanched pigeon peas- based instant<br>porridge enriched with orange fresh<br>sweet potatoes |
| PPIP <sub>ofsp</sub> <sup>r</sup> | Roasted pigeon peas- based instant<br>porridge enriched with orange fresh<br>sweet potatoes  |
| PPIP <sub>pf</sub>                | Pigeon peas- based instant porridge<br>enriched with pumpkin flour                           |
| RU                                | Random Utility   |
| SUA                               | Sokoine University of Agriculture  |
| TPB                               | Theory of Planned Behaviour  |
| TRA                               | Theory of Reasoned Action  |
| TZFACT                            | Tanzania Food Composition Table  |
| URT                               | United Republic of Tanzania  |
| WHO                               | World Health Organization  |
| WTP                               | Willingness to Pay   |



## 1.0 CHAPTER ONE

### GENERAL INTRODUCTION

#### 1.1 Background Information

The global state of food security and nutrition shows that undernourishment and severe food insecurity continue to persist in many developing countries including sub-Saharan Africa (FAO *et al.*, 2021). About 928 million people in the world were severely food insecure in the year 2020. In sub-Saharan Africa, approximately 24.1% of people were undernourished, and among these 28.1% were from East Africa (FAO *et al.*, 2021). Insufficient dietary micronutrient consumption is among the challenges facing the developing world. The situation can be due to low per capita consumption, economic slowdown, and adverse climate events (IFPRI, 2016).

Despite the change in climate and economic level, high post-harvest food losses in quality and quantity are among the factors constraining food and nutrition security (FAO, 2011). These are attributed to limited food preservation capacities caused by a lack of adequate processing technologies, storage capacities, knowledge and inadequate agricultural development. Therefore, to address these challenges, this study aimed at utilising a nutrient-dense legume to improve food and nutrition security. This is a food-based approach to diversify diets and increase market opportunity of cultivated crops. This approach is in line with existing dietary interventions, namely dietary improvement using locally available foods, consumption of bio fortified crops, dietary diversification, food fortification, food supplementation and home gardening fortification (Etheredge *et al.*, 2016; Dhillon *et al.*, 2011; URT, 2013; Masanja *et al.*, 2006).

The study focused on adding value to pigeon peas-based products. Pigeon peas was chosen because it is one of the

most drought-tolerant legumes (Sharma *et al.*, 2011). In Tanzania pigeon peas is ranked as the third most important legume after beans and groundnuts (Simtowe *et al.*, 2011) and Lindi region is the second producer of pigeon peas for household consumption and commercial purposes. The crop is used as food as well as a source of income. It is also among the legumes that are affordable and important sources of protein, vitamins and minerals for the most households which can help to improve nutrition security (Abebe, 2022; Miano *et al.*, 2020; Cheboi *et al.*, 2019).

## **1.2 Pigeon peas Production**

Pigeon peas is among the perennial crops that are grown in semi-arid parts of the world including Asia, Africa, Latin America and the Caribbean region (Sharma *et al.*, 2011). It is a legume that is highly adaptive to climatic conditions and is grown as an intercrop with maize in different areas of Sub-Saharan Africa (Mponda *et al.*, 2014; Abate *et al.*, 2012; Simtowe *et al.*, 2010; Shiferaw *et al.*, 2007). India and Myanmar are the main producers of pigeon peas in Asia (Sharma *et al.*, 2011), whereas, in sub-Saharan Africa, the main producers are Malawi, Kenya, Uganda, Tanzania and Mozambique (Abate *et al.*, 2012). In Sub-Saharan Africa, about 499 000 ha are used for pigeon peas cultivation (Abate *et al.*, 2012).

In Tanzania, pigeon peas is grown in different zones including the southern zone (Lindi and Mtwara regions), northern zone (Kilimanjaro, Arusha, and Manyara regions), lake zone (Shinyanga region), eastern zone (Morogoro and coastal areas of Dar es Salaam and Tanga regions) (Shiferaw *et al.*, 2007). An average of 290 000 ha were cultivated and about 286 000 tons per year has been produced in the year 2016/2017 (Mponda *et al.*, 2014). In Lindi region, an average of 15 863 ha were cultivated with pigeon peas out of which 8 971 ha were in Nachingwea and

4450 ha were in Ruangwa Districts (URT, 2012). It is estimated that about 209 299 households produce pigeon peas, of which 40 405 households are from Lindi region (URT, 2012). Pigeon peas can be used as soil cover due to its ability to bring minerals from deeper soil horizons to the surface, hence improving soil air circulation (Sharma *et al.*, 2011).

### **1.3 Nutrient Composition of Pigeon peas and Consumption Trend**

Pigeon peas plays a significant role in food and nutrition security as one of the important legume crops that is rich in protein. Dried pigeon peas contain about 16.7 and 26.7 g/100g of protein (Abebe, 2022; Miano *et al.*, 2020; Cheboi *et al.*, 2019; Eltayeb *et al.*, 2010), 9.76 g/100g of tryptophan, 35.56 g/100g of histidine, 71.30 g/100g of leucine, 70.09 g/100g of lysine, 22.70 g/100g of methionine and 22.70 g/100g cysteine (Abebe, 2022). It is also rich in minerals and vitamins. It contains 23-54 mg/100g of zinc, 24.52 - 31.98 mg/100g of iron, 1.31 - 10.8 g/100g of calcium, 7.28 - 20.8 g/100g of potassium, 0.1 - 2.62 g/100g of phosphorus, 0.48 - 5.5 g/100g of magnesium and 16.7 to 24.9 mg/100g of manganese. Pigeon peas contains 21.3 - 45.15% of fibres (Abebe, 2022; Miano *et al.*, 2020). Despite its nutritive value, pigeon peas also contains anti-nutritional factors such as phenols that affect its quality (Cheboi *et al.*, 2019). Phenols binds the nutrients available in pigeon peas and affect bioavailability of the nutrients. Therefore, it is very important to process it to reduce its effects on the human diet.

Globally, it is estimated that about 4 982 000 tons of pigeon peas were consumed in 2015 (Indexbox, 2018) as dehulled splits, whole, canned, boiled, roasted or ground into flour to make a variety of desserts, noodles, snacks and main dishes (Opoku *et al.*, 2003; Saxena *et al.*, 2002). By country, the main consumer was India (3 628 000 tons) followed by Myanmar (594 000 tons), Malawi (385 000 tons), Kenya (309

000 tons) and Tanzania (276 000 tons) (Indexbox, 2018). The average consumption of pigeon peas in sub-Saharan Africa was estimated to be around 0.4 kg/person/year (Nedumaran *et al.*, 2015). Malawi was reported to have the highest per capita consumption (22.35 kg/year) followed by Kenya (6.72 kg/year) and Tanzania (5.16 kg/year) (Indexbox, 2018). In addition to human consumption, pigeon peas are used as foliage for cattle feed, alternative protein source for chicken feed, cover crop for soil fertility and dry stems are used as source of fuel (Oppewal & Da Cruz, 2017).

#### **1.4 Pigeon peas Processing**

Food processing involves converting raw materials into a product to maintain the quality, freshness and organoleptic properties of food as well as convenience to use (Earle *et al.*, 2001). Pigeon peas is among the raw materials that can be used to develop different types of food products. It is affordable and acts as an alternative source to expensive animal-based protein, which makes it important for enhancing diets. About 25% of pulses produced are lost after harvesting in the developing world and in the case of Tanzania, farmers lose up to 40% of their produce after harvest (FAO, 2011). High post-harvest food losses in quality and quantity are major factors constraining food and nutrition security due to limited food preservation capacity caused by a lack of adequate processing technologies, storage capacities and knowledge. Inefficient traditional post-harvest processing and preservation techniques account for 10 - 30% of the losses (Hodges *et al.*, 2011).

Several traditional techniques have been used as processing practices to increase the quality and organoleptic properties of pigeon peas (Prodanov *et al.*, 2004). Dehulling and fermentation reduce cooking time and increase the digestibility and textural quality (Fasoyiro *et al.*, 2012). Dehulled splits of pigeon peas can further be processed into flour, which can be used to enrich different food products. It

has been also reported that soaking, cooking, sprouting and germination have for several years been used as traditional processing methods to remove anti-nutritional factors in different foods (Fasoyiro *et al.*, 2012; Prodanov *et al.*, 2004). These anti-nutritional factors can affect the absorption of some nutrients within the body. For example, the presence of phytates in legumes inhibits absorption of iron in the body (Prodanor *et al.*, 2004).

Soaking and blanching have been used as techniques for reducing anti-nutritional factors as well as aiding in the dehulling process (Fasoyiro *et al.*, 2012). Roasting pigeon peas has also been reported to improve taste and overall sensory attributes (Fasoyiro *et al.*, 2012). Therefore, the use of different processing methods can improve the nutritional quality of pigeon peas and enhance absorption of dietary nutrient contained therein. Likewise, processing of legumes can transform them into edible forms and extending the shelf life for future use (Fasoyiro *et al.*, 2012).

### **1.5 Use of Pigeon peas in Making Different Food Products**

Pigeon peas in green or dried form or as dehulled splits are mainly used as a relish. It can also be processed into flour as an effective ingredient to increase the nutritional value of various food products (Karri & Nalluri, 2017). In Nigeria, pigeon peas was mixed with cereals to produce a nutrient-rich food product known as Fiofio (Karri & Nalluri, 2017). Pigeon peas flour has also been used to enrich the quality of pasta (Torres *et al.*, 2007), produce high fibre and protein biscuits (Ashaye *et al.*, 2015; Gupta & Tiwari, 2014), cookies (Okpala *et al.*, 2016) and in bread production (Olanipekun *et al.*, 2018). In addition, instant whole legumes (Ghadge *et al.*, 2008) and convenient products such as extruded food products (Sethi *et al.*, 2014) are among pigeon peas by-products. PP can also be used to prepare fresh sprouts,

tempeh, ketchup, noodles, snacks and various extruded food product (Saxena *et al.*, 2002).

### **1.6 Consumers' Preferences and Willingness to Purchase a food product**

Consumers have tastes and preferences that determine the decision to accept or reject a food product. Hence for a product to be acceptable, it should fit into consumers' preferences. Consumers decide how much should be spent in purchasing foods to maximize utility (Levin and Milgrom, 2004). Thus, understanding consumer food relationship is imperative for successful product development. Several factors may influence product acceptability including socio-economic, product attributes (e.g. sensory, quality and safety), price and price of substitute products (Banterle *et al.*, 2012). A consumer will be willing to pay for a product if it satisfies his/her needs and wants based on the identified attributes. This can be determined by measuring their intentions to purchase which can be assessed from a different perspective including the value of food (Suzuki *et al.*, 2019), quality of the food (Xiao *et al.*, 2019; Mirabi *et al.*, 2015; Yeow *et al.*, 2013; Sobal *et al.*, 2006) and knowledge about the product (Mirabi *et al.*, 2015; Hughner *et al.*, 2007). The ability to purchase ((Xiao *et al.*, 2019; Mirabi *et al.*, 2015; Yeow *et al.*, 2013), attitude towards the product of interest (Ueasangkomsate & Santiteerakul, 2016; Sethi *et al.*, 2014) and physical appearance of the food (Xiao *et al.*, 2019) can also determine the purchase intentions among consumers.

A conceptual model of food choice process over the life course revealed that experiences, social status, resources, sensory perceptions, quality, easy to use and nutritional benefits are some of the determinants for food choice among consumers which influence purchasing intention (Sobal *et al.*, 2006). Also, attitudes are reported to have a positive effect on intention to purchase food (Ueasangkomsate & Santiteerakul, 2016; Sethi *et al.*, 2014). For instance, a study

by Chaniotakis *et al.* (2010) indicates that consumers' purchase intention is directly affected by attitudes which in turn are influenced by perceived benefits, economic situation, brand loyalty and trust. On the other hand, experience with similar food can influence buying choices. For example, consumption of pigeon peas over time can influence purchasing options for newly developed products. If the taste, colour and smell of the previous pigeon peas recipes were acceptable, there is a high chance of accepting the newly developed pigeon peas-based products. Several researchers have shown that consumers experience can affect purchasing intentions positively or negatively (Mirabi *et al.*, 2015; Hughner *et al.*, 2007).

Furthermore, knowledge about the product is important aspect that influences purchasing intention. A person will buy a product if he/she well aware of it in terms of quality and sensory attributes. Studies indicate that knowledge about a product plays an important role in consumption decisions (Saleki *et al.*, 2012; Peter & Olson, 2010). For instance, "consumers who possess good knowledge of organic food are more likely to choose organically produced food compared to those who lack knowledge about organic production method" (Saleki *et al.*, 2012).

Quality of food and ability to purchase have been documented as important factors that influence purchasing intention. Studies have reported positive correlation between quality of food and purchase intention (Xiao *et al.*, 2019; Mirabi *et al.*, 2015; Yeow *et al.*, 2013). A study on the impact of income on retail purchasing decision (Khan and Chawla, 2014) revealed that income is among the factors which determine the quantity of product to be bought. Therefore, changes in income level affect food consumption pattern to maximize the utility of the spendable income. Consequently, it is important to consider product attributes and price when assessing the possibilities of the consumer to buy a newly

developed product. Price has been documented to influence purchasing decisions (Liew & Falahat, 2019). If consumers are price sensitive, they will look for an alternative product that fits their budgets (Liew & Falahat, 2019). Therefore, a product developer needs to consider a set of product attributes that can influence choices and willingness to buy a product from the stage of concept development to launching of the product. Based on the highlighted set of attributes, the valued added pigeon peas products developed has to focus on key attributes demonstrated by the consumer in line with their needs and wants, behavioural characteristics and practices, products attributes as well as income level to get the preferred product at the lowest available price in order to maximize utility for market continuity.

### **1.7 Problem statement and Justification of the Study**

In Tanzania, about 30% of produced pigeon peas are consumed as a relish or main dish (Mponda *et al.*, 2014). Limited information exists on the diversification of pigeon peas into different products (Mponda *et al.*, 2014). Mponda and colleagues reported that 10% of the produced pigeon peas in Lindi region is consumed as green, 2% as dehulled splits which are locally processed, however, there is no documented information on the consumption of pigeon peas in dried form as well as other recipes/dishes (Mponda *et al.*, 2014). Per capita consumption of pigeon peas in Tanzania has been reported to be 14.14 g/ person/day which is lower by almost half of 30 g/person/day recommended by FAO (Mfikwa & Kilima, 2014). Despite the nutritional importance of pigeon peas, the crop has not been adequately diversified and utilized for human consumption in Tanzania. This creates an opportunity for developing value-added pigeon peas-based products for improving consumption and market opportunities.

High post-harvest loss of pigeon peas is among the challenges that face many farmers in the country. About 25% of pigeon peas produced is lost after harvesting in the developing world and in Tanzania, farmers lose up to 40% of their produce after harvest (FAO, 2011). Traditional harvesting, storage and processing technologies, poor access to market systems as well as lack of knowledge in handling, and limited processing and preservation capacities are among factors contributing to high post-harvest losses (FAO, 2011). This led to inadequate supply consequently food insecurity. Also, postharvest losses due to pest attack led to poor quality of pigeon peas. Pigeon peas can be processed to get different types of food products (Saxena *et al.*, 2002), however, in Tanzania, information on processing of pigeon peas into shelf-stable products is not well documented. This creates a new opportunity for promoting domestic processing operations and marketing of processed products.

There is limited information on the exportation of processed pigeon peas (Mponda *et al.*, 2014). Worldwide, the main buyers of pigeon peas are India (URT, 2016) and the United Arab Emirates as an entry port for the Middle East market and emerging processing zone for re-export of the value-added pigeon peas (Monaco, 2006). Malawi, Tanzania, Kenya and Mozambique are among the African countries that export pigeon peas to the above mentioned countries (Akibode & Maredia, 2011). In Malawi, 40% of the produced pigeon peas is processed for exports to India. In Tanzania, it has been reported that about 80% of the produced pigeon peas is exported to international markets, and 10% is traded in domestic markets (Monaco, 2006). However, in recent years, Myanmar has become the major pigeon peas supplier to India, creating competitive pressure to other producers (Monaco, 2006). This may affect the Tanzanian pigeon peas market leading into decreased export, price and farmers' income. All these scenarios call for promoting domestic

marketing opportunities and processing operations of pigeon peas into diversified shelf stable products for human consumption and commercial purposes. This in turn will stimulate increased production, increased utilization, create market opportunities and improve farmers' incomes and nutritional wellbeing of people in the study area and beyond. The findings from this study will act as a basis for different stakeholders to design and develop food products using locally available and culturally acceptable agricultural food produce.

## **1.8 Study Objectives**

### **1.8.1 Overall objective**

To develop value-added pigeon peas-based food products for recipe diversification to meet consumers and market requirements of people in Lindi region.

### **1.8.2 Specific objectives**

- i Characterize existing recipes of pigeon peas and their consumption pattern
- ii Development of value-added pigeon peas-based products and test their sensory attributes
- iii Assessment of consumer preference and acceptability of value-added pigeon peas-based products
- iv Determine consumers' willingness to pay, perceived value and drivers of choice for developed value-added pigeon peas-based products

## **1.9 Theoretical Framework**

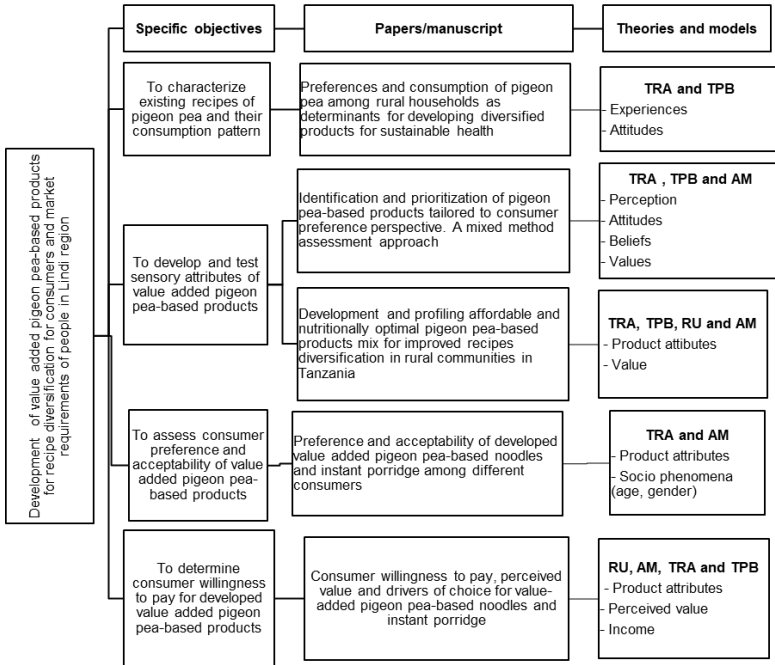
Theories and models that guided the study were the Theory of Reasoned Action (TRA), Theory of Planned Behaviour (TPB), Random Utility (RU) model and Attribute model. The Theory of Reasoned Action (TRA) defines behaviour as a result of intentions that are determined by perceived behavioural control, attitudes, and subjective norms;

resulting from experience, values, knowledge and social phenomena such as age, education, gender and income (Ajzen & Fishbein, 2005). According to the Theory of Planned Behaviour, attitudes and values are important predictors of food consumption behaviour and purchasing intention (Ajzen, 2015). According to the Random Utility model, the consumer is expected to maximize utility at a low cost based on a set of attributes from a set of observable alternatives (price, income, size) and un-observable preferences (beliefs, behaviour, attitude) (Gorton & Barjolle, 2013). Consumer preference models consider four main elements in maximizing product utility; these include available income to purchase a particular product, price of the product, taste, consumer preferences and behavioural approximation (Weddepohl, 1970). The Attribute model (AM) also known as the Lancaster model considers product attributes and the value of individual consumer attributes (Gwin & Gwin, 2003) as a driver for product choice. The model has been used in food industries to assess consumer preferences for food attributes and their willingness to pay based on the set of attributes (Yiridoe *et al.*, 2005). Consumers' knowledge, household income, household size and product attributes reflect the willingness to pay (Aryal *et al.*, 2009).

From the stated theories and models, a consumer will perform the behaviour if she/he has a positive or negative attitude towards a particular behaviour. A positive attitude will result if a consumer has a promising attitude towards a given behaviour that will result into progressive outcome. The poor outcome will result when a consumer has a negative attitude towards a given behaviour. Hence, a consumer may accept a product if she/he is aware that of the product associated risk factors and the consequences of accepting the product. In addition, a consumer may accept a product if she/he has a rational choice/decision about the technology used to come up with that particular product and choose products from available alternatives in the market in order to maximize

utility within the available income, tastes and preferences. Therefore, it is important to consider the relationships among consumer concepts about the product, needs/wants, behaviours and the environment.

In this study, consumers were involved in the identification of the existing pigeon peas-based products in their local communities, selection, and prioritization of other products they wish to be developed after being sensitized on potential pigeon peas-based products. Thereafter, consumers were involved in product development, testing, selection of the ones that fit their preferences, and suggestion of suitable price they are willing and able to pay for the developed products. This approach increases the consumers' knowledge and enable them to gain experiences in development of the targeted products. The findings from this study revealed that the consumers' selected and prioritised the developed products based on their knowledge, experiences, attitudes, beliefs and value of the product on their daily life. Also, consumers' preferences and Willingness to Pay (WTP) was due to product attributes related to composition of the ingredients. This resulted into desirable sensory attributes that reflect willingness of consumers to pay for the newly developed products. All these scenarios fit well with governing theories and models (TRA, TPB, RU and AM) in this research (Fig. 1.1).

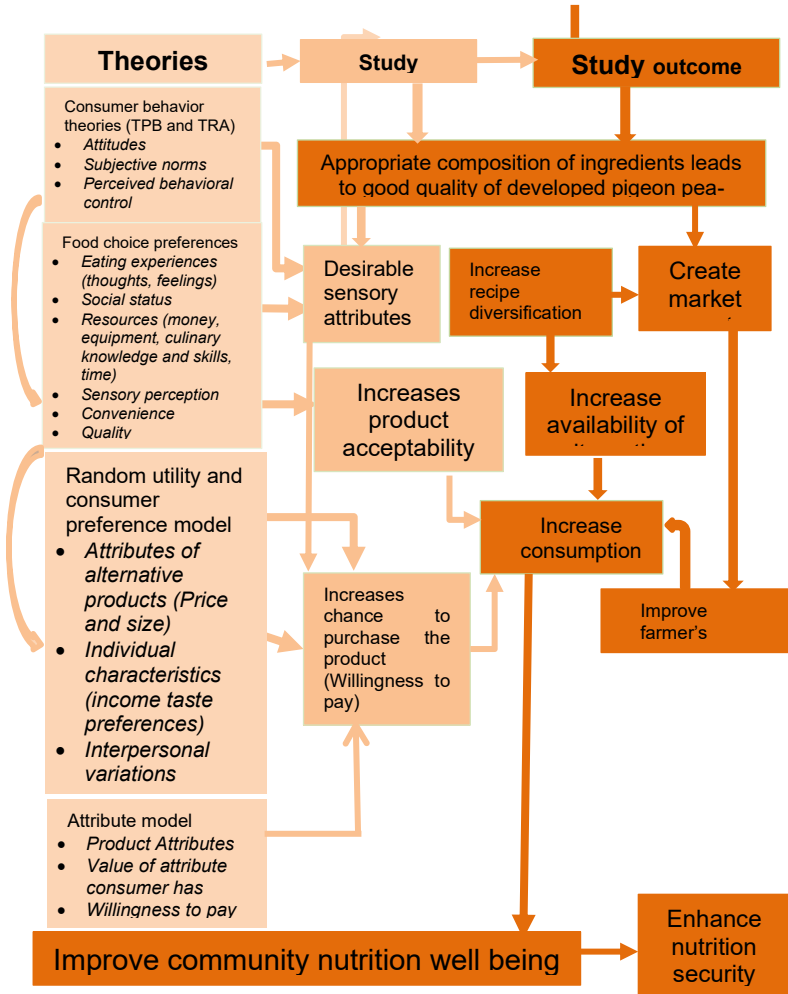


**Figure 1.1: Contribution of study objectives and papers to Theoretical framework**

### 1.10 Conceptual Framework

A conceptual framework was developed to link theories and models described in section 1.10 with the study objectives, and display relationship among the study variables (Fig. 1. 2). Good quality of developed value-added pigeon peas-based products depends on the composition of ingredients and the technology used. Appropriate composition of ingredients produces desirable sensory attributes that influence consumer acceptability of the products and increase chances of consumers' willingness to pay for the developed products. The developed value-added pigeon peas-based products increase recipe diversification and consequently, increase availability. This will consequently increase the demand that in turn will leads into production of

more products to make them available for consumption. Similarly, availability of products with desired attributes that have been developed based on consumer preference maximizes utility since majority of consumers are likely to opt for them. This will in turn create the market opportunity that can lead into improving farmers' economic wellbeing.



**Figure 1.2: Conceptual framework showing underlying theories and relationships among variables**

## **1.11 Materials and Methods**

### **1.11.1 Study design**

This research used cross-sectional, laboratory-based and experimental study designs. A cross-sectional design was used during data collection on the characterization of the existing recipes and their consumption pattern (specific objective one), consumer preference and acceptability of value-added pigeon peas-based products (specific objective three) and willingness to pay for developed value-added pigeon peas-based products (specific objective four). Laboratory-based design was used during product development whereas formulation and production of the samples were carried out (specific objective two). The experimental design was used during Quantitative Descriptive Analysis (QDA) of developed pigeon peas-based noodles and instant porridge (specific objective two). Balanced Incomplete Block Design (BIBD) was used during PPBN sample testing and a Complete Randomized Block Design (CRBD) was used in testing of the PPIP sample (specific objective two).

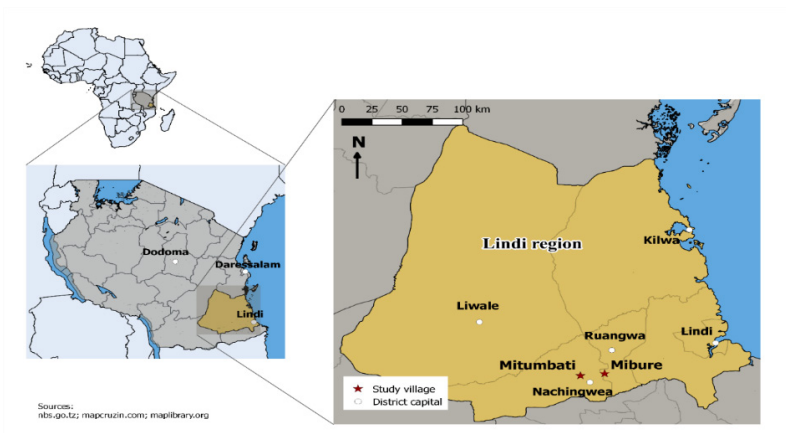
### **1.11.2 Study areas**

The study was conducted in Mibure and Mitumbati villages in Ruangwa and Nachingwea Districts, respectively, in Lindi region (Fig. 1.3). Lindi region is located in the southern zone of Tanzania between latitudes 7° 55' and 10° 50' south of the equator. It lies between 36° 51' and 40° East. Lindi region shares borders with the Indian ocean to the East, the Coast region to the North, Mtwara region to the South, Ruvuma region to the South-West and Morogoro region to the West (URT, 2012). Ruangwa District is located at 10° 04' 00" South and 38° 56' 00" East of Tanzania. It shares borders with Liwale District to the North, Nachingwea District to the South and Morogoro region to the West. Nachingwea District is located at 10° 22' 21.00" South and 38° 45' 45.04" East. It is

bordered by Ruangwa District to the North, Lindi Rural District to the East, Mtwara region to the South-East and Ruvuma region to the South-West (URT, 2012). The region has temperatures between 24.5°C and 27°C throughout the year. The mean air temperature ranges from 22.2°C in Nachingwea to 27.7°C in Kilwa in July and March, respectively. The region receives an average of 500 - 1600 mm of rainfall per year, with the wet season from November/December to April/May (URT, 2012).

Administratively, Lindi region has six districts namely Lindi rural, Lindi urban, Kilwa, Liwale, Ruangwa and Nachingwea. Agriculture, livestock keeping and fishing are the major economic activities in the region. The major food crops grown are maize, pigeon peas, sorghum, rice, cassava, sweet potatoes and banana. The major cash crops are cashew nuts, sesame, pigeon peas, fruits and vegetables, groundnuts, bambara nuts and coconut (URT, 2012).

Lindi region is the 2<sup>nd</sup> leading pigeon peas producer in the Tanzania after Manyara (URT, 2012) whereby 80% of the households grow pigeon peas, contributing nearly 50% of the national total production (Mponda *et al.*, 2014). In Lindi region pigeon peas is mostly consumed compared to other regions that grow the crop. Nachingwea District is the leading producer of pigeon peas in Lindi region in growing followed by Ruangwa, Lindi Rural, Kilwa, Liwale and Lindi Urban (URT, 2012).



**Figure 1.3: A map of Lindi region showing the study villages**

### 1.11.3 Study population

The study involved various consumers of different age groups depending on the specific objectives of the study. Adult males and females aged between 19 and 60 years of age who cultivate pigeon peas at a small-scale level (i.e.  $\leq 5$  acres) were involved in addressing all the study objectives. Children aged 7 - 36 months were involved in an acceptance test of developed pigeon peas-based porridge. School-age children (9 - 13 years) and youth's not in school (14 - 18 years) were involved in the preference tests. District officials, extension workers, cooperative union leaders, traders and influential people in the village were engaged in the in-depth interviews to provide information on marketing opportunities and consumption patterns.

#### **1.11.4 Data collection**

##### **1.11.4.1 Characterize existing recipes of pigeon peas (PP) and their consumption pattern**

Face-to-face interviews were conducted with female or male farmers to get insight of recipes and consumption pattern of pigeon peas in the area. A structured questionnaire (Appendix 1) was used to collect information on household socio-demographic and socio-economic characteristics, pigeon peas consumption patterns and preferences, preparation practices of pigeon peas dishes, consumer acceptance attributes towards pigeon peas and market opportunities for the processed products.

Focus group discussions (FGDs) were carried out to understand individual thoughts, behaviours, perceptions, motives and obstacles related to recipes and consumption of PP. A group of 7 to 10 people of different ages, gender and socio-economic status participated in focus group discussions. The group members were selected from the study area based on their knowledge about particular areas and the study objectives. A prepared checklist was used to guide the discussions (Appendix 6).

##### **1.11.4.2 Development of value-added pigeon peas-based products and test their sensory attributes**

Face-to-face interviews and Focus Group Discussions were employed to identify and prioritize the products the respondents wished to be developed. During face-to-face interviews, consumers were asked to list all pigeon peas-based products they wish to be developed. Thereafter, consumers ranked the listed pigeon peas-based food in order of their preference and the responses were recorded.

Pairwise comparison was used during the Focus Group Discussions. Consumers were asked to list all pigeon peas-based foods they wished to be developed. This was done to fulfil the objectives for the design of the product. A discussion on each pigeon peas-based product mentioned was allowed for common understanding on the inclusion of the product in the list. The chart of the design was drawn on the flip chart and all products mentioned were first written along the first row and column (Table 1.1). Blocking of identical products was conducted by putting a dash diagonally downward on the chart. The pairs for the product were then identified and noted down for reference by the members. A binary comparison of listed pigeon peas-based products was done. The preferred product over the two in each pair was given a score of 1 which was written against the row of the important product preferred. Besides, a zero (0) score was also written on the row of the less preferred products. In case the two products were equally important, the value of 1 was written on both corresponding cells. The matching of the product continued until all boxes were filled up. Summation of row score was done and ranked hierarchically.

**Table 1.1: Chart of design (PC matrix)**

|                         | Bs | Ns | Ch | Sam | Soup | Bread | Milk | Bhaja | Cake | Adon | Kebab | Pflour | PC count | Rank |
|-------------------------|----|----|----|-----|------|-------|------|-------|------|------|-------|--------|----------|------|
| Biscuits (Bs)           | -  | 1  |    |     |      |       |      |       |      |      |       |        |          |      |
| Noodles (Ns)            | 0  | -  |    |     |      |       |      |       |      |      |       |        |          |      |
| Chapati (Ch)            |    |    | -  |     |      |       |      |       |      |      |       |        |          |      |
| Samosa (Sam)            |    |    |    | -   |      |       |      |       |      |      |       |        |          |      |
| Soup                    |    |    |    |     | -    |       |      |       |      |      |       |        |          |      |
| Bread                   |    |    |    |     |      | -     |      |       |      |      |       |        |          |      |
| Milk                    |    |    |    |     |      |       | -    | 1     |      |      |       |        |          |      |
| Bhaja                   |    |    |    |     |      |       | 0    | -     |      |      |       |        |          |      |
| Cake                    |    |    |    |     |      |       |      |       | -    |      |       |        |          |      |
| African donut (Adon)    |    |    |    |     |      |       |      |       |      | -    |       |        |          |      |
| Kebab                   |    |    |    |     |      |       |      |       |      |      | -     |        |          |      |
| Porridge flour (Pflour) |    |    |    |     |      |       |      |       |      |      |       | -      |          |      |

Linear programming (LP) using Simplex methods in MS Excel was used to determine the best combination of the ingredients to be used in product development. The LP model was developed using the objective function, decision variables and constraints. The cost of ingredients used, nutrient composition of each ingredient and Recommended Nutrient Intake (RNI) for protein, iron, vitamin A and zinc were considered as the objective function, decision variables and constraints, respectively. Nutrient composition of each ingredient was obtained from the 2008 Tanzania Food Composition Tables (Lukmanji et al., 2008) and the 2018 Kenya Food Composition Tables (FAO/GOK, 2018). However, in these tables the nutrient content of processed pigeon peas, orange fleshed sweet potatoes and pumpkin into flour forms was lacking. Hence the value of nutrient content was obtained from similar studies which used the processing method and variety of ingredient similar to those used in this study (Adepeju et al., 2015; Dako et al., 2016; Liomba et al., 2018; Pereira et al., 2020; Usha et al., 2010). For vitamin A, raw value of orange fleshed sweet potatoes was used. The pigeon peas were collected from different farmers and transported to Sokoine University of Agriculture, at the Department of Food Science and Agro-processing for processing and development of the products. During product development, several sensory analyses were carried out to determine the best level of combination of the ingredients. Sensory analysis was conducted by trained panellists using descriptive profiling tests as described earlier (Lawless & Hildegarde, 2010). The panellists were trained to perform Quantitative Descriptive Analysis (QDA). They were also asked to determine sensory attributes that will be analysed, descriptors for common understanding, reference product and scale that will be used to rate the product.

#### **1.12.4.3 Assessment of consumer preference and acceptability of value-added pigeon peas-based products**

The method described by Lawless and Hildegarde (2010) was used in assessment of consumer preferences for developed pigeon peas-based noodles (PPBN) and instant porridge (PPIP). A quantitative affective test was conducted to assess consumer preference (liking) of the developed products based on the identified sensory attributes namely colour, aroma, mouthfeel, softness, saltiness and viscosity. The test was conducted at the centre of the village in the study area. A group of 10 - 12 untrained consumers were allowed to participate in one test. Four samples of the developed pigeon peas-based products on identical package coded with a 3-digit random number in randomized order was presented simultaneously to each consumer for testing. Each consumer was asked to taste the product and express the degree of liking the attributes by rating each sensory attribute on a 5-point Hedonic scale whereas 1= extremely dislike 2 = dislike, 3 = neither like or dislike, 4 = like, 5 = extremely like.

#### **1.12.4.4 Determine consumer willingness to pay perceived value and drivers of choice for developed value-added pigeon peas-based products**

Stated Preference (SP) Method is a technique used to estimate willingness to pay based on consumer preference from hypothetical choice sets of products attributes. A structured questionnaire was used to collect information on consumers' willingness to pay, perceived value, price preferences and drivers of choice for the developed value-added pigeon peas-based noodles (PPBN) and instant Porridge (PPIP). During the assessment, the specification of each sample's attributes was described to the consumer.

Consumers were asked to evaluate the attributes by rating the choice of their preference and willingness to buy on a 5-point scale (1= definitely will not buy, 2 = will not buy, 3 = will neither nor will buy, 4 = Will buy and 5 = definitely will buy). Consumers were also requested to propose the price for the products that they were willing to buy. Food product utilities (price, weight, colour, aroma and mouthfeel) were used to create a market model that was used to determine factors that drive consumers into purchasing the developed noodles.

#### **1.11.5 Ethical clearance**

Ethical clearance was requested and approved by National Institute for Medical Research (NIMR) Ethical Committee with reference number NIMR/HQ/R.8a/Vol. IX/3040. Permission to conduct this research was also sought from Sokoine University of Agriculture and Ruangwa and Nachingwea District Councils.

#### **1.11.6 Data analysis**

Data were analysed using SPSS Version 21, Excel version 2011, XLSTAT, R and preference checker software. Normality test using Shapiro-Wilk test was carried out to check data if the data were normally distributed prior to analysis. Data were normal if the Shapiro significance value is greater than 0.05. For data that were normally distributed, the parametric test was computed otherwise non-parametric test was conducted. Box Tidwell test was used to check linearity between continuous independent variables and the logit (log odds) of the outcome variable. Linearity assumptions were considered satisfied when p-value > 0.05.

Descriptive statistics were computed whereas means and standard deviations were used to summarize continuous variables and frequencies to summarize categorical variables. For non-parametric data, median and inter quartile ranges were computed. Inferential statistics such as Analysis

of Variance (ANOVA), Regression analysis (binary, ordinal, and multiple) and Correlations were computed as parametric tests. Kruskal Wallis, Mann–Whitney U and Wilcoxon signed rank test were also computed as non-parametric tests for non-distributed data.

#### **1.12.6.1 Characterize existing recipes of pigeon peas (PP) and their consumption pattern**

Means and standard deviations were used to summarize continuous variables (age, household size) and frequencies to summarize categorical variables (variety of pigeon peas consumed, pigeon peas-based dishes, consumption frequencies, preferences, as well as knowledge and perception scores). Significance tests were computed using the Mann–Whitney U test for comparing categorical variables with two groups (i.e., gender, age, agricultural season, and household heads) against pigeon peas consumption frequency and preference. The Kruskal–Wallis test was used to compare consumption frequency and preferences with categorical variables for three groups, including marital status, education level, occupation, wealth quintiles, and factors influencing their preferences. Moreover, the Spearman correlation was computed to determine the associations between frequencies of consumption and preference of various pigeon peas dishes against the farmers' knowledge, perception, sensory attributes, and drivers for their choice. Multiple linear regressions were computed to determine factors that influence the consumption of pigeon peas. The model was fitted against the dependent variable (frequency of consumption of pigeon peas) and the independent variables (availability, affordability, nutrition knowledge, accessibility, preparation time and taste). The statistical significance was determined at  $p < 0.05$ .

Deductive thematic content analysis was used to analyse qualitative data. Verbatim transcription of the audio was done to create a dataset followed by description of the content to generate the themes. The content was coded to cases and themes. Reviewing of the themes in comparison to the data set created was done to check for accuracy. Themes and factors were summarized in a matrix table where the first column represented the themes and the first rows indicated individual or case responses.

#### **1.12.6.2 Development of value-added pigeon peas-based products and test their sensory attributes**

Frequencies were used to summarize household characteristics. Rank scores for individual preferences were analysed using Henry Garrett Ranking Method. The count and percentage position for each product's rank of preference was calculated. The Garrett value or score was determined using the Garrett Ranking conversion table. Then total Garrett Score and Garrett Mean score (GM score) were calculated. The GM score was then ranked using the Rank command. Compilation of rank scores from different groups was done using excel software where summation of the scores was computed and ranked using the Rank command. Ordinal regression was used to summarize the effect between groups over all levels of the outcome. Preference ranks of the products were set as outcome variables against explanatory variables (consumer categories and pigeon peas-based food types) at a  $p < 0.05$ .

The Linear programming model was used during the formulation of the pigeon peas-based noodles and instant porridge samples. Cost of ingredients used, weights of each ingredient and Recommended Nutrient Intake (RNI) were considered as the objective function, decision variables and constraints, respectively in the model

Means and standard deviations of sensory attributes intensities of the developed pigeon peas-based noodles and instant porridge were computed. Analysis of variance (ANOVA) and post hoc pairwise test –Tukey HDS were used to compare means between samples at  $p < 0.05$ . Two-way ANOVA was computed to determine the mean differences among samples of pigeon peas-based noodles and instant porridge. A post hoc pairwise test (Tukey test) was used to determine differences between the samples of developed noodles and instant porridge against consumer attributes at a  $p < 0.05$ . Sensory attributes were treated as dependent variables against samples and panellists.

#### **1.12.6.3 Assessment of consumer preference and acceptability of value-added pigeon peas-based products**

The means values of preference scores of developed PPIP samples (colour, aroma, mouthfeel, sweetness, and overall acceptability) and amount of porridge consumed by children were computed. One-way analysis of variances (ANOVA) was computed to check whether there was a significant difference among consumers' gender and age group against the sensory attributes. The multivariate analysis was used to determine the multidimensional and possible relationship between the samples against sensory attributes using XLSTAT (Addinsoft, New York, USA). Multivariate regression was done using Consumer checker software (2.3.1 version) to visualize the individual differences between consumers and their preference for sensory attributes of developed pigeon peas-based products. Wilcoxon signed-rank test was conducted to check whether there was a statistical change in the consumption of the maize porridge (control porridge) and pigeon peas-based instant porridge (PPIP).

#### **1.12.6.4 Determine consumer willingness to pay, perceived value and drivers of choice for developed value-added pigeon peas-based products**

The means of age, income expenditure and price preferences of the consumer were computed. Frequencies were used to summarize preferences and factors to consider when buying developed noodles. A chi-square test was computed to determine whether there was a relationship between two categorical variables (i.e., consumer characteristics and noodles samples or instant porridge samples). Logit regression analysis was performed to determine factors that influence consumers' willingness to pay for developed noodles (PPBN) and instant porridge (PIIP). Consumer willingness to pay for the noodles was inserted as a dependent variable and socio-demographic, household expenditure, price and sensory attributes were set as independent variables. Before the analysis, all continuous independent variables were transformed into natural logs to make them comparable. The independent categorical variables were transformed into dummy variables to be used in the equation that represents multiple groups. The value of 0 was coded to the most frequently occurring category and 1 for the less occurring one. The logit regression model was performed to check whether the data fits well in the model. The dependent variable for the model was consumer willingness to pay whereas age, sex, marital status, occupation, residence, education, household expenditure, package size, price, colour, and mouthfeel were independent variables.

**CHAPTER TWO****Preferences and Consumption of Pigeon peas among Rural Households as Determinants for Developing Diversified Products for Sustainable Health**

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Article

# Preferences and Consumption of Pigeon Peas among Rural Households as Determinants for Developing Diversified Products for Sustainable Health

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**Abstract:** Pigeon peas are legumes with a high nutritional value. Existing studies of pigeon peas in Tanzania mainly examine production and marketing, but little has been documented with respect to consumer preferences and the consumption of pigeon peas. This study assesses the preferences surrounding pigeon peas and their consumption as bases for the development of diversified and shelf-stable products for nutrition and income improvement. This study comprised 303 randomly selected farming households. Furthermore, 60 farmers participated in six focus group discussions in the Lindi region. A structured questionnaire and a checklist with guided questions were provided for data collection. The analysis uses SPSS (V.21), with differences between groups established using Kruskal–Wallis and Mann–Whitney tests. The associations were tested using Spearman's  $\rho$  at  $p < 0.05$ . The mean pigeon peas consumption during the harvesting and lean seasons was 80 g/person/day and 18 g/person/day, respectively. The frequency of consumption was higher during the harvesting season (92%) than the lean (29%) season. The majority of farmers (91%) preferred to consume the local variety, with 84% of them consuming pigeon peas as stew. Five pigeon pea recipes exist in the area. The farmers identified availability, taste, source of income, and familiarity as the factors determining pigeon pea consumption and preferences. With limited recipes and other barriers limiting consumption, the creation of innovative ideas for the development of diversified and shelf-stable products fitting their consumption preferences is needed.

**Keywords:** pigeon peas; legumes; preference; consumption; Tanzania

## 1. Background

Consumption and demand for food are among the drivers of food production, which, in turn, exerts their influence on sustainability [1]. The sustainability of diets does not only include nutritional and environmental concerns, but also economic and socio-cultural dimensions [2]. It has been reported that some foods, such as vegetables and legumes, are healthy, as well as having a low environmental impact; hence, all these contribute more towards the goals of sustainability [3]. The pigeon pea is a dry mature legume seed of *Cajanus cajan* L., from the family Fabaceae. It is widely grown in the developing world, including regions of Asia, Africa, Latin America, and the Caribbean [4]. It is mainly grown

in semi-arid tropical regions [5]. It is among the legumes that contribute towards food and nutrition security most significantly, hence contributing greatly to food sustainability in Sub-Saharan Africa.

Food sustainability involves a multitude of interrelated factors, including nutrition, environmental impacts, cultural preferences, safety, and food systems [6]. Adequate, safe, diversified, and nutrient-rich foods contribute to healthy diets; however, there are limitations posed by resource scarcity and environmental degradation, as well as unsustainable production, food losses, and unbalanced distribution and consumption patterns which influence consumers' diets [7]. The consumer behavior theory assumes that a consumer is a rational economic agent who aims to attain the highest possible satisfaction derived from affordable, nutritious, and safe food, as well as from its attributes (e.g., taste, color, and aroma) [8]. For a food product to be acceptable, consumers should identify a product that fits their preferences. Therefore, understanding consumer preferences and consumption behaviors is an important aspect in the designing of interventions related to sustainable diets, as well as the creation of a sustainable food system. This article focuses on presenting key findings that are related to consumer preferences and the consumption of pigeon peas as determinants for developing diversified and shelf-stable products for nutrition and income improvement. Considering consumer preferences and consumption behavior in product development will have a positive effect on physical and economic access to a variety of pigeon pea-based products that are adequate, culturally acceptable, and consumed sustainably.

In Sub-Saharan Africa, about 7.8 million households grow pigeon peas. According to the National Bureau of Statistics, in Tanzania, 209,299 households [9] and more than three-quarters of farmers in the southern zone grow pigeon peas [10,11]. Pigeon peas are rich sources of essential amino acids (lysine, methionine, and tryptophan), fiber, vitamins (riboflavin and niacin), and minerals (phosphorus, iron, and magnesium) [12,13]. Globally, it is estimated that about 4,982,000 tons of pigeon peas was consumed in 2015 [14], either as dehulled splits, whole, canned, boiled, roasted, or grind into flour to make a variety of desserts, noodles, snacks, and main dishes [12,15]. In Africa, it is estimated that 65% of pigeon peas produced are consumed by farmers [16,17]. The average consumption of pigeon peas in Sub-Saharan Africa is estimated to be around 0.4 kg/person/year [18]. In particular, Malawi has been reported to have the highest per capita consumption of pigeon peas (22.35 kg/year), followed by Kenya (6.72 kg/year) and Tanzania (5.16 kg/year) [14]. In Tanzania, pigeon peas are grown in several regions, including Manyara, Arusha, Lindi, Mtwara, Dodoma, Singida, Coastal, and Morogoro. Of the aforementioned 209,299 households that produce pigeon peas in Tanzania, 46,171 are from the Manyara region, followed by 40,405 in Lindi and 25,913 in Mtwara [9]. An average of 15,869 ha is cultivated in the Lindi region, of which 8971 ha are from the Nachingwea district and 4450 ha are from the Ruangwa district [9]. This study was conducted in the Lindi region, the second largest producer of pigeon peas in the country (NBS, 2012), where 80% of the households produce pigeon peas, contributing nearly 50% of Tanzania's total national production [11]. Although Manyara is the biggest producer in the country, its production is mainly for export purposes. Typically, pigeon peas produced in the Lindi region are used for household consumption and as a source of income, while in Manyara it is mainly a cash crop [19].

Despite the nutritional importance of pigeon peas, the crop is not adequately used for human consumption in Tanzania. It has been estimated that the per capita consumption of legumes in Tanzania is 14.14 g/d/person, which is less than the 30 g/d/person recommended by the Food and Agriculture Organization of the United Nations (FAO) [20]. About 30%–35% of the produced pigeon peas were consumed as cooked green pigeon peas or dry peas [11,21]. Although Lindi is a high-pigeon-peas-producing area, it has a chronic malnutrition rate of 23.8% [22], as well as an anemia rate of 61% in children younger than 5 years [22] and of 32.5% in women of reproductive age [22]. Given that pigeon peas are good sources of amino acids and minerals and are affordable, combining them with other food groups will improve the quality of diet, hence reducing the chances of malnutrition.

Although existing studies of pigeon peas in Tanzania are mainly confined to production and marketing [11,23], there are a few studies on the consumption of pigeon peas [11,19,20,24] but no

information published on different recipes or shelf-stable products. Therefore, this study aims to (i) analyze existing recipes and consumption patterns related to consumer preferences, (ii) determine the nutritional knowledge and actual perception of pigeon pea consumption, and (iii) identify influential drivers and obstacles for their consumption in two villages. The results will act as a guide for developing diversified and shelf-stable products for nutrition and income improvement.

## 2. Methods

### 2.1. Study Design and Sample

A preference and consumption study was conducted in two semi-arid villages of Ruangwa (Mibure) and Nachingwea (Mitumbati) districts of Lindi region in October–December 2019 and March 2020. The two districts experience erratic, but adequate, rainfall between December and March, receiving an average of 400–800 mm rainfall per year with a 6.9% chance of precipitation. Despite this unpredictable rainfall, the two areas receive enough rainfall to grow pigeon peas. In these areas, pigeon peas are intercropped with maize. The two districts were selected because they are the leading producers of pigeon peas in the region and because of their varied market accessibility. The selection of villages was based on the high quantity of pigeon peas produced, based on information provided by the district agricultural office.

All adult males and females aged between 19 and 60 years, who grow pigeon peas on a small-scale level (i.e.,  $\leq 5$  acres) in the selected villages, were eligible for this study. Fisher's formula [25], using the proportion of farmers who grow pigeon peas in the study area (80%), was used to calculate the desired sample size. A sample of 303 randomly selected farming households was chosen using the Microsoft Excel Random number function RAND. The lists of farming households were collected, with each household being assigned a unique number using the RAND function followed by the Microsoft Excel Ranking of numbers (RANK function) to generate values that were used to select households to be involved in the study.

The sample size for qualitative data was determined by the principles stipulated in Moser and Korstjens [26]. A total of  $n = 60$  farmers were involved in focus group discussions to obtain insights and in-depth information on the preparation and cooking of pigeon peas as well as its consumption patterns and preferences. The permission for the study was granted by the Tanzania National Institute of Medical Research (NIMR) with reference number NIMR/HQ/R.8a/Vol. IX/3040. Written informed consent was obtained from each farmer before the interviews.

### 2.2. Data Collection

Data collection involved two sessions. During the first session, a household survey with face-to-face interviews was conducted at individual homesteads by trained interviewers. Using mobile tablets loaded with an open data kit tool for data collection, a structured, pretested questionnaire was employed. To ensure the data quality, constraints were loaded for impossible values and relevance for improbable ones. For example, the frequency of consumption should never be less than zero if a farmer reports consuming pigeon peas. Skip was added to remove unnecessary answers. Moreover, a Global Positioning System (GPS) was added to identify the data collection location.

#### 2.2.1. Household Characteristics

Information on age, gender, education level, marital status, income sources, and assets was collected to evaluate household characteristics. Household asset information was used to calculate the wealth index using factor analysis [27,28]. Fifteen assets, including toilet, water, bicycle, TV, radio, cell phone, hand hoe, rake, spade, axe, digging fork, motorcycle, cooking stove, tables, and chairs, were used to calculate the wealth index for each of the villages.

### 2.2.2. Preference and Consumption of Pigeon Peas

Information on the amount of pigeon peas consumed, consumption frequency, preferences, as well as knowledge and perception was also collected. The amount of pigeon peas consumed was collected using the 24 h food recall method [29]. Each interviewee was asked to mention all foods and amounts consumed in the past 24 h. Photos of household utensils were used to estimate the amount consumed and subjects were asked to indicate if the amount was consumed alone or shared to facilitate calculation of the amounts consumed per person per day. Subjects who did not consume pigeon peas during the 24 h prior to their interview received a follow-up phone call to make another appointment. A zero (0) amount was recorded if pigeon peas were not consumed in that particular week. Moreover, each interviewee was asked about the frequency of consumption of other legumes by reporting their usual consumption of each legume. The responses for their frequency of consumption were recorded in terms of the number of days in the week.

### 2.2.3. Nutritional Knowledge and Perceptions Surrounding Pigeon Pea Consumption

Nutritional knowledge and perceptions surrounding pigeon pea consumption were assessed using a three point Likert scale as a reduced scale from what is typically used by researchers [30]. The scale was reduced due to the nature of the study population, which involves respondents with a low level of education. The value of 1 stands for disagree/not acceptable, 2 stands for neither agree nor disagree, and 3 stands for agree/acceptable. A total of fourteen (14) questions related to knowledge and perception of pigeon peas attributes were asked.

### 2.2.4. Qualitative Information

The second session collected qualitative information for the contextualization of the research question through a Focus Group Discussion (FGDs) guided by a checklist. Information on pigeon pea preparation, consumption, and preference was collected. Six focus group discussions were conducted at the village centre, with each village represented by  $n = 30$  farmers, including both males (15) and females (15). In each village, the discussions involved three different groups with an average of  $n = 10$  farmers in each group. The first two groups were gender specific (i.e., either male or female) and the third group included both male and female farmers.

## 2.3. Data Analysis

Statistical analyses were completed using Statistical Product and Service Solutions (SPSS) software version 20. The Shapiro–Wilk test was used to check data normality prior to analysis. During the analysis, all assets variables were changed to binary. International standards were used to categorize information on water and toilets into binary variables [31]. Frequency was analyzed to check the acceptability of each variable. The asset was included in the analysis if the frequency was between 5% and 95%, as a percentage below 5 is considered very rare, while those greater than 95% are considered more common; both extremes are unable to differentiate farmers using the wealth index. Factor analysis was done to compute factor weights, means, and standard deviations for each household asset. Means and standard deviations for each household asset were used for the standardization of assets' data, followed by multiplication of the factor weights to obtain wealth scores. The wealth scores were ranked using the Rank case command in SPSS to rank and assign each household to one of the wealth quintiles from the poorest to the wealthiest [28]. Furthermore, knowledge and perception scores were changed into binary variables before summing to get separate knowledge and perception scores. A score of one (1) was given for a correct response and zero (0) for an incorrect response related to knowledge. Similarly, the scores were given if the respondent agreed (score = 1) or disagreed (score 0) on perceived attitude. The score for both knowledge and perception were then summarized to get meaningful information.

Means and standard deviations were used to summarize continuous variables (age, household size) and frequencies to summarize categorical variables (variety of pigeon peas consumed, pigeon peas based dishes, consumption frequencies, preferences, as well as knowledge and perception scores). Significance tests were computed using the Mann-Whitney U test for comparing categorical variables with two groups (i.e., gender, age, agricultural season, and household heads) against pigeon pea consumption frequency and preference. The Kruskal–Wallis test was used to compare consumption frequency and preferences with categorical variables for three groups, including marital status, education level, occupation, wealth quintiles, and factors influencing their preferences. Moreover, the Spearman correlation was computed to determine the associations in frequencies of consumption and preference of various pigeon peas dishes against the farmers' knowledge, perception, sensory attributes, and drivers for their choice. Multiple linear regressions were computed to determine factors that influence the consumption of pigeon peas. The model was fitted against the dependent variable (frequency of consumption of pigeon peas) and the independent variables (availability, affordability, nutrition knowledge, accessibility, preparation time, and taste). The statistical significance was considered at  $p$  value  $< 0.05$ . Deductive thematic content analysis was used to summarize themes and factors for qualitative information by using a matrix table.

### 3. Results

#### 3.1. Household Characteristics

The mean age of respondent farmers was  $35.8 \pm 8.5$ (SD), with the majority aged between 15 and 49 years (Table 1). The mean household size was  $3.5 \pm 1.5$ (SD) and 80% of the households had a male head. In terms of wealth quintiles, 40% of farming households were poor, including 45% of those from Mibure and 34% from Mitumbati villages (Table 1).

**Table 1.** Household characteristics.

| Variables                                       | Overall<br>(n = 303) |    | Mibure<br>(n = 152) |    | Mitumbati<br>(n = 151) |    |
|---|----------------------|----|---------------------|----|------------------------|----|
|   | n                    | %  | n                   | %  | n                      | %  |
| <b>Age</b>                                      |                      |    |                     |    |                        |    |
| 15–49 years                                     | 289                  | 95 | 148                 | 97 | 141                    | 93 |
| >49 years                                       | 14                   | 5  | 4                   | 3  | 10                     | 7  |
| <b>Gender</b>                                   |                      |    |                     |    |                        |    |
| Male  | 186                  | 61 | 97                  | 64 | 89                     | 59 |
| Female  | 117                  | 39 | 55                  | 36 | 62                     | 41 |
| <b>Household heads</b>                          |                      |    |                     |    |                        |    |
| Female headed household                         | 62                   | 20 | 31                  | 20 | 31                     | 21 |
| Male headed household                           | 241                  | 80 | 121                 | 80 | 120                    | 80 |
| <b>Marital status</b>                           |                      |    |                     |    |                        |    |
| Married   | 215                  | 71 | 104                 | 68 | 111                    | 74 |
| Divorced  | 43                   | 14 | 25                  | 16 | 18                     | 12 |
| Single  | 39                   | 13 | 21                  | 14 | 18                     | 12 |
| Widowed   | 6                    | 2  | 2                   | 1  | 4                      | 3  |
| <b>Education level</b>                          |                      |    |                     |    |                        |    |
| No formal education                             | 42                   | 14 | 31                  | 20 | 11                     | 7  |
| Primary school education                        | 259                  | 85 | 121                 | 80 | 138                    | 92 |
| Secondary education or higher                   | 2                    | 1  | 0                   | 0  | 2                      | 1  |
| <b>Occupation</b>                               |                      |    |                     |    |                        |    |
| Farmer  | 292                  | 77 | 150                 | 77 | 142                    | 76 |
| Employed in the informal sector (casual labour) | 18                   | 5  | 9                   | 5  | 9                      | 5  |
| Self employed                                   | 70                   | 18 | 34                  | 19 | 36                     | 19 |
| <b>Household wealth quintile</b>                |                      |    |                     |    |                        |    |
| Poorest   | 74                   | 24 | 42                  | 28 | 32                     | 21 |
| Middle  | 153                  | 51 | 74                  | 49 | 79                     | 52 |
| Wealthiest                                      | 76                   | 25 | 36                  | 24 | 40                     | 27 |

### 3.2. Pigeon Peas Consumption

#### 3.2.1. Existing Pigeon Peas Recipes: Preparation and Cooking Methods

Five different ways of preparing and cooking pigeon peas dishes were identified in the study area during FGDs (Table 2). All group members in the six FGDs reported preparing pigeon peas in different dishes including stew from whole pigeon pea grains (relish) accompanied by rice or a stiff porridge. There were also reports of boiling green pigeon pea pods to be eaten as a snack, mixed with other foods, or cooked as the main dish. About 83% of farmers reported preparing pigeon peas as a stew cooked with green pigeon peas, dried pigeon peas, or pigeon peas splits (dhal).

**Table 2.** Existing pigeon pea recipes: preparation and cooking methods.

| Themes  | Subthemes     | Preparation Method   | Response |     |
|---|---------------|--|----------|-----|
|   |               |  | n        | %   |
| Dishes consumed                                   |               | We consume pigeon peas in several ways, namely dried pigeon peas stew (DPPS), Green pigeon peas stew (GPPS), Dhal stew (DS), snack (“mikumbu”), main dish (MD), and mixed with another food (MPPF).  | 60       | 100 |
|   | GPPS and DPPS | For green and dried pigeon peas, we peel, wash, and boil until well cooked. Then, we partially fry onions and tomatoes, before adding boiled pigeon peas, salt, and some water to get stew.  | 50       | 83  |
| Existing recipes (Cooking method and preparation) |               | For green and dried pigeon peas, we peel, wash, and boil until well cooked. After boiling, we add onion, tomato, salt, and coconut milk to get a stew that is consumed with rice or stiff porridge   | 40       | 67  |
|   | Snack         | We usually boil green pigeon peas with their pods and consume it as a snack while preparing the meals. This is mostly given to children to reduce hunger while we prepare the main meal.   | 40       | 67  |
|   | DS            | We roast dried pigeon peas in the ashes then grind it in mortar to remove the husk and then grind it with stones to get small split. These splits are then boiled and relished with onion, salt, tomato.   | 50       | 83  |
|   | MPPF          | We also consume dried pigeon peas, which we boil with dehulled maize and relish with oil, coconut milk, or sesame milk before consuming it as a main dish (“makande”) Dried pigeon peas are boiled and mixed with cassava or sweet potatoes, then consumed as the main dish; however, it is rarely prepared in this way. | 35       | 58  |
|   | MD            | Sometimes we boil dried pigeon peas and relish it with salt alone or with salt and coconut milk, then consume it as the main dish with porridge.   | 43       | 72  |

#### 3.2.2. Frequency of Consumption of Pigeon Peas

The majority of farmers consume pigeon peas within a week during the harvesting (280; 92%) and lean (90; 29%) seasons. The mean intake of pigeon peas during the harvesting season is 80 g/person/day,

but only 18 g/person/day during the lean season. The results regarding pigeon pea consumption in terms of residence, agricultural season, and household characteristics are presented in Table 3. During harvesting, 44% of the farmers consumed pigeon peas more than five days in a week, but only 4% do so during the lean season. In terms of residence, 55% of farmers in Mitumbati and 32% in Mibure consume pigeon peas more than five days a week. There is a significant difference in the consumption of pigeon peas across agricultural seasons, area of residence, and source of income. Furthermore, those dependent on farming activities (45%) consume pigeon peas more frequently than those who were self-employed or depend on the informal sector. There is no enough evidence to determine significant differences in terms of age, education level, marital status, head of the households, or wealth tertiles (Table 3).

**Table 3.** Frequency of consumption of pigeon peas.

| Household Characteristics                     | Consumed 1–3 d/w |    | Consumed 4–5 d/w |       | Consumed >5 d/w |    | p-Value |
|---|------------------|----|------------------|-------|-----------------|----|---------|
|   | n                | %  | n                | %     | n               | %  |         |
| <b>Village <sup>a</sup></b>                   |                  |    |                  |       |                 |    | 0.000 * |
| Mibure  | 68               | 45 | 35               | 23    | 49              | 32 |         |
| Mitumbati                                     | 44               | 29 | 24               | 16    | 83              | 55 |         |
| <b>Agricultural season <sup>a</sup></b>       |                  |    |                  |       |                 |    | 0.000 * |
| Harvest season                                | 89               | 29 | 59               | 20    | 132             | 44 |         |
| Lean season                                   | 68               | 22 | 18               | 6     | 4               | 1  |         |
| <b>Age <sup>a</sup></b>                       |                  |    |                  |       |                 |    | 0.181   |
| 15–49 years                                   | 109              | 38 | 57               | 20    | 123             | 43 |         |
| >49 years                                     | 3                | 21 | 2                | 14    | 9               | 64 |         |
| <b>Gender <sup>a</sup></b>                    |                  |    |                  |       |                 |    | 0.395   |
| Male  | 62               | 33 | 43               | 23    | 81              | 44 |         |
| Female  | 50               | 43 | 16               | 14    | 51              | 43 |         |
| <b>Marital status <sup>a</sup></b>            |                  |    |                  |       |                 |    | 0.949   |
| Married                                       | 61               | 69 | 46               | 78    | 92              | 70 |         |
| Divorced/Single/Widowed                       | 28               | 31 | 13               | 22    | 40              | 30 |         |
| <b>Education level <sup>b</sup></b>           |                  |    |                  |       |                 |    | 0.735   |
| No formal education                           | 16               | 37 | 7                | 16    | 20              | 47 |         |
| Primary school education                      | 92               | 38 | 45               | 19    | 104             | 43 |         |
| Secondary education or higher                 | 4                | 21 | 7                | 37    | 8               | 42 |         |
| <b>Occupation <sup>a</sup></b>                |                  |    |                  |       |                 |    | 0.017 * |
| Agriculture                                   | 8                | 91 | 59               | 100.0 | 130             | 99 |         |
| More than agriculture                         | 8                | 9  | 0                | 0     | 2               | 1  |         |
| <b>Household heads <sup>a</sup></b>           |                  |    |                  |       |                 |    | 0.392   |
| Female headed household                       | 22               | 36 | 7                | 11    | 33              | 53 |         |
| Male headed household                         | 90               | 37 | 52               | 22    | 99              | 41 |         |
| <b>Household wealth quintile <sup>b</sup></b> |                  |    |                  |       |                 |    | 0.218   |
| Poorest                                       | 21               | 23 | 15               | 25    | 31              | 23 |         |
| Middle  | 39               | 44 | 32               | 55    | 72              | 55 |         |
| Wealthiest                                    | 29               | 33 | 12               | 20    | 29              | 22 |         |

d/w = days per week. <sup>a</sup> Mann–Whitney U test for two categorical groups (e.g., yes/no), <sup>b</sup> Kruskal–Wallis test for more than two categories. \* Significant at  $p < 0.05$ .

In terms of the consumption of different pigeon pea dishes, the results indicate significant differences regarding the consumption of pigeon pea dishes during the harvesting season and the lean season. Specifically, the farmers consume pigeon pea stews 1–3 days in a week during the harvesting season (55%) and the lean season (46%) seasons. Only 16% of the farmers consume pigeon peas stew more than 5 days in a week (Figure 1).

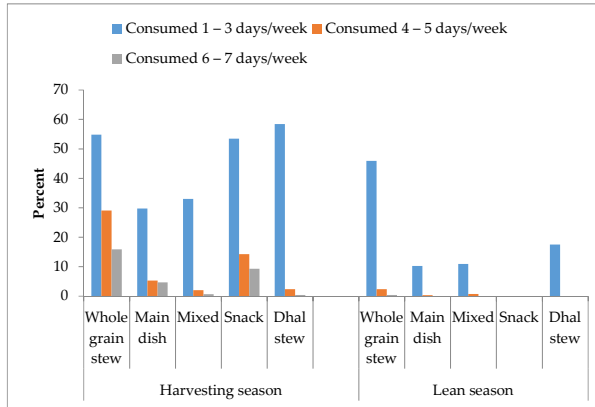


Figure 1. Consumption of pigeon peas dishes during harvesting season and lean season.

Furthermore, the majority (100%) of the FGD members reported consuming pigeon peas more frequently when green during the harvesting season not only because of its taste but also because they cause less flatulence. Furthermore, the short maturity period is reported as a factor for consuming green pigeon peas during the harvesting season. The respondents reported the consumption of dried pigeon peas as a relish (92%) to their main meal as well as the consumption of them, mixed with maize to obtain the maize pigeon pea dish (“Kande”) or mixed with cassava/sweet potatoes (“Futari”). The consumption of pigeon peas during the lean season (50%) is reported to decrease as members claim that, during this time, people are preparing their farms and no green pigeon peas are available. The consumption of dried pigeon peas (62%) observed is due to their availability during the time of the year when people have limited funds: people usually consume what is available at home and pigeon peas are the main legume that almost every household keeps in stock.

### 3.3. Pigeon Peas Consumption Preference

Farmers (91%) prefer consuming local varieties of pigeon peas, with only 8% preferring to consume the improved variety. In terms of dishes, 84% of farmers preferred to consume stews, among them: 47% preferred to consume whole dried pigeon peas, 21% green pigeon peas, and 16% dhal stews. Table 4 indicates the consumption preferences for different pigeon peas based dishes. It is observed that more than 50% of farmers in Mitumbati consumed more than three dishes, but only one dish in Mibure was consumed. The results on the other hand reveal that there is a significant difference in consumer preferences and the consumption of pigeon pea dishes among education level and household heads (Table 4). On the other hand, 100% of the focus group discussion members reported preferring to consume pigeon pea stew either green or dried. They also wished to learn how to store green pigeon peas so that it can be consumed throughout the year. The reason for the choice was that green pigeon peas are tastier than dried ones, which require a lot of spices in order to taste good. Likewise, they

report that dried pigeon peas are easily attacked by pests. Furthermore, dried pigeon peas must be dehulled to get dhal before cooking; this is a long process as they use stones to process it. The FGD members (87%) stated that the familiarity of a consumer's behavior is one of the reasons for their consumption preferences of pigeon pea stew.

**Table 4.** Preference for consumption of pigeon-pea-based dishes.

| Household Characteristics                   | Whole Grain Stew |    | Green Pigeon Peas Stew |    | As Dhal Stew |    | As Snack |    | Main Dish |    | <i>p</i> -Value |
|---|------------------|----|------------------------|----|--------------|----|----------|----|-----------|----|-----------------|
|   | n                | %  | n                      | %  | n            | %  | n        | %  | n         | %  |                 |
| <b>Villages<sup>a</sup></b>                 |                  |    |                        |    |              |    |          |    |           |    |                 |
| Mibure                                      | 63               | 44 | 36                     | 56 | 25           | 52 | 18       | 60 | 10        | 56 | 0.059           |
| Mitumbati                                   | 80               | 56 | 28                     | 44 | 23           | 48 | 12       | 40 | 8         | 44 |                 |
| <b>Age<sup>a</sup></b>                      |                  |    |                        |    |              |    |          |    |           |    |                 |
| 15–49 years                                 | 136              | 95 | 63                     | 98 | 45           | 94 | 29       | 97 | 16        | 89 | 0.764           |
| >49 years                                   | 7                | 5  | 1                      | 2  | 3            | 6  | 1        | 3  | 2         | 11 |                 |
| <b>Gender<sup>a</sup></b>                   |                  |    |                        |    |              |    |          |    |           |    |                 |
| Male  | 86               | 60 | 43                     | 67 | 26           | 54 | 18       | 60 | 13        | 72 | 0.793           |
| Female                                      | 57               | 40 | 21                     | 33 | 22           | 46 | 12       | 40 | 5         | 28 |                 |
| <b>Marital status<sup>b</sup></b>           |                  |    |                        |    |              |    |          |    |           |    |                 |
| Married/cohabitating                        | 90               | 63 | 47                     | 73 | 35           | 73 | 26       | 87 | 17        | 94 | 0.725           |
| Single/Divorced/widowed                     | 53               | 37 | 17                     | 27 | 13           | 27 | 4        | 13 | 1         | 6  |                 |
| <b>Education level<sup>b</sup></b>          |                  |    |                        |    |              |    |          |    |           |    |                 |
| No formal education                         | 12               | 8  | 13                     | 20 | 7            | 15 | 26       | 87 | 3         | 17 | 0.020 *         |
| Primary school education                    | 131              | 92 | 50                     | 78 | 41           | 85 | 3        | 10 | 14        | 78 |                 |
| Secondary education or higher               | 0                | 0  | 1                      | 2  | 0            | 0  | 1        | 3  | 1         | 6  |                 |
| <b>Occupation<sup>b</sup></b>               |                  |    |                        |    |              |    |          |    |           |    |                 |
| Farmer                                      | 135              | 78 | 64                     | 75 | 46           | 75 | 29       | 76 | 18        | 86 | 0.176           |
| Employed in informal sector (casual labour) | 6                | 4  | 3                      | 4  | 5            | 8  | 3        | 8  | 1         | 5  |                 |
| Self-employed (small business)              | 32               | 18 | 18                     | 21 | 10           | 16 | 6        | 16 | 2         | 10 |                 |
| <b>Household heads<sup>a</sup></b>          |                  |    |                        |    |              |    |          |    |           |    |                 |
| Female headed household                     | 37               | 26 | 9                      | 14 | 13           | 27 | 2        | 7  | 1         | 6  | 0.021 *         |
| Male headed household                       | 106              | 74 | 55                     | 86 | 35           | 73 | 28       | 93 | 17        | 94 |                 |

<sup>a</sup> Mann–Whitney U test for two categorical groups (e.g., yes/no). <sup>b</sup> Kruskal–Wallis test for more than two categories.  
\* Significant at  $p < 0.05$ .

### 3.4. Farmer's Nutritional Knowledge and Perception of Consumer Preferences and the Consumption of Pigeon Peas

Table 5 indicates the farmer's knowledge with regards to their preferences and consumption of pigeon peas. Farming household respondents (37%) agreed that the pigeon peas are an important source of protein for their families and 93% perceived pigeon peas to have a good taste. In terms of consumption preferences surrounding pigeon peas, a significant association was observed for good taste ( $r_s = 0.113$ ,  $p = 0.049$ ) (Table 5).

**Table 5.** Farmer's knowledge and perception on consumer preference and consumption of pigeon peas.

| Knowledge Tested   | Agree |    | Consumption Frequency |         | Consumption Preference |         |
|--|-------|----|-----------------------|---------|------------------------|---------|
|  | n     | %  | $r_s$                 | p-Value | $r_s$                  | p-Value |
| Rich in protein  | 13    | 4  | 0.109                 | 0.059   | 0.003                  | 0.957   |
| Rich in iron   | 18    | 6  | 0.013                 | 0.823   | -0.004                 | 0.940   |
| Rich in micronutrients   | 21    | 7  | -0.047                | 0.411   | -0.045                 | 0.437   |
| Not rich in energy   | 260   | 86 | 0.044                 | 0.442   | -0.039                 | 0.500   |
| Correct serving size   | 74    | 24 | -0.102                | 0.077   | -0.100                 | 0.083   |
| Pigeon peas are the important source of protein to your family | 113   | 37 | -0.039                | 0.501   | -0.045                 | 0.440   |
| Children are taught about importance of pigeon peas            | 114   | 38 | -0.014                | 0.808   | -0.070                 | 0.224   |
| <b>Perceived attributes of pigeon peas</b>                     |       |    |                       |         |                        |         |
| Pigeon peas have a good taste                                  | 283   | 93 | 0.031                 | 0.590   | 0.113                  | 0.049*  |
| Pigeon peas are source of income                               | 194   | 64 | 0.060                 | 0.298   | 0.136                  | 0.018*  |
| Colour   | 3     | 15 | 0.002                 | 0.973   | 0.024                  | 0.679   |
| Texture  | 3     | 15 | -0.017                | 0.773   | -0.050                 | 0.384   |
| Flavour  | 4     | 20 | 0.027                 | 0.638   | -0.031                 | 0.589   |
| Size   | 4     | 20 | 0.010                 | 0.860   | 0.009                  | 0.873   |
| Aroma  | 6     | 30 | 0.008                 | 0.884   | 0.003                  | 0.960   |

\* Spearman's correlation coefficient ( $r_s$ ) is significant at 0.05 levels.

### 3.4.1. Drivers for Consumption of Pigeon Peas

Availability (78%) and taste (46%) are among the drivers for the consumption frequency and preferences (Table 6). Spearman's correlation coefficient ( $r_s$ ) indicates that there is a significant association between the consumption frequency of pigeon peas and household preferences ( $r_s = 0.122$ ,  $p = 0.034$ ). It is also observed that the consumption preference for pigeon peas is associated with the availability of pigeon peas ( $r_s = 0.261$ ,  $p = 0.000$ ) and familiarity ( $r_s = 0.120$ ,  $p = 0.036$ ).

**Table 6.** Factors to consider when choosing to eat pigeon peas.

| Factors                             | Agree |    | Consumption Frequency |         | Consumption Preference |         |
|-------------------------------------|-------|----|-----------------------|---------|------------------------|---------|
|                                     | n     | %  | $r_s$                 | p-Value | $r_s$                  | p-Value |
| Taste                               | 139   | 46 | 0.024                 | 0.675   | 0.064                  | 0.265   |
| Quantity                            | 23    | 8  | -0.008                | 0.892   | -0.089                 | 0.123   |
| Availability                        | 237   | 78 | -0.026                | 0.652   | 0.261                  | 0.000** |
| Price                               | 28    | 9  | 0.065                 | 0.263   | -0.069                 | 0.229   |
| Psychological factors (familiarity) | 28    | 9  | 0.006                 | 0.923   | 0.120                  | 0.036*  |
| Social                              | 9     | 3  | 0.004                 | 0.951   | -0.065                 | 0.260   |
| Shelf life                          | 14    | 5  | -0.016                | 0.785   | -0.065                 | 0.263   |
| Preference of the household         | 51    | 17 | 0.122                 | 0.034*  | -0.083                 | 0.151   |

\* Spearman's correlation coefficient ( $r_s$ ) is significant at 0.05 levels, \*\* Spearman's correlation coefficient ( $r_s$ ) is significant at 0.01 levels.

### 3.4.2. Factors Influencing the Consumption of Pigeon Peas

A multiple regression model was statistically significant, predicting the consumption of pigeon peas during harvesting season:  $F(11, 292) = 1.769$ ,  $p(0.035) < 0.05$ . The coefficient of determination ( $R^2$ ) explained 6.8% of the variability of dependent variable. Table 7 indicates variables included in the model. Out of the eleven variables, the availability of pigeon peas in the area significantly influence the consumption of pigeon peas ( $p = 0.10$ ).

Table 7. Multiple linear regression model predict consumption of pigeon peas.

| Factors  | Harvesting Season  |        |         | Lean Season        |        |         |
|--|--------------------|--------|---------|--------------------|--------|---------|
|  | B                  | t      | p Value | B                  | t      | p Value |
| Constant                                       | 1.611              | 0.899  | 0.370   | 0.447              | 0.384  | 0.702   |
| Age  | 0.638              | 1.001  | 0.318   | 0.340              | 0.820  | 0.413   |
| Gender   | −0.250             | −0.867 | 0.387   | −0.045             | −0.237 | 0.813   |
| Marital status                                 | 0.003              | 0.011  | 0.991   | 0.064              | 0.320  | 0.749   |
| Education                                      | 0.017              | 0.051  | 0.959   | 0.289              | 1.364  | 0.174   |
| Occupation                                     | 0.829              | 1.146  | 0.253   | −0.322             | −0.685 | 0.494   |
| Availability                                   | 0.779              | 2.214  | 0.028*  | 0.164              | 0.716  | 0.475   |
| Affordability/price                            | 0.635              | 1.451  | 0.148   | −0.207             | −0.727 | 0.468   |
| Nutrition Knowledge                            | −0.836             | −1.089 | 0.277   | 0.464              | 0.929  | 0.354   |
| Accessibility                                  | 0.390              | 1.176  | 0.241   | 0.044              | 0.205  | 0.837   |
| Preparation time                               | 0.011              | 0.016  | 0.987   | −0.184             | −0.413 | 0.680   |
| Good taste                                     | 0.408              | 1.465  | 0.144   | −0.192             | −1.063 | 0.289   |
| F- statistic of the model                      | F (11,292) = 1.769 |        |         | F (11,292) = 0.556 |        |         |
| Coefficient of determination (R <sup>2</sup> ) | 6.8%               |        |         | 2.1%               |        |         |
| Significance of the model (p-value)            | 0.035              |        |         | 0.863              |        |         |

\* Significant at  $p < 0.05$ .

#### 4. Discussion

##### 4.1. Pigeon Peas Consumption

Pigeon pea is a semi-arid tropical legume that is rich in protein and micronutrients. It is widely used as an affordable source of protein. In the Lindi region, pigeon peas are used for both household consumption and as a source of income. The findings of the study indicate that the amount of pigeon peas consumed during harvesting season is greater than that recommended by the FAO for legumes consumption (30 g/person/day). The high frequency of pigeon peas consumption observed during harvesting season could be due to their high availability, as almost all households in the study area grow pigeon peas. On the contrary, the situation is different during the lean season, when the mean intake of pigeon peas and all legumes drop to 18 g/person/day and 20 g/person/day, respectively. These values are less than the FAO recommendations. The low amount of the consumed pigeon peas is due to their unavailability caused by inadequate storage and processing techniques as well as the dependency of agricultural activities on rainfall. This situation affects the sustainable consumption of pigeon peas as a nutritious and affordable legume in the study area. According to Szczepbyło and colleagues, increasing the consumption of pulses constitutes an important component of the dietary shift toward more sustainable and healthy diets [32].

Furthermore, less diversified recipes exist in the study area. It is found that pigeon peas are mostly consumed as a stew made from green, dried, and dehulled splits of pigeon peas and limited other forms of consumption. This limits the frequency of consumption of pigeon peas due to their monotonous taste, which is among the determinants underlying their consumption. Worldwide, pigeon peas can be used in a variety of recipes, thus increasing the quality and organoleptic properties of pigeon peas [12,15,33–36] and increasing the frequency of their consumption. The observed cooking preparations (recipes) are due to limited knowledge on how to prepare pigeon peas in different ways owing to limited exposure to different preparation techniques. The lack of knowledge surrounding legumes' preparation and the time involved in this preparation is reported by Figueira and colleagues as limiting factors for the consumption of legumes [37]. Hence, increasing the skills and techniques regarding the preparation of pigeon peas into diversified products could reduce preparation and cooking time. It would also

widen culinary attribute choices and increase the frequency of consumption. Doing so would mean that Tanzanians could sustainably consume the recommended amount of legumes year round.

The frequency of the consumption of pigeon peas decreases during the lean season for all kinds of dishes. The proportion of farmers consumed pigeon peas, both whole seed and dhal stew, decreased by 4% and 48% during the lean season, respectively. The reason for the low frequency of consumption could be due to low grain yields because a significant amount is consumed while green due to high post-harvest losses. Other researchers [38,39] report significantly low yields due to consumption of green peas as well as pest infestations affecting the quality of pigeon peas grain. A large decrease in the consumption of dhal stew is due to limited availability of time to prepare dhal, as reported during focus group discussions. Dhal is prepared locally, using a traditional grinding stone to make the splits after having been roasted for some time. This is time consuming, and, hence, farmers opt for other dishes as, during harvest time, farmers are busy with farm work and they are unable to stay at home. Additionally, the existing processing capacity among farming household hinders the frequency of consumption of pigeon peas due to inadequate storage capacity and poor processing technology. The barrier for consumption of dhal due to perceived time for preparation and the use of stone for processing is an opportunity for promoting innovative processing technologies that ensure availability in large quantities as well as reducing postharvest losses. The dependency on the rainy season and a lack of irrigation schemes in the study area contribute to the decreased frequency of consumption of pigeon peas in the form of green boiled pods (snack) during the lean season. This limits the availability of green pigeon peas, which are mostly used for snacking and preferred for cooking as stews. Thus, promoting home gardening could increase the availability of pigeon peas.

#### *4.2. Consumption Preferences of Pigeon Peas*

It was found that farmers in the study area preferred to consume pigeon peas as a stew and as a snack (boiled green pods). The reason for their preference is a learning experience (familiarity), as they grew up consuming pigeon peas in these ways, as reported during focus group discussions. This is also observed during the survey, where people reported consuming pigeon peas in a way similar to their elders. Thus, the taste is familiar. Similar findings are reported by Vabø and Hansen [40] as well as Monge and colleagues [41]. According to Lipsky and colleagues, people may prefer to eat certain food due to what is available in their environment [42]. Similar behavior is observed in the study area, where more than 75% of the households grow pigeon peas on their farms or around their homestead. This makes pigeon peas more readily available than other legumes, which are either grown in very small quantities or not grown at all due to climatic conditions. Hence, this makes other legumes more expensive than what they grow themselves.

In terms of varieties, both survey results and focus group discussions reveal that local or traditional pigeon peas are preferred due to their taste, availability, and resilience against pests. This is consistent with the findings of Dalton and Regier [23]. Moreover, the preference of the consumption of pigeon pea dishes differs significantly with education level and household heads. Those with primary education preferred to consume pigeon peas dishes more frequently than those with other education levels. This is because the majority of them depend on farming, and pigeon peas are among the leguminous crops grown in the area, hence making them available. This is different from the results of the previous studies, which found that it is the well-educated individuals who consumed more pigeon peas [20,43]. It is also observed that farmers consume pigeon peas due to their taste and familiarity, not because of their nutritional benefits. Therefore, educating families on the nutritional benefits of pigeon peas could increase consumer preferences for, and the frequency of consumption of, pigeon peas for health reasons.

#### *4.3. Knowledge and Perception about Pigeon Peas Consumption*

Farmers in the study area know little about the importance of pigeon peas for consumption. This could be due to the limited nutrition education they have with regard to healthy eating. The majority of respondents have only completed primary education, where little is taught about the importance of

nutritious and diversified diets. Thus, children entering adulthood are not educated about good eating habits and diverse diets. However, there is a nutrition education program in the study area provided through health centers. Unfortunately attendance is limited, mainly by those seeking reproductive and child health services. The education provided in these centers mostly focuses on maternal and infant feeding, with little given on the nutritional well-being of other groups, especially those not of productive ages. Thus, the majority of the farmers does not have general nutritional knowledge or understand the importance of consuming different food groups, including legumes. This affects their consumption patterns, hence leading to a poor nutritional status that could result in lower labor productivity. Ultimately, this increases food and nutrition insecurity in the community. The results also indicate significant differences in terms of perception, consumption frequency, and preferences of pigeon peas. The farmers in the study area tend to consume what is readily available; this is also evident from the differing frequency of pigeon pea consumption across harvesting and lean seasons. During the lean season, a limited amount of pigeon peas is available; hence, it is consumed less frequently. Furthermore, occupation is among the observed determinants for the consumption of pigeon peas. The majority of farmers in the study area practice a subsistence way of farming; hence, they have little income. This hinders the consumption of other protein-rich foods that are more expensive. Pigeon peas are also a source of income in the community, if the market value of grain pigeon peas was high, it would negatively affect consumption. Hence, diversifying pigeon peas into different products will promote the use of pigeon peas within the country, consequently increasing their use as a source of income. This will promote greater production of pigeon peas as they improve soil fertility, which in turn contributes to environmental and agricultural sustainability. In addition, pigeon peas have the ability to bring minerals from deep soil horizons surface and hence improving soil air circulation [4]. Moreover, they have the ability to maintain photosynthetic function during stress compared to other legumes. Hence, promoting the consumption of pigeon peas will create more demand, resulting in more production and increased agricultural sustainability.

## 5. Conclusions and Recommendations

In the study area, pigeon peas are among the most important legumes for helping families to consume the recommended amounts of nutrients. However, limited recipes and knowledge of how to prepare pigeon peas, along with poor nutrition education, inadequate storage and processing techniques, social behavior learning as well as rainfall dependency and the use of stones for processing dhal are among the barriers for pigeon peas consumption. All these necessitate not just the need to develop new recipes and provide cooking demonstrations but also to conduct research that finds innovative ideas for the development of diversified and shelf-stable products that improve nutrition and income. Additionally, nutrition education should be implemented. Its design should foster on promoting healthy eating to all age group, thus improving the preference for, and consumption of, pigeon peas and other food groups throughout the year.

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### 3.0 CHAPTER THREE

#### **Identification and Prioritization of Pigeon Peas-based Products Tailored to Consumer Preference Perspective. A Mixed Method Assessment Approach**

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# Identification and prioritization of pigeon pea-based products tailored to consumer preference perspective: A mixed method assessment approach

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## Abstract

Pigeon pea is frequently consumed in Southern Tanzania but in limited value-added recipes. The aim of this study was to identify and prioritize pigeon pea-based products that could be developed to improve organoleptic preferences and increase the diversification of the recipes. A descriptive cross-sectional study was conducted involving 355 consumers. Quantitative and qualitative information was collected through focus group discussions (FGDs) and face-to-face interviews. Pairwise comparison (PC) method and assigning scores in order of their preference was used in ranking pigeon pea-based products at the group and individual levels, respectively. PC counts and Garrett rank scores were computed and ranked using the Rank command in Excel software Version 2016. Ordinal regression was used to summarize the effect between groups' overall levels of the outcome at  $p$ -value < 0.05. Twelve and eleven pigeon pea-based products were identified during face-to-face interviews and FGDs, respectively. The highest Garrett mean scores were observed on pigeon pea-based noodles (70.6), flour (61.4) and chapati (60.4). Similarly, the highest PC counts were observed on pigeon pea-based noodles and chapati. The PC rank scores differed significantly by consumers' age categories. Pigeon pea-based noodles, flour and chapati are the utmost prioritized products due to their perceived value, sensory attributes, convenience and attitudes about the food product. However, knowledge and skills about using pigeon peas on producing the product were mentioned as limiting factors. Hence, the provision of practical hands-on skills on the preparation of pigeon pea-based products will increase the chances of diversifying pigeon pea recipes at the household level for improving food security and nutrition well-being.

## KEYWORDS

identification, mixed method, pigeon pea-based products, prioritization

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## 1 | INTRODUCTION

Pigeon pea is widely grown in the developing world including Asia, Latin America, the Caribbean region and Africa (Sharma et al., 2011). It is mainly grown in semi-arid tropical regions (Sarkar et al., 2020). In sub-Saharan Africa, about 7.8 million households grow pigeon peas. In Tanzania, 209,299 households (URT, 2012) and more than three-quarters of farmers in southern zone grow pigeon peas (Mponda et al., 2014; Simtowe et al., 2011). It is cultivated mainly for household consumption as an alternative protein food source as well as source of income (Mergeai et al., 2001; Shiferaw et al., 2007). Pigeon peas are rich sources of protein and amino acids (lysine, methionine, tryptophan), fibre, vitamins (riboflavin, niacin) and minerals (phosphorus, iron, magnesium) (Karri & Nalluri, 2017; Saxena et al., 2002). Despite being used as a food source, consumption of pigeon peas in all forms is very limited during lean season where only 18 g/p/d of all legumes, pigeon pea inclusive, is consumed (Majili et al., 2020). The less amount consumed will also lead to less intake of recommended amount of protein, amino acids, fibre, vitamins and minerals if not replaced by other foods rich in particular nutrient. The low consumption was due to different factors such high post-harvest losses due to pest attack, which leads to unavailability of pigeon pea throughout the year. Another factor is less diversified products (Majili et al., 2020), which limit consumption frequency of pigeon pea due to monotonous taste. Furthermore, inadequate knowledge on different ways of pigeon pea preparation practices owing to limited exposure on different pigeon pea-based recipes necessitates the need of identifying new recipes that can increase diversification and household consumption of culturally acceptable pigeon pea-based products as well as increase perennial availability of pigeon pea through product development. It is therefore important to consider consumer needs and preferences as rational agent in acceptability of newly developed products. Hence, consumer studies are essential from identification, development, testing and launching of new products. This article present one of the specific objectives of a bigger research project that aimed at developing value-added pigeon pea-based product for improved nutrition through diversification of the recipes. Hence, the article explains the identification and prioritization approach of pigeon pea-based products. Information collected will provide an insight on typical choice preferences that can increase chance of product acceptance among households. According to Van Kleef et al. (2005), the successful product acceptance is mainly based on the quality of the identification and prioritization process.

Prioritization is one of the most important aspects to ensure better results in production process. However, the task is complex when you have various aspects that require judgement of large group of people with diverse consumption behaviour and preferences. Several methods have been used in product identification and prioritization depending on the objectives of the study. For example, multi-voting technique (Anand & Dinakaran, 2017), nominal group technique (Olsen, 2019; Søndergaard et al., 2018), the Hanlon method (Choi et al., 2019; Mokhtari et al., 2013) and prioritization matrix (Tovar-perilla et al., 2018) have been used in health and agricultural

sectors. With special attention to food sectors, prioritization such as Fuzzy MoSCoW method (Burgess & Sunmola, 2021), KANO (Ponnam et al., 2011; Ulewicz, 2016) and pairwise comparison (PC) method (Kou et al., 2016) has been used in food product identification and prioritization. All these methods have merits and demerits. They are adapted to each analytical situation (contextualization) and therefore tailored with the highest adequateness for use, quality of results and feasibility. Generally, all methods aim at minimizing distortional effects such as domination of opinion holders and strategic behaviour of respondents. Thus, use of quantitative rankings, charts and matrices reduces domination of one idea during discussion. In this study, mixed techniques will be used, whereas the PC and Garrett techniques have been used in ranking products in order of their preference. The PC is the simplest type of interviews that weigh the importance of comparing two food products (i.e. binary choices). It is also considered as an effective decision tool in decision making where there are many alternatives (Kou et al., 2016). Additionally, it uses individual knowledge and experiences to make binary comparison of their choices and bring together in a comparison's matrix. The Garrett technique is also considered simple in rating the choices in order of merits. It provides the change of orders of choices into numerical scores based on their preference whereas the same product may have given different rank by different consumer (Zalkuwi et al., 2015).

On other hand, knowing the consumer choice priorities is a key element on designing and developing new products. Therefore, it is important to understand consumer choice preferences. Each consumer has a set of preferences and values that are determined by several interrelating factors related to food product, individual person and environment they live in (Barjolle et al., 2013). These are guided by consumer desires that satisfy his/her needs as believed and acceptable to their living environment. Therefore, it is important to understand consumer behaviour towards food consumption and choice preferences as well as ability to access the food product or wealth, availability of the product and preference. Based on random utility theory, each consumer has different preferences, which appear to behave in a certain way (Barjolle et al., 2013). These behaviours make them to rank order all possible combinations of consumption bundles placed in front of them based on their preferences and level of satisfaction. Hence, it is important to consider relationship between consumer concepts about the product, needs/wants, their behaviours and the environment around them. In order to select a pigeon pea-based product that fit their preferences, this study aims to (i) identify pigeon pea-based product that preferred to be developed, (ii) rank identified pigeon peas-based product in order of their priority and (iii) determine the motives behind their prioritization preferences.

## 2 | METHODS AND STUDY APPROACH

### 2.1 | Study design, sample and participants

A descriptive cross-sectional study was conducted in Mibure (Ruungwa district) and Mitumbati (Nachingwea districts) villages in

Lindi region Tanzania in March 2020. The selection criteria of the two village was explained elsewhere (Majili et al., 2020). The sample was determined using Fisher's formula and the principles stipulated earlier (Moser & Korstjens, 2018). A total of 355 consumers were included based on their age, sex, participation in baseline study, knowledge about pigeon pea recipes and willingness to participate in the study. Among these consumers, 303 were involved in face-to-face interviews, and 52 were involved in focus group discussions (FGDs). The ones involved in face-to-face interviews participated in the previous study conducted in 2019 (Majili et al., 2020). A total of six FGDs sessions were conducted in both villages involving different age groups of consumers.

## 2.2 | Data collection and analysis

A participatory approach was used to identify and rank pigeon pea-based products to be developed. Face-to-face interviews and FGDs were conducted in each respective village. In both methods, information on social demographic characteristics of all consumers was recorded. The process approach involved presentations, listing of

preferred pigeon pea-based products and ranking of the listed products and analysis as indicated on process approach flow chart (Figure 1).

## 2.3 | Presentation of existing products in and outside the study site

Before the interviews and discussions, feedback of identified pigeon pea-based recipes in the area was presented to consumers in pictorial form (Figure 2). Then presentation of other existing different pigeon pea-based recipes in the world was followed (Figure 3). Each recipe was elaborated to consumers to make them familiar with the composition and technology used to prepare it.

## 2.4 | Listing of potential products to be developed

FGDs and face-to-face interviews were used during listing of the potential products. During interviews and discussions, consumers were asked to mention pigeon pea-based recipes of their choice that

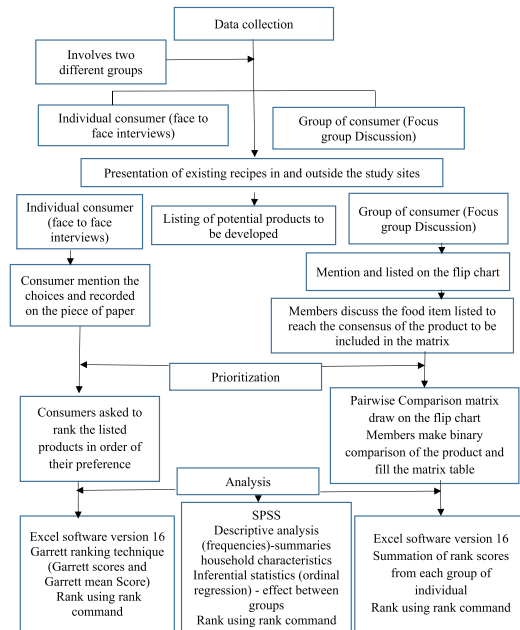
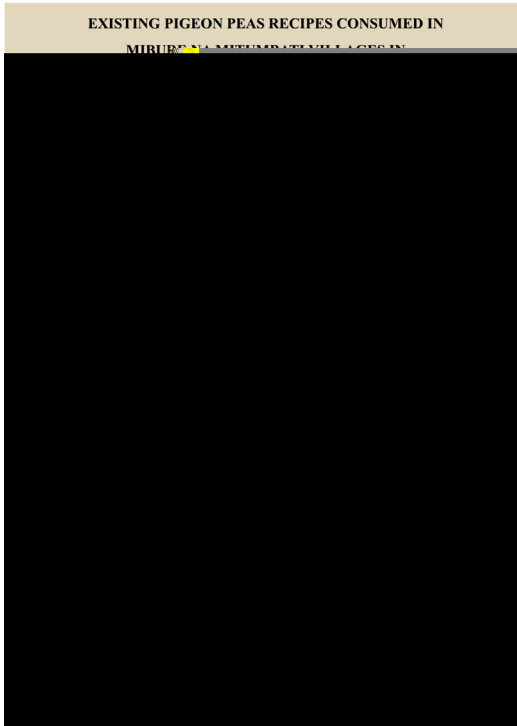


FIGURE 1 Summarized data collection process and analysis



**FIGURE 2** Existing pigeon peas recipes consumed in the area

can be developed and consumed in their locality as part of their daily meal or as a source of income. At individual level, the interviewer recorded all pigeon pea-based recipes mentioned before the ranking exercise. At group level, for each pigeon pea-based product mentioned, it was allowed to develop consensus prior listing in the flip chart by the moderator. The discussion was based on their ability to develop the products in their locality, consumers of the product and shelf life of the product. After consensus all pigeon pea-based recipes were listed in a flip chart for ranking.

## 2.5 | Prioritization

At the individual level, prioritization was done by ranking food in order of their preference. The consumers were asked to rank the food item of their choice and all responses were recorded. Garrett's ranking

techniques as described by Dhanavandan (2016) was used to arrange the pigeon pea-based products based on consumer's choice preferences in such a way that the same number of consumer on two or more pigeon pea-based products can have different rank scores. The count and per cent position for each product rank preference estimated was converted into scores. The following is Garrett's formula used for converting ranks into per cent:

$$\text{Percent position} = 100 \times \left( \frac{R_{ij} - 0.5}{N_j} \right)$$

where  $R_{ij}$  = rank given for  $i$ th constraint by  $j$ th individual

$N_j$  = number of constraints ranked by  $j$ th individual

The Garrett value or score was determined using Garrett ranking conversion table. The score of each product for everyone was added. Then total Garrett score and Garrett mean score (GM score) were

FIGURE 3 Pigeon peas recipes consumed in different parts of the world



calculated. The GM score was then ranked in using Rank command in Excel software Version 2016.

On the other hand, the PC method was used for ranking the competing pigeon pea-based recipes of their preference during FGDs session. Binary comparison was used to understand which pigeon pea-based product was most ideal than the other. Each product preference was then tabulated for the importance. Six steps were involved in PC. The first step was listing of pigeon pea-based product to determine objectives products design. Then the chart of design was drawn on the second flip chart, and all products mentioned were first written along the first row and column (Table 1). Third step involved blocking identical products by putting a dash diagonally downwards the chart. The pairs for the product were then identified and noted down for reference of the members. A total of 132 pairs were identified and discussed with the guide of the facilitator. Consumers were asked to

compare two pigeon pea-based products under comparison starting with Pair 1 to Pair 132 and choose the most important product on each pair. The preferred product over the two in each pair was given a score of 1, which was written against the row of the important product preferred. Besides a zero (0), score was also written on the row of less preferred product. For FGD, this was done after all participants agreed based on their discussion. In case the two products were equally important, the value of 1 was written on both corresponding cells. The matching of the product continued until all boxes were filled up.

Summation of row score was done and ranked hierarchically. The PC matrix was summarized by summing up the score of each product to get PC counts. The PC counts were then ranked using Rank command in Excel software 2016 to get rank scores of each pigeon pea-based product for each consumer group. The summation of the PC

TABLE 1 Chart of design (PC matrix)

|                         | Bs | Ns | Ch | Sam | Soup | Bread | Milk | Bhajia | Cake | Adon | Kebab | Pflour | PC count | Rank |
|-------------------------|----|----|----|-----|------|-------|------|--------|------|------|-------|--------|----------|------|
| Biscuits (Bs)           | -  | 1  |    |     |      |       |      |        |      |      |       |        |          |      |
| Noodles (ns)            | 0  | -  |    |     |      |       |      |        |      |      |       |        |          |      |
| Chapati (Ch)            |    |    | -  |     |      |       |      |        |      |      |       |        |          |      |
| Samosa (Sam)            |    |    |    | -   |      |       |      |        |      |      |       |        |          |      |
| Soup                    |    |    |    |     | -    |       |      |        |      |      |       |        |          |      |
| Bread                   |    |    |    |     |      | -     |      |        |      |      |       |        |          |      |
| Milk                    |    |    |    |     |      |       | -    | 1      |      |      |       |        |          |      |
| Bhajia                  |    |    |    |     |      |       | 0    | -      |      |      |       |        |          |      |
| Cake                    |    |    |    |     |      |       |      |        | -    |      |       |        |          |      |
| African donut (Adon)    |    |    |    |     |      |       |      |        |      | -    |       |        |          |      |
| Kebab                   |    |    |    |     |      |       |      |        |      |      | -     |        |          |      |
| Porridge flour (Pflour) |    |    |    |     |      |       |      |        |      |      |       | -      |          |      |

| Variables                | All (355)<br>n (%) | Individual consumer (n = 303)<br>n (%) | FGD members (n = 52)<br>n (%) |
|--------------------------|--------------------|--|-------------------------------|
| <b>Age</b>               |                    |  |                               |
| Children (<15 years)     | 18 (5)             | 0 (0)                                  | 18 (34)                       |
| Youth (15–35 years)      | 160 (45)           | 153 (51)                               | 17 (33)                       |
| Adults (>35 years)       | 177 (50)           | 150 (49)                               | 17 (33)                       |
| <b>Sex</b>               |                    |  |                               |
| Male                     | 210 (59)           | 186 (61)                               | 24 (44)                       |
| Female                   | 145 (41)           | 117 (39)                               | 28 (56)                       |
| <b>Area of residence</b> |                    |  |                               |
| Mibure                   | 174 (49)           | 152 (50)                               | 22 (42)                       |
| Mitumbati                | 181 (51)           | 151 (50)                               | 30 (58)                       |

TABLE 2 Consumer characteristics

counts for each pigeon pea-based product from different consumer category was computed, and the rank scores were obtained using Rank command. Furthermore, descriptive analysis was computed, whereas frequencies were used to summarize participants' characteristics (age, sex and residence). Using SPSS software Version 25, ordinal regression analysis was computed to summarize the effect between groups over all levels of the outcome. Preference ranks of the products were set as outcome variables against explanatory variables (consumer categories and pigeon pea-based food types) at  $p < 0.05$  with an assumption that ranking of pigeon pea-based food types are the same across consumer categories. The following is an ordinal regression equation used to explain an outcome variable.

From

$$\text{Logit}(Y) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_{n-1}$$

$$\begin{aligned} \text{Logit}(\text{Pigeon}) = & 5.351 + 5.112 \times \text{Noodles} + 3.298 \times \text{Chapati} + 0.552 \\ & \times \text{Bread} + 1.156 \times \text{Samosa} + 2.585 \times \text{Bhajia} + 1.700 \\ & \times \text{Dhal} - 4.005 \times \text{Milk} + 2.812 \times \text{Biscuit} - 3.022 \\ & \times \text{Cake} + 5.351 \times \text{African donut} + 5.587 \times \text{Kebab} \end{aligned}$$

## 3 | RESULTS

### 3.1 | Participants' characteristics

A total of 355 consumers were involved in identification and prioritization of pigeon pea-based products. Among them, 303 (85%) were involved in face-to-face interviews and 52 (15%) in FGD sessions. About 50% of consumers interviewed were adults aged above 35 years, and 5% were children (Table 2).

### 3.2 | Identified pigeon pea-based products

A total of 12 and 11 pigeon pea-based products were identified during face-to-face interviews and FGD, respectively. All foods mentioned during face-to-face interviews except pigeon pea-based flour were also mentioned during FGD session (Table 1). On the other hand, kebab was only mentioned during FGD and not during face-to-face interviews.

### 3.3 | Prioritized pigeon pea-based product

The GM scores indicated that noodles, pigeon pea-based flour and chapati ranked the first three preferred pigeon pea-based products compared with cake, soup and African donuts, which scored the lowest (Table 3). In terms of area of residence and gender, there was no significant difference on the first two preferred pigeon pea-based products, whereas noodles scored the highest followed by pigeon pea-based flour.

Figure 4 indicates the total PC counts for each pigeon pea-based product identified by different consumers of varied age during FGD sessions. Noodles have the highest total counts compared with other products mentioned followed by chapati, bread and samosa, whereas kebab has the lowest score.

In addition, priority of pigeon pea-based product differed among age groups (Table 4). For children, chapati scored the highest followed by noodles, whereas for adults, noodles and milk ranked the second most important products. However, noodles, chapati, soup, dhal, milk, cake and African donuts were among the products ranked highest among different groups.

In ordinal regression analysis, the log-likelihood ratio chi-square test ( $\chi^2 = 43.067$ ,  $p = 0.001$ ) indicated that the model fitted well in ranking pigeon pea-based products among consumer type and pigeon pea-based food types. The likelihood ratio (Nagelkerke pseudo  $R^2 = 0.703$ ) suggested that there is a relationship between outcome variable (preference rank scores) and explanatory variables (consumer categories and pigeon pea-based food types). The test parallel line ( $\chi^2 = 133.808$ ,  $p = 0.392$ ) revealed that rank food type is different

TABLE 3 Prioritized pigeon pea-based product among individual consumers based on Garret mean scores

| Pigeon pea-based product | All      |      | Area of residence |      |           |      | Gender   |      |          |      |
|--------------------------|----------|------|-------------------|------|-----------|------|----------|------|----------|------|
|                          |          |      | Mibure            |      | Mitumbati |      | Male     |      | Female   |      |
|                          | GM score | Rank | GM score          | Rank | GM score  | Rank | GM score | Rank | GM score | Rank |
| Soup                     | 36.74    | 11   | 20.32             | 10   | 16.42     | 11   | 23.07    | 11   | 13.66    | 12   |
| Bhajia                   | 48.26    | 7    | 23.66             | 7    | 24.60     | 7    | 29.75    | 7    | 18.51    | 7    |
| Milk                     | 42.40    | 9    | 20.71             | 9    | 21.69     | 8    | 25.32    | 9    | 17.07    | 9    |
| Samosa                   | 43.02    | 8    | 21.41             | 8    | 21.60     | 9    | 25.93    | 8    | 17.08    | 8    |
| Dhal                     | 57.78    | 4    | 30.36             | 3    | 27.42     | 5    | 35.55    | 4    | 22.23    | 4    |
| Cake                     | 35.48    | 12   | 17.18             | 12   | 18.30     | 12   | 21.75    | 12   | 13.73    | 11   |
| Biscuits                 | 52.39    | 6    | 25.87             | 6    | 26.51     | 6    | 32.48    | 6    | 19.91    | 6    |
| Pigeon pea-based flour   | 61.40    | 2    | 31.09             | 2    | 30.30     | 2    | 37.72    | 2    | 23.67    | 2    |
| Noodles                  | 70.40    | 1    | 35.28             | 1    | 35.11     | 1    | 42.90    | 1    | 27.48    | 1    |
| Bread                    | 54.52    | 5    | 26.48             | 5    | 28.04     | 4    | 33.06    | 5    | 21.45    | 5    |
| Chapati                  | 60.41    | 3    | 30.32             | 4    | 30.09     | 3    | 37.43    | 3    | 22.97    | 3    |
| African donut            | 38.68    | 10   | 19.01             | 11   | 19.67     | 10   | 24.22    | 10   | 14.44    | 10   |

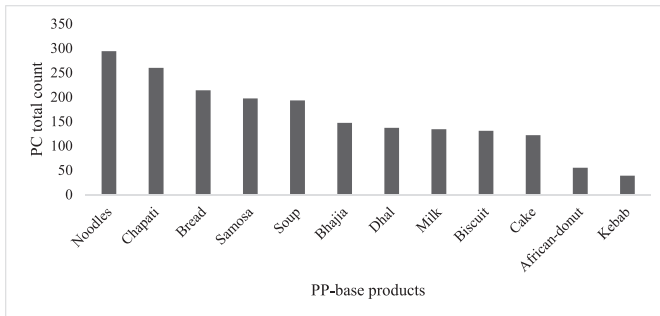


FIGURE 4 Prioritized pigeon pea-based product among individual consumers based on PC total counts for each identified pigeon pea-based product

TABLE 4 Prioritized pigeon pea-based product among different consumer age groups based on PC

| Pigeon pea-based products | Children (<15 years) |                | Youth (15–35 years) |                | Adults (>35 years) |                |
|---------------------------|----------------------|----------------|---------------------|----------------|--------------------|----------------|
|                           | PC counts            | PC rank scores | PC counts           | PC rank scores | PC counts          | PC rank scores |
| Noodles                   | 85                   | 2              | 95                  | 1              | 106                | 1              |
| Chapati                   | 91                   | 1              | 69                  | 3              | 93                 | 2              |
| Bread                     | 71                   | 5              | 67                  | 5              | 72                 | 4              |
| Samosa                    | 81                   | 4              | 54                  | 6              | 62                 | 6              |
| Soup                      | 82                   | 3              | 69                  | 3              | 42                 | 9              |
| Bhajia                    | 46                   | 7              | 29                  | 10             | 66                 | 5              |
| Dhal                      | 0                    | 12             | 54                  | 6              | 75                 | 3              |
| Milk                      | 23                   | 11             | 81                  | 2              | 23                 | 10             |
| Biscuit                   | 50                   | 6              | 32                  | 9              | 44                 | 8              |
| Cake                      | 36                   | 9              | 36                  | 8              | 48                 | 7              |
| African donut             | 33                   | 10             | 20                  | 11             | 0                  | 11             |
| Kebab                     | 39                   | 8              | 0                   | 12             | 0                  | 11             |

TABLE 5 Ordinal regression results for pigeon pea-based food type identified

| Pigeon pea-based products | $\beta$        | Sig    |
|---------------------------|----------------|--------|
| Intercept                 | 5.351          | 0.002  |
| Noodles                   | 5.112          | 0.017* |
| Chapati                   | 3.298          | 0.069  |
| Bread                     | 0.552          | 0.704  |
| Samosa                    | 1.156          | 0.430  |
| Bhajia                    | 2.585          | 0.090  |
| Dhal                      | 1.700          | 0.252  |
| Milk                      | -4.005         | 0.012* |
| Biscuit                   | 2.812          | 0.067  |
| Cake                      | -3.022         | 0.050  |
| African donut             | 5.351          | 0.002* |
| Kebab                     | 5.587          | 0.001* |
| Soup                      | 0 <sup>a</sup> | -      |

<sup>a</sup> The parameter is set to zero because it is redundant.

\*Significant at  $p < 0.05$ .

across consumer categories. The estimated logit regression coefficient (Table 5) for noodles, milk, African donut and kebab indicated a significant variation on ranking pigeon pea-based food types.

### 3.4 | Motives for preference ranking

It was reported during FGD sessions that familiarity about the product was the key motivation against their prioritization. Other reasons mentioned were sensory attributes, availability, preparation skills and convenience to prepare. Chapati ranked highest among school-age children; the reason was due to familiarity, whereas noodles were selected due to desire and perception. They said, 'chapati is among

the food prepared at home and we like it because it is accustomed to us'. On the other hand, they perceived noodles as something sweet that someone should never miss. For the case of the youth, they said that 'noodles and milk are the quickest foods to prepare, you need hardly 20 minutes to have both on the table. They are also available from different food vendors where you can buy for only 1000 Tanzanian shillings'. Similarly, adults said they ranked noodles the highest due to short time to prepare as well as that it is a meal that can be consumed by all family members.

## 4 | DISCUSSION

### 4.1 | Listed pigeon pea-based products listed

Pigeon pea-based products mentioned were based on prior knowledge of similar products available in their area. For example, we observed availability of noodles, bhajia, chapati, breads, African donuts, biscuits and samosa in the local food vendors around their village or nearby village. This indicates that the product is customarily consumed in the area. However, these foods have been made by food ingredients other than pigeon pea. Therefore, listing them was not by mistake, but because of familiarity and availability as the key driver for their consumption behaviour. Past experience about food was reported to be among factors that significantly affect food consumption behaviour (Majili et al., 2020; Mak et al., 2012). Furthermore, changing of recipes influence food experiences. In this study, dhal was among the products itemized, due to its familiarity. It is consumed as relish to main staple food to change recipes/variety as well as sensory attributes. Recipe variety was reported to be one of the key attributes that affect food experience (Chang et al., 2011). However, inadequate processing technique such as use of stones to process dhal is time consuming, hence limiting availability of variety of pigeon pea recipes. Pigeon pea were not adequately used in preparation of different

recipes. This was due to lack of exposure to different recipes as reported by FGD members. Lack of exposure affect consumption preferences. Repeated exposure to different foods increases familiarity hence a tendency to increase preference (Beckerman et al., 2017; Boyland & Whalen, 2015; Luckow et al., 2006; Promsivapallop & Kannaovakun, 2020).

Despite the scarcity of milk in the area, milk was mentioned due to participants' wish to for it to be available in their locality. They said that 'milk is good for the health of our children however we cannot get it, so if it is possible to have pigeon pea milk it will be of great importance for our children'. The scarcity of milk was due to a small number of cattle kept in Lindi region. It is estimated that 203,446 cattle are kept in Lindi region, which is equivalent to 0.59% of all cattle kept in Tanzania in the year 2019/2020 (URT, 2021). This results in a limited supply of milk among residents, hence low per capita consumption. It is estimated per capita consumption of milk in Tanzania in the year 2019/2020 was 52.4 L/person/year (URT, 2021), which is less than 200 L/person per year recommended by FAO (Katjuongua & Nelgen, 2014).

#### 4.2 | Prioritized pigeon pea-based products

Consumers identified noodles as higher priority items due to its sensory aspects and ability of improved shelf-life when not cooked. Consumers during FGD sessions said that 'we like noodles because it has good taste and aroma and can be stored for longer time when not cooked'. Taste and aroma preferences are established over repeated consumption, which develop experiences that are influenced by their attitudes and perception about the product. Based on Ajzen's theory of reasoned action (TRA), consumers will perform a behaviour if they have a feeling (Ajzen, 1991). This feeling could be a positive or negative attitude towards a particular behaviour. A positive attitude will result if a consumer has a promising feeling towards a given behaviour that will result in progressive outcome. From this model, a consumer may accept a product if he/she has knowledge about it and associated risk factors as well as acquisition of new skills or technology if has rational decision about technology used to get a particular product. Therefore, consumers in this study prioritized noodles due to their perceptions and attitudes about the product. They perceived noodles as the food consumed during Ramadan as well as the food for people of certain income position. However, knowledge and skills about producing noodles and cost were mentioned as limiting factors for availability, accessibility and consumption of noodles. This creates an opportunity for provision of knowledge and skills on noodles production using locally available ingredients that can reduce production costs as well as maintain sensory attributes, increase nutritional value and make them available for household consumption.

Preference ranking can also be influenced by food characteristics such sensory attributes, convenience and perceived value of the food (Costell et al., 2009; Konuk, 2019). Pigeon pea-based flour and chapati were the second choice during the interviews and FGD sessions, respectively. The pigeon pea-based flour is perceived as a key

ingredient in production of different pigeon pea-based products. Therefore, having it in the household may ease diversification of the pigeon pea recipes. Chapati is among the foods consumed in the areas during breakfast. It is preferred due to its convenience and perceived value. The perceived value and portion size of the products are important factor for consumer choice (Konuk, 2019; Livingstone et al., 2020; Steenhuis, 2011). The portion size of chapati observed is bigger compared to African donuts and bhajia. Also, the price of one piece of chapati is lower compared with an African donut of similar weight. On the other hand, the process of preparing the dough for chapati and cooking time is more convenient than African donut and bread, which require time to rise up before cooking. These factors make chapati to be placed on the highest rank.

Preference ranking is also related to consumer age and is influenced by multiple factors including intrapersonal, interpersonal and environmental factors (Dwyer et al., 2008; Fitzgerald & Spaccarotella, 2009; IOM (Institute of Medicine) and NRC (National Research Council), 2013; Larson & Story, 2009). The intrapersonal factors are individual level factors include personal knowledge and skills about the food, personal traits, taste preferences, perception and motivation (Fitzgerald & Spaccarotella, 2009). The food preferences are also influenced by social relationships surrounding of an individual such as food availability at home, social support, culture and time constraints. It is also influenced by food environment such as accessibility of food (Dwyer et al., 2008; IOM (Institute of Medicine) and NRC (National Research Council), 2013). In the current study, it was observed that the prioritization of pigeon pea-based products differed among children, the youth and adults. In early life, children's food choices are influenced by parents' habits and home food environments until when they start to interact with the outside home environment (Larson & Story, 2009) This could be the reason why the noodles and chapati were ranked almost the same as mentioned by adults. In addition, pigeon pea soup was also among the three highest top ranked foods by children. This is because soup is one of the foodstuffs sold by street food vendors whereby children pass on their way to school or around the environment they play. They see people consuming it, but for them, they cannot afford it; that is why children selected it so as to be able to have it in their households.

On the other hand, the youth as emerging adulthood group experience transitions from family to personal dependency. At this life stage, the youth increase self-dependency in decision making, establish self-identity and financial independence and increase self-sufficiency and non-compliance to most of family rules (Nelson et al., 2008). These changes impact their life style behaviour including food preferences. The food preferences of the youth are influenced by personal and environmental factors including lack of time to plan, prepare and cook their meal, peer influences and preference taste (Livingstone et al., 2020). Due to this, they prefer to eat convenient tasty food; that is why their ranking focuses on noodles, milk, chapati and soup, which does not cost them time to prepare compared with dhal mentioned by adults. The chapati and soup ranked the same as in most places of Tanzania; these foods are sold together and can be

found in many places where cooked food vendors are available. However, the chapati and soup in these places are of different ingredients. Noodles and milk require approximate 10–15 min to be ready for consumption, hence preferred food to youth. Furthermore, during the survey, the study found that cooked noodles and milk were sold around the village and the major consumers were the youth. This may be due to the fact that most youth have not yet establish families, so eating from food vendors is convenient and saves time to plan, prepare and cook food. Also, at this life stage, most youth spend less time with their parents looking for their self-identity and financial independency through different opportunities such as involving in petty or vending business. This situation makes them to eat where they are. These behaviours are also reported in different studies (Forsythe et al., 2017; Munt & Partridge, 2016; Van Zyl et al., 2010).

Furthermore, noodles and chapati were ranked highest by the youth and adults. This may be because adults are key agents of influencing food behaviour since early childhood. Unlike school-age children and the youth, adults also prioritized dhal among the foods to be developed. The reason behind is that dhal is commonly used as relish in the society. However, the use of stones to process dhal hinders their consumption frequency. Therefore, innovative technologies for developing dhal will have great importance to the community. Production of dhal is one of the key process of making pigeon pea flour that can be used for developing different pigeon pea-based products. This will increase availability of dhal for household consumption as well as aid in development of different products by reducing processing time.

## 5 | CONCLUSION AND RECOMMENDATIONS

Prioritization of pigeon pea-based product is important in identifying the suitable products that will be acceptable among consumers and hence maximizing its utility. The PC and Garrett ranking techniques simplify the preferential ordering of pigeon pea-based products as these are easy to administer and require less skills in collection of information. The analysis of the two techniques leads to unbiased decision making on selection of the product to be developed. Hence, food product developer should consider using these techniques in prioritizing food products before actual food production. Pigeon pea-based noodles, flour, chapati and dhal are among the products identified and ranked highest that should be considered for production due to their perceived value, sensory attributes and convenience. It is also important to consider multiple interrelated factors such as price per portion size and familiarity about the product to increase chances of product acceptability.

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### CONFLICT OF INTEREST

The authors of this article declare no conflicts of interest.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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## 4.0 CHAPTER FOUR

### **Development and Profiling of Affordable and Nutritionally Optimal Pigeon Peas-based Products for Improved Recipes Diversification in Rural Communities in Tanzania**

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## Development and Profiling of Affordable and Nutritionally Optimal Pigeon Pea-Based Products for Improved Recipes Diversification in Rural Communities in Tanzania

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### Abstract

Pigeon pea is an affordable source of protein, vitamins and minerals. Despite its nutritional importance, the legume has not been adequately utilized for human consumption in Tanzania due to limited recipes. Therefore, the study aimed to develop and profile quantitative attributes of value-added pigeon pea-based noodles (PPBN) and instant porridge (PIIP) flour for diversification of recipes in rural Tanzania communities. The computation on the amount of ingredients, the cost of the product mix and optimization was done using Linear programming, simplex method. PPBN and PIIP were developed and Quantitative Descriptive Analysis (QDA) was done by trained panelists. Data were analysed using R and XLSTAT software. Eight and four samples of PPBN and PIIP respectively were formulated and developed. Major ingredients for PPBN was pigeon pea, wheat and orange flesh sweet potatoes flour and for PIIP was pigeon pea, maize, orange flesh sweet potatoes flour (or pumpkin flour). The protein content for PPBN ranged from 41.0 to 58.2 g. The highest amount of iron content was observed in sample PPBN193 (26.4 mg), followed by PPBN1718 (21.0 mg), PPBN267 (19.3 mg) and PPBN136 (18.3mg). The highest value of zinc and pro-vitamin A was observed in sample PPBN136. For instant porridge the highest value of protein (17.1 g), iron (7.9 g), zinc (5.4 mg) and pro-vitamin A (308.5 µg) was observed in sample PIIP<sub>ofsp</sub><sup>r</sup>. The highest mean intensity score for colour, aroma and mouthfeel was observed in samples PPBN718, PPBN193 and PPBN136. For sample PIIP<sub>ofsp</sub><sup>r</sup>, colour (8.7) Aroma (7.7), mouthfeel (7.8), sweetness (7.1) and viscosity (7.9) had the highest mean intensity score. There was a significant increase in protein, iron, zinc and pro-vitamin A with an increase in the amount of pigeon pea and/or orange flesh sweet potato flour. Sample PPBN718, PPBN193, PPBN136 and PIIP<sub>ofsp</sub><sup>r</sup> had better nutritional and sensory qualities that make them suitable for consumption.

**Keywords:** *Pigeon pea-based noodles, Pigeon pea-based instant porridge, Linear programming, Descriptive profiling*

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## Introduction

Food product development involves converting raw materials into a product to maintain the quality, freshness and organoleptic properties of food (Earle *et al.*, 2001). It also involves processing and preservation to provide a safe nutritious diet and increase the shelf life (Habwe & Walingo, 2008). Pigeon pea is among the raw materials used for making various food products (Ashaye *et al.*, 2015; Fasoyiro *et al.*, 2012; Silim *et al.*, 2001). Pigeon peas has been documented to contain protein ranging from 17.9 to 26.3 g (Akubor, 2017; Adepeju *et al.*, 2015). It is rich in amino acids such as lysine (but deficient in methionine and cysteine) (Akubor, 2017; Saxena *et al.*, 2010), iron (24.52 – 31.98 mg); and zinc (23-54 mg) (Abebe, 2022). Household meals in rural Tanzania communities are characterised by limited portions of vegetables, fruits and legumes, which cannot provide adequate amounts of micronutrients and protein. Therefore, pigeon peas can be mixed with other ingredients to optimize nutrient content and improve organoleptic properties. It has been used in different blends in making various foods including biscuits, cookies (Ashaye *et al.*, 2015; Karri & Nalluri, 2017; Okpala & Chinyelu, 2011), bread (Olanipekun *et al.*, 2018) and complementary food (Liomba *et al.*, 2018; Nwaoha & Obetta, 2016). Despite the nutritional importance of pigeon peas, the legume has not been adequately utilized for human consumption in Tanzania due to limited recipes (Majili *et al.*, 2020). This creates an opportunity to develop value-added pigeon pea-based products for recipe diversification that can lead to increased consumption and market opportunities.

Noodle is an extruded product, traditionally made from wheat mixed with water and salt to form a dough (Okpala *et al.*, 2016). Noodles are consumed in different parts of the world in various forms such as vermicelli, spaghetti, pasta or macaroni (Lande *et al.*, 2017; Kaushal & Sharma, 2014; Mogra & Midha, 2013; Torres *et al.*, 2006). Worldwide, it is consumed as a snack, meal and iftar during fasting months (Ramadan) for Muslims'. Based on experience, the consumption of noodles in Tanzania is very limited, especially in rural households. It is mainly consumed during Ramadan as iftar. The surface appearance,

texture and minimal cooking time make wheat flour suitable for making noodles. Wheat is used in the production of noodles due to the presence of gluten that contributes to the dough rheology. Gluten level determines the appearance and the structure of cereal-based products. In addition, wheat is a good source of pyridoxine, niacin, thiamine, riboflavin, pantothenic acid manganese, phosphorus, magnesium, selenium, zinc, copper, iron, and potassium but is deficient in lysine (Lande *et al.*, 2017; Mogra & Midha, 2013). Noodle flour with less gluten has poor texture and is more brittle due to weaker formation of protein linkage (Li *et al.*, 2017; Barak *et al.*, 2014). Pigeon peas have fewer viscoelastic properties (Olanipekun *et al.*, 2018) compared to wheat flour. Therefore, blending wheat flour and pigeon pea to make noodles will improve the physical and sensory quality of the developed PPBN. It will also optimize the nutrient content of the noodles.

Traditionally, porridge is made from different cereal and root flours such as maize, sorghum, millet and cassava flour. In Tanzania, porridge flour is mainly made from cereal-based flour such as maize and finger millet (Mollay *et al.*, 2021; Muhimbula *et al.*, 2011; Martin *et al.*, 2010). These flours are low in protein, lysine and tryptophan (Muhimbula *et al.*, 2011). Currently, it is common practice among farmers and informal small-scale food processors to mix several types of cereal flours, and oilseed or legume. Although it is common knowledge that oilseeds such as groundnuts and legumes such as soybean improves the protein content, the basis of mixing the ingredients and amounts of ingredients are however not known to the processors. The use of soybean is limited among rural households due to cost and difficulties in processing to reduce anti-nutritional factors such as phytates, tannins, trypsin inhibitors and oligosaccharides. It is also considered to take long time to cook to reduce off beany flavour (Kalumbi *et al.*, 2019). The use of pigeon peas in flour blend and extrusion cooking methods can be an alternative approach offering the potential to reduce processing difficulties and reduce cooking time as well as providing required nutrients for growth and development.

In this study, Linear Programming was used to determine the amount of pigeon pea that can be

mixed with wheat and orange flesh sweet potato flour to meet recommended daily nutrient intakes of protein, iron, zinc and pro-vitamin A for adults. Linear programming has also been used to formulate complementary porridge for infants and young children. Linear programming has been used in previous studies as a useful tool to formulate affordable, cost-effective, nutrient-dense, and culturally acceptable products (Sheibani *et al.*, 2018; Briend *et al.*, 2003; Briend *et al.*, 2001).

All these calls for the use of pigeon peas in different blends for nutrient optimization of different food products. The objectives of this study were therefore to (i) determine the best combinations of ingredients to formulate pigeon pea-based noodles and instant porridge flour using Linear programming, (ii) develop pigeon pea-based noodles and instant porridge flour, (iii) test whether the developed products meet the consumer needs

## Materials and Methods

### *Sample Procurement and Collection*

Maize grains and pumpkin were bought at local markets around Morogoro municipality, Tanzania. Wheat flour was bought at the nearby shops around Sokoine University of Agriculture. Orange flesh sweet potatoes flour (OFSP) was bought at Sokoine University Graduate Entrepreneurs Cooperative (SUGECO) premises located at the Sokoine University of Agriculture, Morogoro. Pigeon peas were bought from farmers in the study site described earlier (Majili *et al.*, 2020) and transported to Sokoine University of Agriculture, Department of Food Science and Agro-processing. Ingredients for producing noodles were pigeon peas, wheat and orange flesh sweet potatoes flour (or pumpkin flour).

### *Sample Preparation and Processing*

#### *Maize Flour (MF)*

Maize was sorted to remove all dirt and damaged one. The maize sample was then washed and dried in the direct sunlight. The samples were then milled to get fine flour. After milling, the maize flour was stored on a well-tight bag and labelled.

#### *Pumpkin Flour (PF)*

The pumpkins were cleaned with distilled water and peeled to remove the skin. The seeds were removed and manually chopped into small pieces of about 3 to 4 cm in length and 1 to 1.5 cm in width for easy drying. The chopped pieces were then dried on the oven dryer at 60°C for 24hrs to a moisture content of 10%. The dried pumpkin sliced were milled, packed and labelled.

#### *Pigeon Pea-Based Flour (PPBF)*

Soaking, dehulling and cooking of pigeon peas were used as processing practices to increase the nutritional quality and organoleptic properties and reduce anti-nutritional factors (e.g. phytates) (Prodanor *et al.*, 2004). Before processing the pigeon peas were sorted to remove all dirty and damage grains. The pigeon pea was then divided into two portions. One portion was immersed in boiled water at 100°C for 30 minutes to allow the testa to swell. The boiled water was then discarded and cold water was added to cool the grains for easing the removal of the seed coat/testa. The cooled grains were rubbed by clean hands to remove the seed coat/testa, and later dried on the direct solar dryers. The second portion of PP was roasted in an oven at the temperature of 180°C for 20 minutes. The roasted grain was then soaked in cold water overnight and manually rubbed to remove the seed coat. Thereafter, the grains were dried on the direct solar dryers and milled twice using stainless steel electric grain mill grinder (model F67A, MXBAOHENGus Instrument Co. Storefront) and a heavy-duty food blender (STRONGERTECH-PMC) to get fine flour. The flour was sieved through a 250µg testing sieve (Tokyo Screen. Co. Ltd Japan) and packed well for further processes. The flour made from boiled pigeon pea was used on noodle production (PPBN) whereas the flour made from both boiled and roasted pigeon pea was used on the production of porridge flour (PPIP)

#### *Formulation*

Formulation of the product was done using Linear programming (LP) in Microsoft excel software version 2020. The LP model was developed using the objective function, decision variables and constraints. The cost of ingredients used, nutrient composition of each ingredient

and Recommended Nutrient Intake (RNI) for protein, iron, vitamin A and zinc were considered as the objective function, decision variables and constraints, respectively. The objective functions were formulated to minimize the cost as well as maximizing the nutrient content of developed products.

The objective function of noodles formulations is

$$1. Z1_{nd} = 10^{-3}(C_{pp} + C_{wf})$$

.....  
(Equation 1a)

$$2. Z2_{nd} = 10^{-3}(C_{pp} + C_{wf} + C_{ofspf})$$

..... (Equation 1b)

The objective function for instant porridge formulation is

$$3. Z1_{ip} = 10^{-3}(C_{pp} + C_{mf} + C_{pf})$$

..... (Equation 2a)

$$4. Z2_{ip} = 10^{-3}(C_{pp} + C_{mf} + C_{ofspf})$$

..... (Equation 2b)

Where Z1 and Z2 = total cost of 100g of the product mix for formulations 1 and 2 respectively, nd = noodles, ip = instant porridge,

$10^{-3}$  = Conversion factor from kg to grams, pp = pigeon pea, wf = wheat flour, ofspf = orange flesh sweet potatoes flour, pf = pumpkin flour, mf =maize flour.

The decision variables used in the LP model were the nutrient composition of each ingredient in the formulation (Table 1). The LP constraints were RNI based on the World Health Organization and USA Institute of Medicine recommendations (FAO and WHO, 2004; IOM, 2002). The RNI for adults aged above 18 years were used as LP constraints for noodles and for the instant porridge, the RNI for children aged 12 to 36 months were used (Table 1). In terms of gender differences in nutrient requirements, the highest value was used in the computation to accommodate those with the highest and lowest requirements. The equation for calculating the amount of each nutrient in 100g of the product mix for noodles and instant porridge to meet the nutritional requirements for protein, iron, vitamin A and zinc (constraints) is as follows:

**Table 1:**  
*Decision variables and constraints used in the formulation*

| Nutrients                  | Decision variables |                   |                   |                   |                   |                  | Constraints              |                            |
|----------------------------|--------------------|-------------------|-------------------|-------------------|-------------------|------------------|--------------------------|----------------------------|
|                            | PP <sub>r</sub>    | PP <sub>b</sub>   | wf                | ofspf             | pf                | mf               | RNI/day<br>(1 - 3 years) | RNI/day<br>(19 - 55 years) |
| Protein (g)                | 17 <sup>b</sup>    | 15 <sup>b</sup>   | 11.2 <sup>h</sup> | 2.48 <sup>i</sup> | 0.12 <sup>a</sup> | 8.1 <sup>c</sup> | 13 <sup>d</sup>          | 56 <sup>d</sup>            |
| Iron (mg)                  | 6.8 <sup>b</sup>   | 3.5 <sup>b</sup>  | 5.6 <sup>h</sup>  | 11.5 <sup>i</sup> | 1.47 <sup>i</sup> | 3.5 <sup>c</sup> | 11 <sup>f</sup>          | 18 <sup>f</sup>            |
| Pro-vitamin A* (µg)-<br>RE | 23.3 <sup>e</sup>  | 23.3 <sup>e</sup> | 93 <sup>h</sup>   | 1467 <sup>c</sup> | 575 <sup>g</sup>  | 0 <sup>c</sup>   | 300 <sup>f</sup>         | 900 <sup>f</sup>           |
| Zinc (mg)                  | 6.1 <sup>b</sup>   | 4.3 <sup>b</sup>  | 0.87 <sup>h</sup> | 0.93 <sup>i</sup> | 3.1 <sup>a</sup>  | 1.8 <sup>c</sup> | 8.3 <sup>f</sup>         | 14 <sup>f</sup>            |

\*the RNIs is for vitamin A not for pro-vitamin. PP<sub>r</sub>, roasted pigeon pea, PP<sub>b</sub> blanched pigeon pea, w<sub>r</sub>refined and fortified wheat flour; <sup>a</sup> Ivanova *et al.*, 2016; <sup>b</sup> (Liomba *et al.*, 2018), <sup>c</sup> (Lukmanji *et al.*, 2008); <sup>d</sup> (IOM, 2002), <sup>e</sup> (Adepoju *et al.*, 2019), <sup>f</sup> (FAO and WHO, 2004), <sup>g</sup> (Pereira *et al.*, 2020), <sup>h</sup> (FAO/GOK, 2018), <sup>i</sup> (Dako *et al.*, 2016), <sup>j</sup> (Usha *et al.*, 2010)

The minimum amount of nutrient X in 100g of noodle mix was calculated as

$$F1 \quad 10^{-3}(X_{ppf} + X_{wf}) \geq m_X$$

..... (Equation 3a)

$$F2 \quad 10^{-3}(X_{ppf} + X_{wf} + X_{ofspf}) \geq m_X$$

..... (Equation 3b)

The minimum amount of nutrient X in the instant porridge flour mix was calculated as

$$F3 \quad 10^{-3}(X_{ppf} + X_{mf} + X_{ofspf}) \geq m_X$$

..... (Equation 4a)

$$F4 \quad 10^{-3}(X_{ppf} + X_{mf} + X_{pf}) \geq m_X$$

..... (Equation 4b)

Where

X = nutrient of interest (protein/iron/pro-vitamin A/zinc)  
 m = minimum amount of nutrients of interest in 100g of the product mix for formulation F1...F4,  
 p<sub>pf</sub> = pigeon pea flour, wf = wheat flour,  
 of<sub>spf</sub> = orange flesh sweet potatoes flour,  
 p<sub>f</sub> = pumpkin flour.

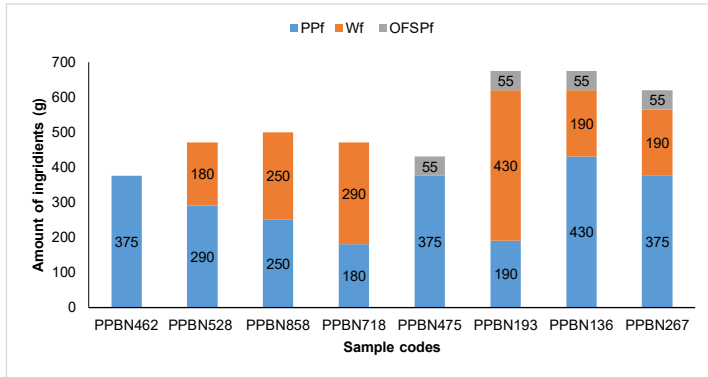
#### Database Setting and Optimization

MS excel software 2020 was used to create a database for the composition of the ingredients. Number of nutrients in 100g, cost per 1000g of each ingredient, and RNI for each selected nutrient (Table 1) were included in the database. Nutrient composition of pigeon pea, pumpkin, all-purpose wheat flour and maize was extracted from different food composition databases (FAO/GOK, 2018; Lukmanji *et al.*, 2008). Kenya food composition table was used for the nutrient content of wheat flour used in the formulation and Tanzania food composition table was used to obtain information on pro-vitamin A content of orange flesh sweet potatoes. Also, different literature was used to obtain information of protein, iron, zinc and pro-vitamin A for pigeon pea flour, orange flesh sweet potatoes flour, pumpkin and maize flour (Table 1) (Adepoju *et al.*, 2019; Dako *et al.*, 2016; Liomba *et al.*, 2018; Pereira *et al.*, 2020; Usha *et al.*, 2010). The changing variable cells (proportion/amount of each ingredient to be added to the product mix) and cell reference (amount of nutrient in the product mix) were introduced in the software. The

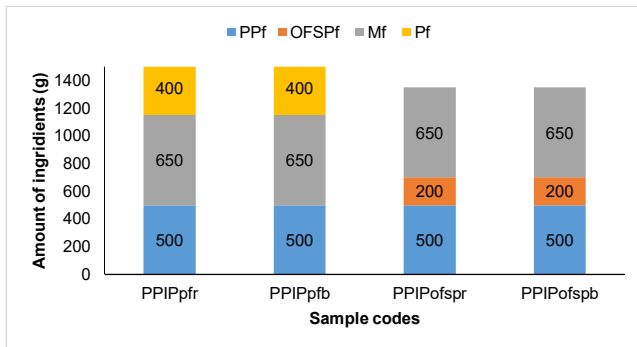
computation of the amount of each ingredient and the cost of the product mix was done using the simplex method. The optimization was done using Solver add-in Microsoft Excel 2010 (Microsoft, Inc., Redmond, WA, USA). A solver command was used to minimize the cost of the pigeon pea-based food product mix while optimizing the nutrient content of the product mix.

#### Amount of Ingredients in Each Formulation

Figure 1 and 2 presents the amount of each ingredient used in different formulations. A total of 12 samples were formulated, eight samples of noodles (designated as PPBN) and four samples of instant porridge (designated as PPIP). The assumption for the formulation is to meet at least 75% of RNI for protein and 50% of RNI for iron, zinc and vitamin A. Another objective was to change the amount of ingredients to check for sensory attributes that will be acceptable. For pigeon pea-based instant porridge flour, the objective function was to maximize the protein, iron, zinc and vitamin A content of the product mix. An equal amount of ingredients was used in all formulations with the difference in the type of ingredients used and processing methods. Sample PPIP<sub>pf</sub><sup>r</sup> and PPIP<sub>osp</sub><sup>r</sup> were mixed with roasted pigeon pea and samples PPIP<sub>pf</sub><sup>b</sup> and PPIP<sub>osp</sub><sup>b</sup> were mixed with pigeon pea that has been blanched before being processed into flour (Fig. 2). The reason for the variation is to increase the chances of acceptance.



**Figure 1:**  
*Amount of ingredients used in the different formulations of pigeon pea-based noodles*



**Figure 2:**  
*Amount of ingredients used in the different formulations of pigeon pea-based noodles*

#### ***Pigeon Pea-Based Noodles Development***

Noodles ingredients included pigeon pea, wheat, and orange flesh sweet potatoes (or pumpkin flour) in different formulations. The amount of water to be added to the mixture was also measured (ranging from 200 to 300 ml) and boiled to reach the temperature of 30°C. Water was added to the dry flour blend and mixed well using a pasta mixer (Model: MSM-15, Henan Alchemy machine, Zhengzhou, China). The pasta mixer was run for 5 to 7 minutes depending on the flour blend formulation to allow the

ingredients to mix well. The mixture was then left to rest for 15 minutes to allow the spreading of water and improvement of gluten properties. Thereafter, little amount of the flour blends at a time was added to the hopper for the extrusion process using a single screw extruder pasta machine (model MST-30, Henan Alchemy machine, Zhengzhou, China). The noodles were then dried outdoor in solar driers at a temperature between 27 to 37°C. The weight of each sample was recorded before being taken to the drier and each day around 2 pm until the

weight remains constant. After drying the noodles were packed well in a zip bag and labelled.

#### *Pigeon Pea-Based Instant Porridge Development*

Four pigeon pea based instant porridge samples were developed using extrusion technology as one of the modern food processing technologies used to improve functionality, physical state and shelf stability of food products. The main ingredient was pigeon pea flour mixed with maize flour and OFSP (or pumpkin) flour. Each ingredient was measured and put into a basin for mixing and labelled as samples 1(a), 1(b), 2(a), and 2(b). Distilled water was added to the mixture of each sample to raise the moisture content of the flour to 14%. Then each sample was extruded using a twin-screw extruder (Model JS 60 D, Qitong Chemical Industry Equipment Co. Ltd, Yantai, China). Sample 1(a) and 1(b) was extruder at a motor speed rate of 30.23rpm, feeder speed rate of 06.2rpm, and temperature of

135 °C at zone I and 89 °C at zone II. For samples 2(a) and 2(b) the motor speed rate of 28.83rpm, feeder speed rate of 06.2rpm, and temperature of 123 °C at zone I and 107°C at zone II. After extrusion, the samples were left to cool and dry at room temperature. The samples were then milled using a commercial hammer mill (Intermech, Tanzania) to get fine flour. The flour was packed in a clean and well-labelled tight container.

#### *Quantitative Descriptive Analysis of Pigeon Pea-Based Noodles (PPBN) and Instant Porridge (PIIP)*

Quantitative Descriptive Analysis (QDA) was conducted at the Department of Human Nutrition and Consumer Sciences, Sokoine University of Agriculture. The conduct of QDA involved several steps as summarized in the flow chart (Figure 3).

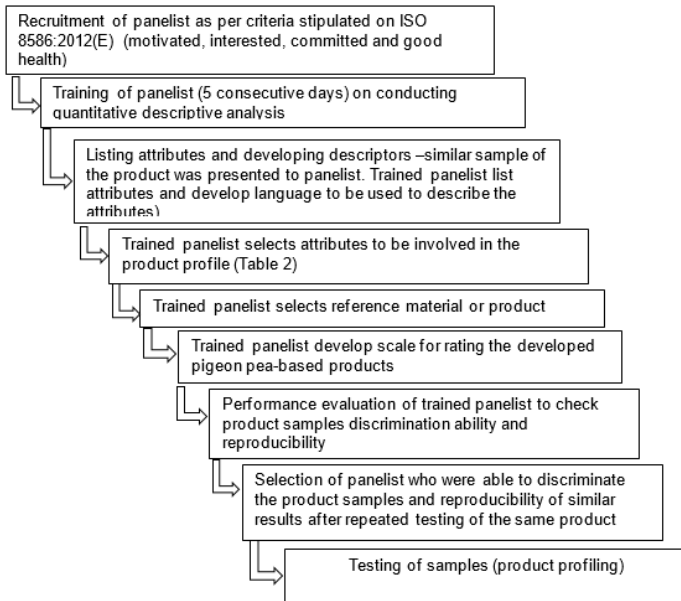


Figure 3:

*A flow chart showing QDA steps for developed pigeon pea-based products*

A total of 26 panellists were recruited and trained to conduct QDA. Fifteen product attributes were identified and listed for QDA, after a similar sample of product was presented to the panellist for testing and developing a common language to be used. Only 5 attributes for PPBN and PPIP were selected for inclusion in final product testing (Table 2). Trained panellist developed a 9-point scales (1 = not noticeable, 2 = trace, 3 = not sure, 4 = faint, 5 = slight, 6 = mild, 7 = moderate,

8 = definite strong, 9 = very strong) for the 5 attributes. Performance evaluation of trained panellist was done to check the product samples discrimination ability and reproducibility. One of the panellists was disqualified after performance evaluations and remained with 25 panellists to conduct QDA. Among them, 14 panellists were involved in the QDA of pigeon pea-based noodles and 11 panellists were involved in the QDA of instant porridge.

**Table 2:**

*Description of product attributes and scale for PPBN and PPIP*

| Attribute               | Descriptor   | Reference  | Rating scale (1 to 9 point)                           |
|-------------------------|--|--|---|
| Colour (PPBN & PPIP)    | Ivory colour   | Santa Lucia pasta  | Light to deep ivory                                   |
| Aroma (PPBN & PPIP)     | Aroma of cooked dried pigeon pea                       | Cooked pigeon pea  | Less to very strong aromatic                          |
| Mouthfeel (PPBN & PPIP) | Slippery feel when chewing products                    | Ripen banana (PPBN)<br>Instant finger millet porridge (PPIP) | Less slippery<br>Course to very strong fine particles |
| Saltiness (PPBN)        | 1g of NaCl <sub>2</sub> in 1000mls of water            | Solution of Table salt                                       | Less to too much salt                                 |
| Softness (PPBN)         | Easy chewiness associated with normally cooked noodles | Cooked noodles (Santa Lucia Pasta)                           | slightly to very soft                                 |
| Viscosity (PPIP)        | Resistance to flow (Thickness/thinness)                | ASAS yoghurt   | Low (watery) to high viscosity                        |
| Sweetness (PPIP)        | 1g of sugar in 1000mls of water                        | Solution of sugar  | Slightly to very sweet                                |

**Sample Preparation for QDA**

Noodle samples were cooked in boiling water, a pinch of salt was added and letting them boil for 5 minutes. The remained water was drained and cold water was poured on it to stop further cooking that can affect the appearance and texture of the sample. Sugar and cardamom were then added to drained noodle and mixed well. The noodle was then partially fried. During cooking equal amount of salt, sugar, cardamom and cooking oil were added to each sample. The cooked noodles were then removed from the cooker and served in identical containers. Each container was labelled with 3- digit random

numbers (e.g. 462, 571 etc.); that vary from one sample to another on each test session. The samples were stored in hot flask to maintain the temperature ready for serving.

Porridge samples were prepared by mixing 750 ml of hot water and 100g of PPIP flour. The PPIP flour was poured in the bowl and little amount of hot water was added at a time while continuous stirring the porridge until all water has been added and the porridge is free from lumps. The mixed porridge was then taken to the cooker and boiled for 5 minutes to make it hot and reduce any contamination made during mixing. The

porridge was then stored in the hot flask to keep it hot during testing.

#### **Design and Procedures for Testing Developed PPBN and PPIP**

Balanced incomplete block design (BIBD) was used during PPBN sample testing (Lawless & Hildegarde, 2010). The BIBD was used because the samples to be tested were many and could not be served to panellists all at a time. However, all PPBN samples were served in an equal number of times into each experimental unit. The experimental unit (blocks) for this was trained panellist and developed pigeon pea-based products were set as the treatments. The statistical model used is

$$Y_{ij0} = \mu + t_i + p_j + r_k + e_{ij0} \dots\dots\dots \text{(Equation 5)}$$

Where  $Y_{ij0}$  = the observed response (o) to the  $i^{\text{th}}$  treatment in the  $j^{\text{th}}$  block (panellist),  $\mu$  = total mean,  $t_i$  = the effect of  $i^{\text{th}}$  treatment,  $P_j$  = random effect of the  $j^{\text{th}}$  panellists,  $r_k$  = random effect of the  $k^{\text{th}}$  replicate and  $e_{ij0}$  = random error associated to  $ij0$ . It is assumed that  $e_{ij0}$  is normally distributed with mean zero and variance  $\sigma_e^2$ .

Four samples of PPBN were simultaneously served at a time, followed by 3 hours of resting before testing another 4 samples. Testing was conducted around 9 am for the morning session and 3 pm for the evening session to avoid physiological biases that may be caused by being hungry or full. Panellists were instructed to test each sample served and evaluate it independently by indicating the intensity of each specified attributes by rating it in a 9-point scale where 1 = not noticeable, 2 = trace, 3 = not sure, 4 = faint, 5 = slight, 6 = mild, 7 = moderate, 8 = definite strong, 9 = very strong. The ratings were filled in the respective column in the provided questionnaire (Appendix 2). The testing was done in triplicate for each sample. During testing, panellists were provided with water for mouth rinse before testing another sample.

A complete randomized block design (CRBD) was used in testing PPIP samples as there were few (four) samples. The treatments were PPIP samples, and the blocks were panellists. The statistical model used is as follows:

$$Y_{ij} = \mu + t_i + e_i$$

.....  
... (Equation 6)

Where  $Y_{ij}$  = the observed response for the  $i^{\text{th}}$  treatment in the  $j^{\text{th}}$  block (panellist),  $\mu$  = total mean,  $t_i$  = the effect of  $i^{\text{th}}$  treatment,  $e_i$  = random effect of the  $j^{\text{th}}$  panellists

Four PPIP samples were served at once in random order. Ten millilitres of porridge were served in labelled disposable glass coded with 3 unique digit numbers in random order. Each panellist was requested to test the porridge and rate it against each PPIP attribute (Table 2). The samples were served in triplicates.

#### **Data Analysis**

Data were analysed using R software (3.6.2 version) for quantitative descriptive analysis of developed pigeon pea-based noodles and instant porridge. Mean and standard deviation was computed. Two-way ANOVA was computed to determine the mean differences among formulations. A post hoc pairwise test (Tukey test) was used to determine differences between the samples at a p-value < 0.05. Sensory attributes were treated as dependent variables against sample formulations and panellists. The Principal Component Analysis (PCA) was done to determine the multidimensional and possible relations of the samples against sensory attributes using XLSTAT (Addinsoft, New York, USA).

#### **Results**

##### **Nutrient Content of Developed PPBN and PPIP Flour**

The protein content of PPBN ranged from 41.0 to 58.2 g (Table 3). Iron content in samples PPBN193 was 26.4 mg and PPBN136 was 18.3 mg. Pro-vitamin A, content for sample PPBN136 was 867.4  $\mu\text{gRE}$ . Sample PPBN462 had a zinc content of 12 mg. For PPIP samples protein content was between 13.8 and 17.1 g and pro-vitamin A content of 245.1 - 308.5  $\mu\text{gRE}$  was observed. Sample PPIP<sub>ofsp<sup>r</sup></sub> had an iron content of 7.9 mg and 5.4 mg of zinc (Table 3).

Table 3

*Amount of nutrients in 100g of the optimized PPBN and PPIP and percent contribution to the nutrient requirement of the study population*

| Product | Sample code                      | Protein g(%) | Iron mg (%) | Zinc mg (%) | Pro-vitamin A<br>µg(%) |
|---------|----------------------------------|--------------|-------------|-------------|------------------------|
|         | RNI/day-adults                   | 56           | 18          | 14          | 900*                   |
| PPBN    | PPBN462                          | 41 (74)      | 10(53)      | 12.0(84)    | 64(7)                  |
|         | PPBN528                          | 44 (79)      | 16(87)      | 8.0(60)     | 37(4)                  |
|         | PPBN858                          | 45.9 (82)    | 15.9(88)    | 9.0(65)     | 40.8(5)                |
|         | PPBN718                          | 56.0(100)    | 21.0(116)   | 10.0(71)    | 42.0(5)                |
|         | PPBN475                          | 42.6 (76)    | 15.9(89)    | 12.3(88)    | 870.9(97)              |
|         | PPBN193                          | 54.5(97)     | 26.4(147)   | 9.6(69)     | 844.1(94)              |
|         | PPBN267                          | 49.3(88)     | 19.3(107)   | 12.8(92)    | 870.9(92)              |
|         | PPBN136                          | 58.2(104)    | 18.3(102)   | 12.7(91)    | 867.4(96)              |
| PPIP    | RNI children                     | 13           | 11          | 7           | 300*                   |
|         | PPIP <sub>pf</sub> <sup>f</sup>  | 17.1(131)    | 6.2(56.7)   | 5.3 (76)    | 245.1(82)              |
|         | PPIP <sub>pt</sub> <sup>b</sup>  | 13.8(106)    | 4.6(42)     | 3.8(53.9)   | 245.1(82)              |
|         | PPIP <sub>osp</sub> <sup>f</sup> | 17.5(134)    | 7.9(72)     | 5.4 (77)    | 308.5(102)             |
|         | PPIP <sub>osp</sub> <sup>b</sup> | 14.2(109)    | 6.3(57)     | 3.8(55)     | 308.5(102)             |

\* the value presented is for RNI of vitamin A

#### *Panellists' Characteristics*

A total of 14 panellists were involved: 57% males and 43% females. Their mean age was  $22.78 \pm 0.57$  (SD) years ranging from 22 to 24 years. For PPIP panellists the mean age was  $23.54 \pm 1.21$  (SD) years ranging from 22 to 25 years, among them 6 (55%) were male and 5 (45%) were female.

#### *Quantitative Descriptive Profiling of Developed PPBN and PPIP Flour*

Table 4 presents the mean intensity scores of the PPBN sample. The highest mean intensity score for colour was  $7.1 \pm 0.66$  (SD) found in sample PPBN718, followed by PPBN193 ( $7.0 \pm 1.02$  (SD)) and PPBN136 ( $7.0 \pm 0.74$  (SD)). The lowest mean intensity score was  $5.1 \pm 0.83$  (SD) observed in sample PPBN462. Similarly, the highest mean intensity scores for aroma and mouthfeel were observed in samples PPBN718, PPBN193 and PPBN136. There were significant differences ( $p <$

0.05) in mean intensity scores in terms of colour and aroma between samples PPBN718, PPBN193 and the remaining formulations. In terms of mouthfeel there was no significant difference between sample PPBN193 and PPBN136; sample PPBN528 and PPBN858 at  $p$ -value  $< 0.05$ . The means values with different superscript letters within a column are significantly different at ( $p < .05$ ). The multivariate analysis for noodle samples against sensory attributes indicated 91% of the total variation in sensory attributes for different PPBN samples. The F1 axis which was also a principle component 1 explained 71% of the variability between samples on the right of the Y-axis (PPBN718, PPBN193, PPBN136) and those on the left of the Y-axis (PPBN462, PPBN528, PPBN267, PPBN475, PPBN858) (Fig. 4).

Table 4

Mean intensity scores of sensory attributes for PPBN samples

| Sample code | Colour<br>Mean $\pm$ SE       | Aroma<br>Mean $\pm$ SE        | Mouthfeel<br>Mean $\pm$ SE    | Saltiness<br>Mean $\pm$ SE      | Softness<br>Mean $\pm$ SE   |
|-------------|-------------------------------|-------------------------------|-------------------------------|---------------------------------|-----------------------------|
| PPBN462     | 5.1 $\pm$ 0.83 <sup>c</sup>   | 5.9 $\pm$ 0.94 <sup>b</sup>   | 4.0 $\pm$ 1.52 <sup>e</sup>   | 5.3 $\pm$ 1.75 <sup>a,b</sup>   | 5.1 $\pm$ 2.55 <sup>a</sup> |
| PPBN528     | 6.0 $\pm$ 0.72 <sup>b</sup>   | 6.0 $\pm$ 1.16 <sup>a,b</sup> | 6.1 $\pm$ 0.88 <sup>c,d</sup> | 5.8 $\pm$ 1.74 <sup>a</sup>     | 5.1 $\pm$ 1.94 <sup>a</sup> |
| PPBN858     | 5.9 $\pm$ 1.53 <sup>b,c</sup> | 6.1 $\pm$ 1.47 <sup>a,b</sup> | 5.8 $\pm$ 1.55 <sup>c,d</sup> | 5.1 $\pm$ 1.42 <sup>a,b,c</sup> | 4.7 $\pm$ 1.98 <sup>a</sup> |
| PPBN718     | 7.1 $\pm$ 0.66 <sup>a</sup>   | 7.1 $\pm$ 0.83 <sup>a</sup>   | 7.2 $\pm$ 0.87 <sup>a</sup>   | 4.7 $\pm$ 1.91 <sup>b,c</sup>   | 5.3 $\pm$ 1.99 <sup>a</sup> |
| PPBN475     | 5.4 $\pm$ 1.73 <sup>b,c</sup> | 6.0 $\pm$ 1.04 <sup>a,b</sup> | 5.5 $\pm$ 1.29 <sup>d</sup>   | 4.9 $\pm$ 1.86 <sup>b,c</sup>   | 4.6 $\pm$ 2.22 <sup>a</sup> |
| PPBN193     | 7.0 $\pm$ 1.02 <sup>a</sup>   | 7.1 $\pm$ 1.06 <sup>a</sup>   | 7.0 $\pm$ 0.76 <sup>a,b</sup> | 5.1 $\pm$ 1.62 <sup>a,b,c</sup> | 5.5 $\pm$ 1.96 <sup>a</sup> |
| PPBN136     | 7.0 $\pm$ 0.74 <sup>a</sup>   | 7.1 $\pm$ 0.98 <sup>a,b</sup> | 7.0 $\pm$ 1.00 <sup>a,b</sup> | 4.4 $\pm$ 1.45 <sup>c</sup>     | 5.2 $\pm$ 1.93 <sup>a</sup> |
| PPBN267     | 5.7 $\pm$ 1.53 <sup>b,c</sup> | 6.6 $\pm$ 1.81 <sup>a,b</sup> | 6.3 $\pm$ 1.06 <sup>b,c</sup> | 4.9 $\pm$ 1.72 <sup>a,b,c</sup> | 4.8 $\pm$ 2.42 <sup>a</sup> |

The F1 was also associated with high intensity in aroma, mouthfeel, colour and softness for samples PPBN718, PPBN193 and PPBN136 while sample PPBN528 and PPBN462 had higher saltiness intensity. Looking at F2 which accounts for 20% of variability, samples PPBN528 and PPBN462 were associated with saltiness while

sample PPBN193 was associated with softness and sample PPBN718 was associated with colour, aroma and mouthfeel.

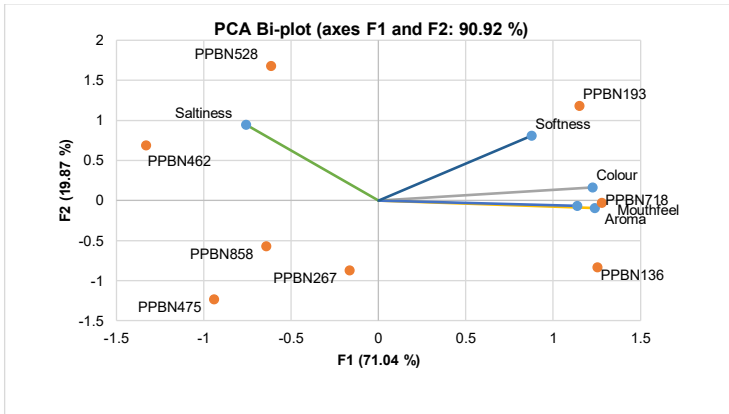


Figure 4

#### PCA Bi-Plots for PPBN

The highest mean intensity scores for colour (8.7) aroma (7.7), mouthfeel (7.8), sweetness (7.1) and

viscosity (7.9) were observed in sample PPIP<sub>ofsp</sub><sup>r</sup> (Table 5). The lowest mean intensity scores for

colour (5.3) and mouthfeel (5.8) were observed in sample PPIP<sub>pf</sub><sup>r</sup>. Sample PPIP<sub>ofsp</sub><sup>r</sup> and PPIP<sub>ofsp</sub><sup>b</sup> were significantly different in colour, mouthfeel

and sweetness with sample PPIP<sub>pf</sub><sup>r</sup> and PPIP<sub>pf</sub><sup>b</sup> at p-value < 0.05 (Table 5). There were no significant differences in the aroma for all samples.

**Table 5**

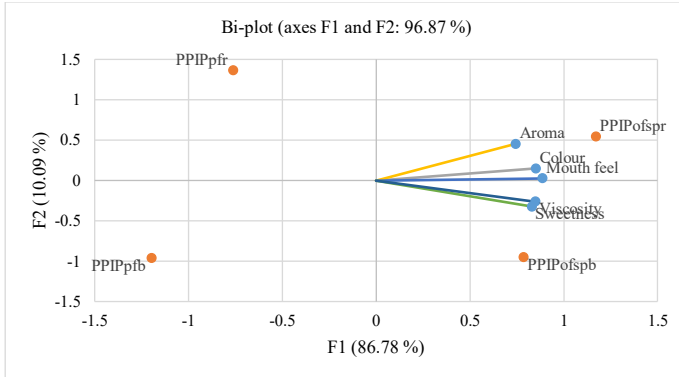
*Mean intensity scores of attributes for developed PPIP sample*

| Sample code                        | Colour<br>Mean ± SD   | Aroma<br>Mean ± SD    | Mouth feel<br>Mean ± SD | Sweetness<br>Mean ± SD  | Viscosity<br>Mean ± SD  |
|------------------------------------|-----------------------|-----------------------|-------------------------|-------------------------|-------------------------|
| PIPIP <sub>pf</sub> <sup>r</sup>   | 7.0±0.97 <sup>b</sup> | 7.3±0.08 <sup>a</sup> | 6.4±2.23 <sup>b</sup>   | 5.9±2.17 <sup>b</sup>   | 6.9±1.18 <sup>c</sup>   |
| PIPIP <sub>pf</sub> <sup>b</sup>   | 5.3±1.23 <sup>c</sup> | 7.0±1.88 <sup>a</sup> | 5.8±1.82 <sup>b</sup>   | 6.2±1.99 <sup>a b</sup> | 7.1±1.47 <sup>b c</sup> |
| PIPIP <sub>ofsp</sub> <sup>r</sup> | 8.7±0.67 <sup>a</sup> | 7.5±1.50 <sup>a</sup> | 7.8±0.99 <sup>a</sup>   | 7.1±0.90 <sup>a</sup>   | 7.9±1.02 <sup>a</sup>   |
| PIPIP <sub>ofsp</sub> <sup>b</sup> | 8.7±0.49 <sup>a</sup> | 7.3±1.02 <sup>a</sup> | 7.7±0.84 <sup>a</sup>   | 7.1±0.76 <sup>a</sup>   | 7.8±0.73 <sup>a b</sup> |

The means values with different superscript letters within a column are significantly different at (p<0.05).

The XLSTAT PCA output explained 97% of the total variation among PPIP samples. The results in Figure 5 show the relationship between sensory attributes and the PPIP sample. The F1 accounted for 87% of variability in sensory attributes. Aroma, colour, mouthfeel, viscosity and sweetness were significantly associated with

samples PPIP<sub>ofsp</sub><sup>r</sup> and PPIP<sub>ofsp</sub><sup>b</sup>. There was no association in sensory attributes between samples PPIP<sub>pf</sub><sup>r</sup> and PPIP<sub>pf</sub><sup>b</sup>. The F2 explained 10% of the variability in aroma, colour and mouthfeel between samples PPIP<sub>ofsp</sub><sup>r</sup> and PPIP<sub>pf</sub><sup>r</sup> as well as viscosity and sweetness among samples PPIP<sub>ofsp</sub><sup>b</sup> and PPIP<sub>pf</sub><sup>b</sup>.



**Figure 5**

*PCA Bi-plots for pigeon pea-based instant porridge*

## Discussion

Pigeon pea-based noodles and porridge were formulated to maximize protein, iron, pro-vitamin A and zinc content while minimizing the cost of producing the product using Linear programming. The amount of ingredients that will be mixed to meet nutrient requirements of protein, iron, zinc and vitamin A for children aged 7 - 36 months and adults were also determined.

### *Nutrient Content of the Developed Noodles (PPBN) and Instant Porridge Flour (PIPI)*

*Protein content of developed PPBN and PPIP flour*  
The protein content of all developed PPBN is 5 times higher than that of wheat-based noodles which contain only 11-15 percent of the protein requirement (Mahmoud *et al.*, 2012). If 100 g of developed PPBN is consumed there is likely a person to get at least 50% of RNI for protein per day. The addition of pigeon peas in the production of noodles improves the protein content of the product.

The protein level of the developed PPIP is significantly higher than cereal-based porridge flour used by community members in the study area. This is due to the addition of pigeon peas which contained a considerable amount of protein. A similar finding was reported earlier in a study by Muhimbula *et al.* (2011) who revealed that legumes such as common beans and soybeans have been used to increase the protein content of different complementary foods (Keyata *et al.*, 2021; Trehan *et al.*, 2015; Martin *et al.*, 2010; Lukmanji *et al.*, 2008). Supplementing legumes in cereal-based foods not only raises the protein level but also complement each other. Studies show that blending cereals and legumes improve the nutritional and functional properties of food (Keyata *et al.*, 2021; Martin *et al.*, 2010).

### *Iron content of developed PPBN and PPIP flour*

The iron content of developed pigeon pea-based noodles was three times higher than in traditional noodles which are composed of 4 to 4.90 mg of iron per 100g (Sunil *et al.*, 2019; Thi Le *et al.*, 2007). The addition of pigeon pea and orange flesh sweet potato flour increased iron content. Sample PPBN193, PPBN136, and PPBN267 have the

highest amount of iron than other samples. This is due to the reported high content of iron in orange flesh sweet potatoes (Dako *et al.*, 2016) than in wheat (FAO/GOK, 2018) and pigeon pea flour (Liomba *et al.*, 2018). Since iron content in pigeon peas is less bioavailable due to the presence of phytates, the developed products were made from pre-treated pigeon peas to reduce these inhibitors of nutrient absorption.

Sample PPIP<sub>ofsp<sup>r</sup></sub> had higher iron content which contributes 72% of RNI than sample PPIP<sub>ofsp<sup>b</sup></sub>. This is attributed to the higher iron content in roasted pigeon pea than in raw and blanched pigeon pea. Comparing the PPIP sample with pumpkin flour and orange flesh sweet potato flour, the former has less amount of iron content. This is due to the high amount of iron content in orange flesh sweet potatoes (Dako *et al.*, 2016) compared to the amount available in pumpkin flour (Usha *et al.*, 2010).

### *Zinc content of developed PPBN and PPIP flour*

Sample PPBN136 had a significant higher amount of zinc content attributed to a large amount of pigeon pea. Literature indicates that pigeon peas have zinc content ranging from 3 - 8.2 mg/100g dry matter (Karri & Nalluri, 2017; Amarteifio *et al.*, 2002). Therefore, the addition of pigeon pea flour in the food product mix resulted in an increase in zinc content. Similarly, sample PPIP<sub>ofsp<sup>r</sup></sub> and sample PPIP<sub>pf<sup>r</sup></sub> was observed to have a significantly higher content of zinc than another sample despite of an equal amount of pigeon pea and maize flour were added in all samples. This is due to roasted pigeon pea having more zinc content than the blanched ones (Ojwang *et al.*, 2021).

### *Pro-vitamin A content of developed PPBN and PPIP flour*

Higher pro-vitamin A content was observed in all samples with OFSP flour (PPBN475, PPBN193, PPBN267, PPBN136 which contributes more than 90% of RNI. This is due to the amount of pro-vitamin A available in orange flesh sweet potatoes. Orange flesh sweet potatoes had a higher amounts of pro-vitamin A than the amount available in pumpkin (Lukmanji *et al.*, 2008). Similarly, sample PPIP<sub>ofsp<sup>r</sup></sub> and PPIP<sub>ofsp<sup>b</sup></sub>

had higher pro-vitamin A content due to added orange flesh sweet potatoes.

#### **Quantitative Descriptive Profiling of Developed PPBN and PPIP Flour**

Samples PPBN718, PPBN193 and PPBN136 were highly preferred samples due to higher mean intensity scores observed. This was due to the favourable composition of the ingredients that enhanced organoleptic attributes. All samples composed of pigeon pea, wheat flour and/or OFSP have higher mean intensity scores than the sample which has pigeon pea alone or the one with pigeon pea and OFSP flour. Colour change was attributed to the additional wheat flour, which is white, as a result, it reduces the deep colour of OFSP and PP. The Colour of Sample PPBN718 was mostly preferred due to the high amount of wheat flour in the sample. This makes the colour to be lighter and closer to the Pasta Santa Lucia (WILMAR Pasta Tanzania Limited) as a reference food. Saltiness is associated with samples PPBN528 and PPBN462 due to the higher amount of pigeon pea than other ingredients. Other samples had composed of OFSP flour which naturally had a sweet taste that masks the saltiness. Similar observation exists in sample PPBN475 and PPBN267 which has an equal amount of PPs with sample PPBN462 but has fewer saltiness intensities.

The Principal Component Analysis (PCA) loadings for samples PPBN193, PPBN718 and PPBN136 were positioned in a similar direction. This indicates the three samples had a similar intensity of colour, aroma and mouthfeel as the key drivers for liking the samples. Sample PPBN718 was closer to the origin, hence contributing less to the aroma, colour and mouthfeel variability. This means that almost all consumers feel the same in terms of aroma, colour and mouthfeel for sample PPBN718. Sample PPBN136 was a little bit far from origins and contributes more to variability of aroma, colour and mouth feel due to higher PCA loadings. Colour and aroma are among the quality attributes that attract consumer acceptability (Methakhap *et al.*, 2005). Samples PPBN462 and PPBN528 were far and opposite directions from other samples hence contributing more to variability of colour, aroma, mouthfeel and softness. This was due to their appealing

characteristics influenced by pigeon peas and less amount of wheat flour and no OFSP flour added to the mixture.

Moreover, there was a significant difference in terms of colour, mouthfeel and sweetness between the porridge flour samples composed of OFSP flour (PPIP<sub>ofsp<sup>r</sup></sub>, PPIP<sub>ofsp<sup>b</sup></sub>) and those with pumpkin flour (PPIP<sub>pf<sup>r</sup></sub>, PPIP<sub>pf<sup>b</sup></sub>). This was due to the colour differences of these samples. Sample PPIP<sub>ofsp<sup>r</sup></sub> and PPIP<sub>ofsp<sup>b</sup></sub> had colour which is closer to ivory colour as a reference food product. The colour for samples PPIP<sub>pf<sup>r</sup></sub>, PPIP<sub>pf<sup>b</sup></sub> that were composed of pumpkin flour was very far from the reference sample. This was due to the deep orange or yellow colour of the pumpkin. Among samples composed with OFSP, sample PPIP<sub>ofsp<sup>r</sup></sub> had a higher mean intensity score in all attributes which may be attributed to the addition of roasted PPs flour. According to Tumuhimbe and colleagues, OFSP products have been reported to have many positive attributes (Tumuhimbe *et al.*, 2019). All samples were different in terms of viscosity; this could be due to serving temperature as all samples were served at one time while the testing was done one sample after another. As the time for testing porridge passes the temperature of the other samples decreases and makes them thicker and consequently less viscosity. Samples PPIP<sub>ofsp<sup>r</sup></sub> and PPIP<sub>ofsp<sup>b</sup></sub> had higher PCA loadings and contributed more to variability of aroma, mouthfeel, colour, sweetness and viscosity with samples PPIP<sub>pf<sup>r</sup></sub> and PPIP<sub>pf<sup>b</sup></sub>. These variations were contributed by different compositions of the ingredients. Samples which were composed of pigeon pea, maize and OFSP flour were highly associated with higher intensity scores of aroma, mouthfeel, colour, sweetness and viscosity.

#### **Conclusion and Recommendations**

The protein, iron and zinc content of developed noodles and instant porridge were higher compared to wheat-based noodles. The addition of pigeon pea flour in developed noodles and instant porridge improves the protein, iron and zinc content in the developed noodles and instant porridge. Higher amount of iron and zinc in developed PPBN and PPIP is attributes to considerable amount of pigeon pea and OFSP added to the flour blend. Roasted pigeon pea

flour used in the development of PPIP contributes a significant amount of iron and zinc content.

All samples which are composed of pigeon pea, wheat flour and/or OFSP have higher mean intensity scores for selected sensory attributes than sample which has pigeon pea alone or the one with pigeon pea and OFSP flour. Samples PPBN193, PPBN718 and PPBN136 have similar colour, aroma and mouthfeel intensities. Sample PPIP<sub>ofsp</sub><sup>r</sup> has a higher mean intensity score in aroma, mouthfeel, colour, sweetness and viscosity attributed to the addition of roasted PPs flour. Samples PPIP<sub>ofsp</sub><sup>r</sup> and PPIP<sub>ofsp</sub><sup>r</sup> have higher PCA loadings and contribute more to variability of aroma, mouthfeel, colour, sweetness and viscosity with samples PPIP<sub>pf</sub><sup>r</sup> and PPIP<sub>pf</sub><sup>b</sup>. Generally, samples PPBN718 and PPIP<sub>ofsp</sub><sup>r</sup> are accepted due to their higher intensities in colour, aroma and mouthfeel. This study recommends that consumers should use the developed value-added pigeon pea-based products to improve their nutritional status (protein, iron, zinc and vitamin A status). Also consumers should use pigeon pea-based flour to enrich different food products in the household.

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## 5.0 CHAPTER FIVE

### **Preferences and Acceptability of Developed Value-Added Pigeon peas-based Noodles and Instant Porridge among Different Consumers in Rural Tanzania**

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## Abstract

Quantitative descriptive analyses for developed pigeon peas-based noodles (PPBN) and instant porridge (PPIP) has been done to quantify the perceived intensities of the sensory attributes. However, this does not inform about consumers' preferences and acceptability of the product. Thus, evaluating preferences and acceptability among consumers is crucial for sustainable consumption. Therefore, this article aimed at assessing the preferences and acceptability of the developed PPBN and PPIP products. A total of 352 consumers were involved out of which 162 consumers (preference tests) and 190 children aged 7 - 36 months (for acceptance test) in selected centres in Mitumbati and Mibure villages in Nachingwea and Ruangwa districts, respectively. Data were analysed using SPSS (v.25), R software (v.3.6.2), and Consumer checker software (v.2.3.1). Among the consumers who participated in the preference test 46% were aged 25 - 49 years, 73% were female, married (70%), farmers (86%) and 77% had primary school education. The highest mean preference scores for colour, aroma and mouthfeel were observed in sample PPBN 718 and PPIP<sub>ofsp</sub><sup>r</sup>. The correlation loadings indicated that sample PPBN718 was preferred due to its colour and aroma whereas sample PPIP<sub>ofsp</sub><sup>r</sup> was preferred due to its mouthfeel, sweetness, colour and aroma attributes. The mean age of children aged 7 - 36 months was  $22.99 \pm 9.75$  (SD) months. The average amount (g) of maize porridge (MP) and PPIP consumed among children was  $137.7 \pm 48.4$  (SD) and  $128.3 \pm 47.1$  (SD) but differed between age groups. The amount of MP and PPIP consumed by children aged 7 - 12 months was significantly lower than the amount consumed by children aged above 12 months. About 88% of children consumed PPIP more than 50% of the amount of maize porridge. About 90% of children were quick in opening their mouth, responsive and satisfied with MP and PPIP. The developed products were preferred by the majority due to their colour,

aroma and mouthfeel as the key attributes for product acceptability. It is recommended that consumers' preferences and acceptability tests should be taken into account during product development in order to come up with the best choice of product that will be acceptable among the intended consumers.

**Key words:** *Consumer, preference, acceptance, pigeon peas, noodles, instant porridge flour*

## 1.0 Introduction

Preference and acceptance test for food attributes is very important to ensure the suitability and sustainability of a newly developed food products. The test determines the important criteria for food choice as well as consumer sensory perception of the developed products. The consumer behaviour theory assumes that a consumer is a rational economic agent aimed at attaining the highest possible satisfaction derived not only from the food itself but also from its attributes (Hanf & Winter, 2017). Consumers have tastes and preferences that determine their decision to accept or reject a food product. Several factors may influence product acceptability including taste, quality and safety (Banterle *et al.*, 2012). Based on the Theory of Reasoned Action (TRA), the consumer will perform the behaviour if she/he has a positive or negative attitude feeling towards a particular behaviour (Ajzen & Fishbein, 2005). Also, a consumer may accept a food product if she/he has feelings and rational decisions about the characteristics of the particular food product. Hence, analysing consumer preferences for developed pigeon peas-based noodles (PPBN) and instant porridge (PPIP) is an important stage that will help to determine the acceptable product attributes. Traditionally, mothers are used to test children's food as children's behaviour towards food choices are influenced by their mother's acceptance (Amod *et al.*, 2016). Also, mothers

can discriminate the product and provide rational judgement on the sensory attributes of the product (Pillay *et al.*, 2018; Amod *et al.*, 2016). However, this does not ensure acceptability among children. Hence in this study, children were used to test the developed PPIP as it is mainly intended for them and not for their mothers.

Micronutrient deficiencies such as iron, iodine and vitamin A deficiency, have been recognized as health problems in different developing countries including Tanzania. It is estimated that about 58% of Tanzanian children are iron deficient (MoHCDGEC *et al.*, 2019), 33% are vitamin A deficient (NBS & ICF, 2011), and 34% have chronic malnutrition (MoHCDGEC *et al.*, 2019). In terms of dietary diversification, the proportion of Tanzanian children (35%) who receive more than three food groups is still low (MoHCDGEC *et al.*, 2019). In Lindi region, the prevalence of anaemia in both under five children (58%) and women of reproductive age (51%) is high compared to national averages (MoHCDGEC *et al.*, 2016, 2019). In the Lindi region, only 1.9% of children consume a minimum acceptable diet (MoHCDGEC *et al.*, 2019). Inadequate intake of micronutrient-rich foods due to poor feeding practices, infections and low nutrient density in foods (NBS & ICF, 2011) are among the causes of micronutrient deficiency. For instance, the main meal of children aged 1-3 years in Lindi region is cereal-based porridge made from either a single or mixture of more than one cereal flour which is low in protein and micronutrients, subjecting the children to the risk of micronutrient deficiency. Hence, supplementing children with enriched complementary developed pigeon peas-based instant porridge will be likely to be of the practical solution for the problem.

Adults' good health status is important for the wellbeing of the children and overall socio economic development. Since adults are productive assets; undernourishment can result

into poor health that can negatively impact productivity due to reduced physical and intellectual ability. This situation status affects the community and national development. Worldwide, it is estimated that in the year 2020 about 2.37 billion people suffered from inadequate food, whereby among them 928 million people did not consume adequate food (FAO *et al.*, 2021) and 2 billion people suffers from micronutrient deficiencies (FAO *et al.*, 2020). In developing countries, adult health receives little attention in public health forums that affect the labour force.

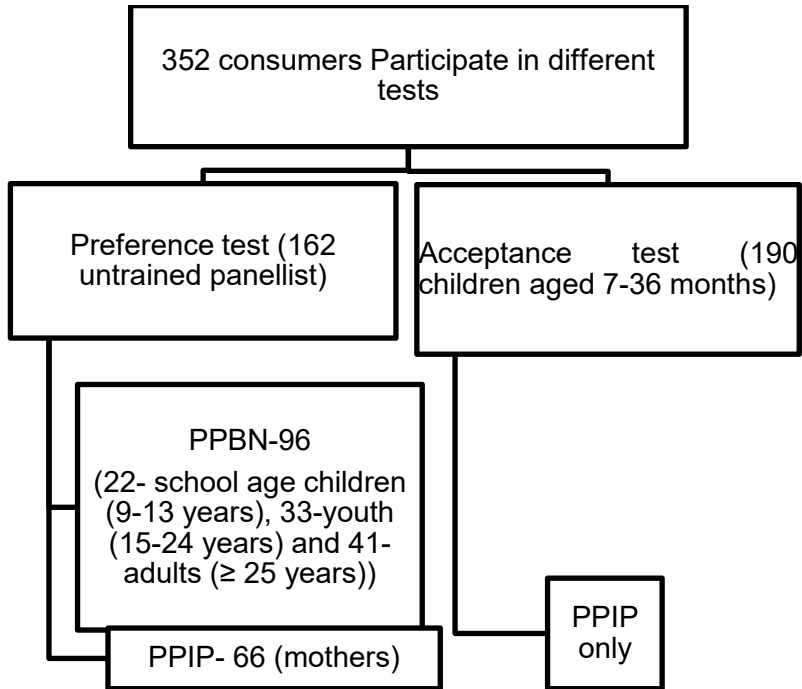
Several nutritional interventions addressing micronutrient deficiency have been implemented in the Tanzania including micronutrient supplementation and fortification (Etheredge *et al.*, 2016; Dhillon *et al.*, 2011; URT, 2013; Masanja *et al.*, 2006). Although, most of these interventions have immediate solutions to reduce micronutrient deficiencies in children but they do not reach out all those affected including adults. Food-based interventions such as dietary diversification and modification are considered as the long-term strategy for improving nutrition (Nair *et al.*, 2016; Gibson *et al.*, 2006). Furthermore, it accounts for sustainable, feasible and culturally acceptable solutions. Hence, advocating consumption of the developed pigeon peas-based noodles can help to improve adult health through food-based approach. The developed products aimed at improving the quality of food by diversifying recipes using the locally available foods such as pigeon peas. This article aimed at assessing (i) consumer preference for developed pigeon peas-based noodles and instant porridge and (ii) the acceptability of developed pigeon peas-based instant porridge among children.

## **2.0 Methodology**

### **2.1 Study Design, Location and Participants**

Incomplete Randomized Block Design (IRBD) was used to assess consumer preferences of the developed pigeon peas-based noodles (PPBN). This design was opted based on the fact that many samples of PPBN (eight samples) that were involved in the assessment, which was unable to present them to panellists in a single session. According to Lawless and colleague all samples should be served at once, but if not possible appropriate experiment plan such as incomplete block design should be used (Lawless & Hildegarde, 2010). Due to this, panellist evaluated four samples in first session and the other four samples were evaluated in the second session. Complete Randomized Block Design (CRBD) was used to assess preferences of developed pigeon peas-based instant porridge (PPIP). This design was used as only four samples were assessed in a single session. Each sample of PPBN and PPIP was coded with three unique digit numbers to avoid biases. During testing, the samples (treatment) of PPBN and PPIP were randomly assigned to panellists (blocks) for testing.

The study was conducted in Mibure and Mitumbati villages in Ruangwa and Nachingwea districts respectively, in Lindi region. A total of 352 untrained panellists (Fig. 1) of different age groups including school-aged children, youth, male adults and mothers with under-five children were recruited. In this study untrained panellists are also referred to as consumers. Mothers were engaged in different stages of production and selection of the preferred samples of porridge flour that will fit their children's preferences. In this study, mothers were involved in a preference test to determine the mostly preferred products' sample, which was later taken to the target group of children for the acceptance tests.



**Figure 1: Study participants**

## 2.2 Study Approach

### 2.2.1 Preference test

A preference test for all samples of developed products was conducted among different age groups (Fig. 1). A structured questionnaire was used to collect socio-demographic characteristics and preference ratings. Before the test, the study objective was explained to the panellists and their written consent was requested. All samples of PPBN and PPIP were cooked by selected mothers under the guidance of the main investigator in selected centres in the respective villages. PPBN samples were cooked by boiling in water until well cooked. An equal amount of cardamom, salt and sugar was added in the boiled noodles samples and mixed well

before partially fried. A total of 162 untrained panellists in a group of 10 were allowed to sit for one test. Each panellist was served four samples at a time and requested to test and rate colour, aroma, mouthfeel, saltiness, softness and overall liking on a five-point scale. The rating score was 1 = extremely not preferred, 2 = less preferred, 3 = neither preferred nor preferred, 4 = preferred and 5 extremely preferred. The PPIP sample with the highest score was taken for the acceptance test among children aged 7 - 36 months.

### **2.2.2 Acceptance test of PPIP among children**

All children aged 7 - 36 months in Mibure and Mitumbati villages were recruited with the assistance of village leaders and community health workers. Focus group discussions which engaging children mothers/caregivers to collect information on feeding practices, method for processing of porridge flour and cooking of the porridge to get an insight and plan for the acceptance test. During testing, a questionnaire was used to collect information on age, sex and feeding practices. The acceptance test was conducted in selected centres in each hamlet. For hamlets with a bigger sample size, multiple centres were established to create centres of similar size. A total of 16 centres were established and each centre had 10 - 15 children. The centres selected were located close to households of selected children for easier access.

Porridge was cooked by a selected mother in each hamlet under the supervision of the first author. During cooking margarine and powdered milk were added. Sugar or salt was also added because mothers reported that those ingredients were frequently added in children's porridge. After the porridge was well cooked, it was divided into two parts, thereafter sugar was added in one portion and in the other portion salt was added and mixed well. Mothers were requested to report to the selected centre at 7 am each morning along with their children as agreed during FGDs.

Mothers were requested to refrain from feeding their children other foods before and during the testing period.

The porridge was served and consumed at the centre. Each mother was asked to come with feeding utensils that were normally used for a child. A measured quantity of the porridge was served to each child between 7.00 and 8.30 am as their first meal apart from breast milk. The weight of the empty utensil in was measured using a digital weighing scale before serving and after consuming the porridge. The measurement was recorded to the nearest 0.1ml.

Children were provided with control porridge (maize porridge) during the first three days. This was followed by a one-day washout. Afterwards, pigeon peas-based instant porridge was fed for three days. The initial amount of maize flour porridge served was 150 ml and in case the child was not satisfied, more porridge was given. This was done to establish the amount of porridge consumed by the child. An average amount of porridge consumed for the first three days was calculated to establish the amount of PPIP to be served to each child after a one-day washout. For PPIP, the amount served varied based on the amount consumed by the child when fed on the control porridge (maize porridge) with an addition or reduction of 10 -15 ml upon the mother's request. Mothers were asked to feed their children the served amount of porridge until the child refused to eat more. The child was considered to have rejected to eat when three pauses of two minutes' interval and moved their head away from food or shut their mouth. Other signs which implied that the child was full were spitting off the food or holding the food in the mouth for more than 3 minutes without swallowing, crying or clenching of teeth. The main investigator and research assistants observed the mothers as they were feeding their children on the porridge to note if there was any force applied in the course of feeding the child. A child was assumed to have accepted the PPIP if she/he consumed more than 50%

of the amount of control (Maize) porridge. Maize porridge was used as control porridge because children in the study area are usually fed maize porridge. Therefore, comparing the amount of maize porridge consumed and the developed PPIP will provide the basis of acceptability of the porridge.

### **3.0 Data Analysis**

Data were analysed using SPSS software version 25. Means and standard deviation were used to summarize acceptability scores of the porridge and the Wilcoxon signed test was conducted to check whether there was a statistical change in consumption of the two samples of porridge (MP and PPIP). R software (3.6.2 version) was used for descriptive analysis of preference scores of developed PPIP samples in terms of colour, aroma, mouthfeel, sweetness, and overall acceptability. Analysis of variance (ANOVA) and post hoc pairwise test –Tukey HDS were used to compare means among samples at  $p < 0.05$ . One-way ANOVA was also performed to check whether there was a significant difference among consumers' gender and age groups. Multivariate regression analysis was performed using Consumer checker software (2.3.1 version, Norway) to visualize the individual differences between consumers and their preference for sensory attributes of the developed pigeon peas-based products.

## **4.0 Results**

### **4.1 Socio-demographic Characteristics of Consumers Participated in the Preference Test**

A total of 22 school-age children, 33 youth and 107 adults participated in the preference test. The mean age (years) of consumers who participated in the preference test was  $11.05 \pm 1.91$  (SD) for consumers aged < 15 years,  $20.7 \pm 2.53$  (SD) for consumers aged 15 - 24 years,  $36.6 \pm 6.63$  (SD) for consumers aged 25 - 49 years, and  $56.9 \pm 6.82$  (SD) for consumers aged > 49 years. Table 1 shows that consumer socio-demographic characteristics. About 46% were aged between 25 - 49 years, 73% were female, 70% were married, 77% had attained primary school education and 86% were farmers. Furthermore, a total of 190 children were involved in the acceptance test. The mean age of the children was  $22.99 \pm 9.75$  (SD) months. About 41% of children were aged between 13 – 24 months, 38% were aged between 25 - 36 months and 21% were aged between 7 - 12 months. In terms of sex, 51% were female and 48% were male.

**Table 1: Consumers' socio-demographic characteristics**

| <b>Characteristics</b>   | <b>n</b> | <b>%</b> |
|--------------------------|----------|----------|
| <b>Age</b>               |          |          |
| <15 years                | 22       | 13.6     |
| 15 -24 years             | 33       | 20.4     |
| 25 - 49 years            | 76       | 46.9     |
| > 49 years               | 31       | 19.1     |
| <b>Sex</b>               |          |          |
| Female                   | 118      | 72.8     |
| Male                     | 44       | 27.2     |
| <b>Marital status</b>    |          |          |
| Married monogamous       | 113      | 69.8     |
| Widowed/Divorced/ Single | 27       | 16.7     |
| Student                  | 22       | 13.6     |
| <b>Education level</b>   |          |          |
| no formal education      | 7        | 4.3      |
| Primary school           | 125      | 77.2     |
| In school                | 22       | 13.6     |
| Secondary school         | 8        | 4.9      |
| <b>Occupation</b>        |          |          |
| Farmer                   | 140      | 86.4     |
| Student                  | 22       | 13.6     |

#### **4.2 Consumer Preferences for Samples of Noodles (PPBN)**

Table 2 presents results on the overall liking of developed PPBN. The overall liking of PPBN was differed significantly among the samples at  $p < 0.05$ . The overall mean of liking for sample PPBN193 was  $4.5 \pm 1.02$  (SD), PPBN136 was  $4.5 \pm 1.08$  (SD) and sample, PPBN718 was  $4.5 \pm 1.25$  (SD). There was a significant difference among the sample and overall liking of colour, aroma, mouthfeel, saltiness and softness, with the lowest mean scores were observed in sample PPBN462 and PPBN475.

Preference correlation loadings for PPBN in component 1 are explained by 62% in X- axis and 45% in Y- axis indicating systematic variation among consumer liking of PPBN samples and drivers for their preference (Fig. 2). The preference map indicated that more consumers were on the upper right of the plot and their preference was associated with products with high intensity for colour followed by the aroma. Preference for colour and aroma were associated with samples PPBN718, PPBN193 and PPBN136. Samples on the lower right part of the plot have high intensity for mouthfeel. The left upper part of the plot implies that, saltiness was less preferred and that characteristic was highly related to sample PPBN462.

**Table 2: Preference scores for noodles samples**

| <b>Sample code</b> | <b>Colour<br/><math>\bar{x} \pm SD</math></b> | <b>Aroma<br/><math>\bar{x} \pm SD</math></b> | <b>Mouth feel<br/><math>\bar{x} \pm SD</math></b> | <b>Saltiness<br/><math>\bar{x} \pm SD</math></b> | <b>Softness<br/><math>\bar{x} \pm SD</math></b> | <b>Overall Liking<br/><math>\bar{x} \pm SD</math></b> |
|--------------------|---|--|---|--|---|---|
| PPBN462            | 4.1±1.39 <sup>b</sup>                         | 3.9±1.47 <sup>b</sup>                        | 3.9±1.46 <sup>b</sup>                             | 4.7±1.73 <sup>a</sup>                            | 4.1±2.40 <sup>a</sup>                           | 4.0±1.44 <sup>b</sup>                                 |
| PPBN528            | 4.4±1.01 <sup>ab</sup>                        | 4.3±1.04 <sup>ab</sup>                       | 4.1±1.34 <sup>ab</sup>                            | 4.3 ± 1.74 <sup>b</sup>                          | 4.1±2.55 <sup>a</sup>                           | 4.3±1.24 <sup>ab</sup>                                |
| PPBN858            | 4.3±1.27 <sup>ab</sup>                        | 4.3±1.20 <sup>ab</sup>                       | 4.1±1.26 <sup>ab</sup>                            | 4.1±1.75 <sup>b</sup>                            | 4.2±2.80 <sup>a</sup>                           | 4.2±1.25 <sup>ab</sup>                                |
| PPBN718            | 4.5±1.07 <sup>a</sup>                         | 4.4±1.28 <sup>a</sup>                        | 4.3±1.28 <sup>a</sup>                             | 4.1±1.9 <sup>b</sup>                             | 4.2±2.25 <sup>a</sup>                           | 4.4±1.25 <sup>ab</sup>                                |
| PPBN475            | 4.2±1.21 <sup>ab</sup>                        | 4.0±1.31 <sup>ab</sup>                       | 3.9±1.40 <sup>b</sup>                             | 4.4±1.42 <sup>ab</sup>                           | 4.1±1.98 <sup>a</sup>                           | 4.1±1.37 <sup>ab</sup>                                |
| PPBN193            | 4.5±0.85 <sup>a</sup>                         | 4.4±0.99 <sup>a</sup>                        | 4.4±1.10 <sup>a</sup>                             | 4.06±1.61 <sup>b</sup>                           | 4.4±2.08 <sup>a</sup>                           | 4.5±1.02 <sup>a</sup>                                 |
| PPBN136            | 4.5±1.04 <sup>a</sup>                         | 4.4±1.17 <sup>a</sup>                        | 4.4±1.11 <sup>a</sup>                             | 4.1±1.15 <sup>b</sup>                            | 4.2±2.06 <sup>a</sup>                           | 4.5±1.08 <sup>a</sup>                                 |
| PPBN267            | 4.3±1.31 <sup>ab</sup>                        | 4.3±1.32 <sup>ab</sup>                       | 4.1±1.50 <sup>ab</sup>                            | 4.1±1.72 <sup>b</sup>                            | 3.8±2.50 <sup>a</sup>                           | 4.3±1.45 <sup>ab</sup>                                |

The means values with different superscript letters within a column are significantly different at  $p < 0.05$ .

X & Y correlation loadings

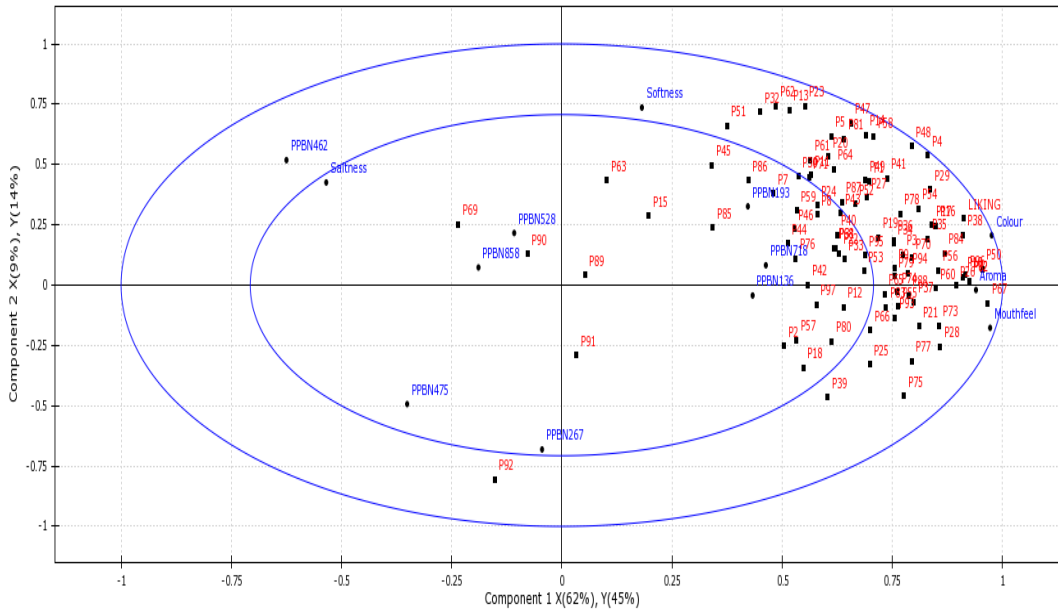


Figure 2: Preference loadings for PPBN

### **4.3 Gender and Age Preferences in Rating PPBN**

Results in Table 3 indicated that there were significant differences in rating aroma, mouthfeel, and softness for sample PPBN136 among males and females (Table 3). The mean ranking for aroma was 53.9, mouthfeel (54.4) and softness (53.8) among females and that was higher than the ranking for the male counterparts. There were no significant differences between males and females in terms of overall liking of the samples. The significant differences were also observed in rating softness for sample PPBN528 whereas female rank the highest than male counterparts. There were no significant differences in rating other samples (PPBN193, PPBN267, PPBN462, PPBN718, PPBN475, PPBN858) among male and females.

Table 3: Preferences for noodles samples (PPBN) by gender

| Sample  | Sex | N  | Colour         |         | Aroma          |         | Mouthfeel      |         | Saltiness      |         | Softness       |         | Overall acceptability |         |
|---------|-----|----|----------------|---------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|-----------------------|---------|
|         |     |    | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank        | p-value |
| PPBN136 | F   | 54 | 52.0           | 0.08    | 53.9           | 0.01*   | 54.4           | 0.0*    | 52.0           | 0.08    | 53.8           | 0.00*   | 49.2                  | 0.73    |
|         | M   | 42 | 44.1           |         | 41.6           |         | 41.0           |         | 44.0           |         | 41.7           |         | 47.7                  |         |
| PPBN193 | F   | 54 | 49.6           | 0.55    | 50.8           | 0.26    | 50.6           | 0.30    | 50.8           | 0.25    | 49.3           | 0.67    | 49.5                  | 0.59    |
|         | M   | 42 | 47.1           |         | 45.6           |         | 45.8           |         | 45.6           |         | 47.5           |         | 47.2                  |         |
| PPBN267 | F   | 54 | 51.8           | 0.09    | 51.5           | 0.14    | 51.1           | 0.21    | 51.5           | 0.15    | 51.6           | 0.10    | 48.2                  | 0.88    |
|         | M   | 42 | 44.3           |         | 44.7           |         | 45.1           |         | 44.7           |         | 44.5           |         | 48.8                  |         |
| PPBN462 | F   | 54 | 47.8           | 0.73    | 48.3           | 0.93    | 46.6           | 0.38    | 47.8           | 0.76    | 48.6           | 0.96    | 45.4                  | 0.13    |
|         | M   | 42 | 49.4           |         | 48.7           |         | 51.0           |         | 49.4           |         | 48.4           |         | 52.5                  |         |
| PPBN475 | F   | 54 | 50.9           | 0.26    | 48.6           | 0.96    | 51.7           | 0.17    | 51.2           | 0.22    | 52.5           | 0.07    | 49.7                  | 0.57    |
|         | M   | 42 | 45.4           |         | 48.4           |         | 44.5           |         | 45.0           |         | 43.3           |         | 46.9                  |         |

| Sample  | Sex | N  | Colour         |         | Aroma          |         | Mouthfeel      |         | Saltiness      |         | Softness       |         | Overall acceptability |         |
|---------|-----|----|----------------|---------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|-----------------------|---------|
|         |     |    | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank | p-value | $\bar{x}$ Rank        | p-value |
| PPBN528 | F   | 54 | 51.3           | 0.21    | 51.8           | 0.14    | 50.0           | 0.51    | 50.5           | 0.39    | 53.4           | 0.01*   | 44.1                  | 0.05    |
|         | M   | 42 | 44.9           |         | 44.2           |         | 46.6           |         | 45.9           |         | 42.1           |         | 54.1                  |         |
| PPBN718 | F   | 54 | 50.0           | 0.48    | 52.0           | 0.09    | 50.0           | 0.48    | 50.6           | 0.29    | 50.9           | 0.24    | 47.1                  | 0.46    |
|         | M   | 42 | 46.6           |         | 44.0           |         | 46.6           |         | 45.8           |         | 45.5           |         | 50.3                  |         |
| PPBN858 | F   | 54 | 48.3           | 0.91    | 50.7           | 0.35    | 49.7           | 0.59    | 49.6           | 0.64    | 52.8           | 0.05    | 46.3                  | 0.33    |
|         | M   | 42 | 48.8           |         | 45.7           |         | 46.9           |         | 47.1           |         | 42.9           |         | 51.3                  |         |

$\bar{x}$ Rank = mean rank

Results in Table 4 show that, there was no significant difference in the overall liking scores and consumers age. However, significant difference was observed in mouthfeel for sample PPBN462 whereas the mean rank of 56.69 was observed among consumers aged above 49 years followed by 49.09 for consumers who are aged below 15 years. There was no significant difference in mean ranking among consumers' marital status, occupation, and education level.

Table 4: Preferences for noodles samples (PPBN) by age

| Sample  | Age (years) | Colour         |         | Aroma          |         | Mouthfeel      |         | Saltiness      |         | Softness       |         | Overall liking |         |
|---------|-------------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|
|         |             | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value |
| PPBN136 | < 15        | 51.3           | 0.48    | 49.3           | 0.98    | 49.6           | 0.91    | 44.7           | 0.66    | 50.6           | 0.71    | 42.9           | 0.15    |
|         | 15 - 24     | 40.2           |         | 48.5           |         | 51.5           |         | 50.7           |         | 52.5           |         | 40.4           |         |
|         | 25 - 49     | 50.4           |         | 49.2           |         | 46.5           |         | 47.2           |         | 45.4           |         | 51.5           |         |
|         | > 49        | 47.8           |         | 47.0           |         | 48.7           |         | 52.2           |         | 48.8           |         | 53.2           |         |
| PPBN193 | < 15        | 46.6           | 0.23    | 41.0           | 0.33    | 45.5           | 0.54    | 44.4           | 0.46    | 45.9           | 0.57    | 46.3           | 0.59    |
|         | 15 - 24     | 49.1           |         | 53.2           |         | 44.2           |         | 51.9           |         | 50.6           |         | 42.6           |         |
|         | 25 - 49     | 44.2           |         | 49.3           |         | 48.0           |         | 46.2           |         | 45.9           |         | 51.1           |         |
|         | > 49        | 55.2           |         | 51.4           |         | 53.6           |         | 53.1           |         | 52.8           |         | 49.9           |         |
| PPBN267 | < 15        | 51.6           | 0.40    | 48.4           | 0.97    | 48.1           | 0.92    | 48.9           | 0.91    | 50.4           | 0.89    | 46.6           | 0.88    |
|         | 15 - 24     | 39.1           |         | 46.6           |         | 44.9           |         | 44.3           |         | 44.8           |         | 52.3           |         |
|         | 25 - 49     | 49.4           |         | 49.8           |         | 50.2           |         | 48.8           |         | 49.2           |         | 47.9           |         |
|         | > 49        | 49.4           |         | 47.7           |         | 48.4           |         | 49.7           |         | 47.8           |         | 48.9           |         |
| PPBN462 | < 15        | 46.5           | 0.36    | 48.2           | 0.08    | 49.1           |         | 51.5           | 0.09    | 50.8           | 0.71    | 51.9           | 0.74    |
|         | 15 - 24     | 42.5           |         | 33.5           |         | 32.5           | 0.04*   | 34.3           |         | 46.9           |         | 44.4           |         |
|         | 25 - 49     | 46.9           |         | 49.4           |         | 47.7           |         | 47.0           |         | 45.2           |         | 49.7           |         |
|         | > 49        | 54.9           |         | 54.8           |         | 56.7           |         | 54.8           |         | 51.5           |         | 46.2           |         |
| PPBN475 | < 15        | 52.9           | 0.40    | 51.0           | 0.19    | 48.8           | 0.48    | 52.0           | 0.31    | 48.3           | 0.71    | 41.9           | 0.21    |
|         | 15 - 24     | 41.5           |         | 50.7           |         | 42.9           |         | 42.6           |         | 50.6           |         | 42.9           |         |
|         | 25 - 49     | 45.6           |         | 41.4           |         | 45.7           |         | 44.0           |         | 44.9           |         | 49.3           |         |
|         | > 49        | 51.9           |         | 54.3           |         | 54.4           |         | 54.1           |         | 52.2           |         | 55.5           |         |

| Sample  | Age (years) | Colour         |         | Aroma          |         | Mouthfeel      |         | Saltiness      |         | Softness       |         | Overall liking |         |
|---------|-------------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|----------------|---------|
|         |             | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value | $\bar{x}$ Rank | P-value |
| PPBN528 | < 15        | 51.2           | 0.18    | 44.9           | 0.05    | 54.2           | 0.40    | 46.6           | 0.91    | 47.5           | 0.10    | 53.0           | 0.46    |
|         | 15 - 24     | 39.2           |         | 39.7           |         | 44.0           |         | 47.5           |         | 55.6           |         | 41.9           |         |
|         | 25 - 49     | 54.2           |         | 58.2           |         | 50.7           |         | 51.2           |         | 53.3           |         | 45.6           |         |
|         | > 49        | 43.6           |         | 43.4           |         | 43.3           |         | 47.2           |         | 39.9           |         | 51.8           |         |
| PPBN718 | < 15        | 52.7           | 0.14    | 40.0           | 0.06    | 54.2           | 0.40    | 44.5           | 0.49    | 45.1           | 0.45    | 49.1           | 0.45    |
|         | 15 - 24     | 40.3           |         | 43.5           |         | 44.0           |         | 45.3           |         | 45.4           |         | 50.0           |         |
|         | 25 - 49     | 44.1           |         | 48.9           |         | 50.7           |         | 48.2           |         | 47.3           |         | 44.1           |         |
|         | > 49        | 54.5           |         | 57.4           |         | 43.3           |         | 53.7           |         | 54.3           |         | 52.9           |         |
| PPBN858 | < 15        | 49.6           | 0.90    | 51.7           | 0.83    | 48.0           | 0.50    | 45.5           | 0.21    | 43.0           | 0.57    | 51.5           | 0.12    |
|         | 15 - 24     | 43.6           |         | 51.5           |         | 49.3           |         | 57.9           |         | 48.4           |         | 38.3           |         |
|         | 25 - 49     | 49.0           |         | 46.0           |         | 44.1           |         | 43.0           |         | 52.5           |         | 44.5           |         |
|         | > 49        | 49.4           |         | 47.6           |         | 54.2           |         | 53.4           |         | 48.0           |         | 56.0           |         |

$\bar{x}$ Rank = mean rank

#### 4.4 Consumer Preferences for Developed PPIP

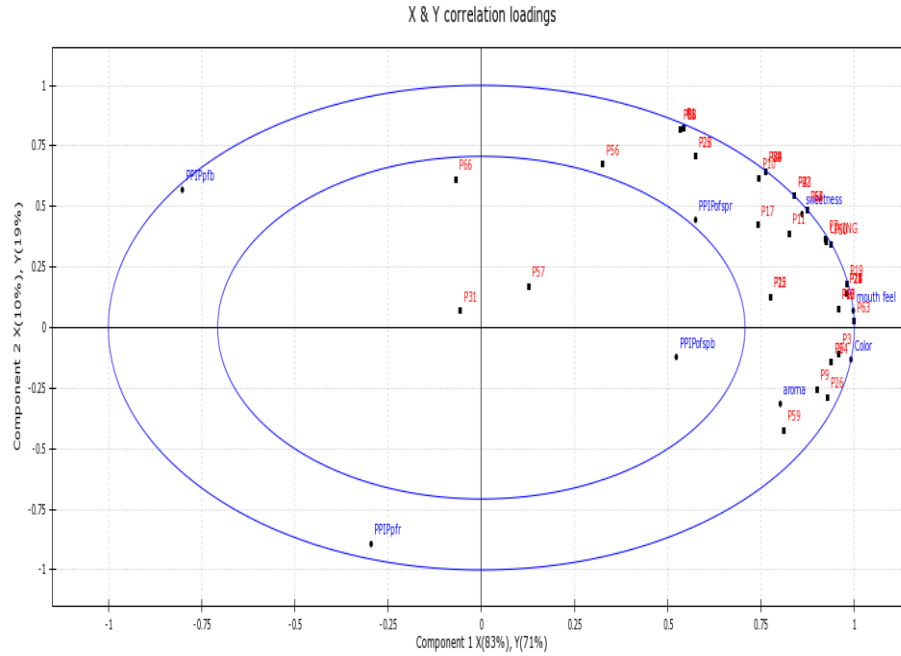
For develop PPIP, there was a significant difference in colour, aroma, and mouthfeel between samples with pumpkin flour (PPIP<sub>pr<sup>r</sup></sub> and PPIP<sub>pr<sup>b</sup></sub>) and those with orange fleshed sweet potatoes flour (PPIP<sub>ofsp<sup>r</sup></sub> and PPIP<sub>ofsp<sup>b</sup></sub>) at  $p < 0.05$ . All samples were similar in terms of sweetness. The average overall liking of PPIP was  $4.9 \pm 0.29$  (SD) for sample PPIP<sub>ofsp<sup>r</sup></sub> and  $4.9 \pm 0.25$  (SD) for sample PPIP<sub>pr<sup>r</sup></sub> (Table 5). Overall liking was significant difference between samples with blanched pigeon peas (PPIP<sub>pr<sup>b</sup></sub> and PPIP<sub>ofsp<sup>b</sup></sub>) and roasted pigeon peas (PPIP<sub>pr<sup>r</sup></sub> and PPIP<sub>ofsp<sup>r</sup></sub>) at  $p < 0.05$ .

**Table 5: Mean preference scores for PPIP**

| <b>SAMPLE</b>                     | <b>Colour<br/><math>\bar{x} \pm SD</math></b> | <b>Aroma<br/><math>\bar{x} \pm SD</math></b> | <b>Mouth feel<br/><math>\bar{x} \pm SD</math></b> | <b>Sweetness<br/><math>\bar{x} \pm SD</math></b> | <b>Overall Liking<br/><math>\bar{x} \pm SD</math></b> |
|-----------------------------------|---|--|---|--|---|
| PPIP <sub>pf</sub> <sup>b</sup>   | 4.7±0.91 <sup>ab</sup>                        | 4.5±0.98 <sup>ab</sup>                       | 4.5±0.95 <sup>ab</sup>                            | 4.7±0.70 <sup>a</sup>                            | 3.7±0.94 <sup>C</sup>                                 |
| PPIP <sub>pf</sub> <sup>r</sup>   | 4.7±0.82 <sup>b</sup>                         | 4.2±1.22 <sup>b</sup>                        | 4.1±1.30 <sup>b</sup>                             | 3.9±1.56 <sup>a</sup>                            | 3.7±0.94 <sup>C</sup>                                 |
| PPIP <sub>ofsp</sub> <sup>b</sup> | 4.8±0.69 <sup>ab</sup>                        | 4.8±0.41 <sup>a</sup>                        | 4.9±0.35 <sup>c</sup>                             | 4.8±0.48 <sup>a</sup>                            | 4.8±0.85 <sup>b</sup>                                 |
| PPIP <sub>ofsp</sub> <sup>r</sup> | 4.9±0.29 <sup>a</sup>                         | 4.8±0.42 <sup>a</sup>                        | 4.8±0.49 <sup>c</sup>                             | 4.9±0.35 <sup>a</sup>                            | 4.9±0.29 <sup>a</sup>                                 |

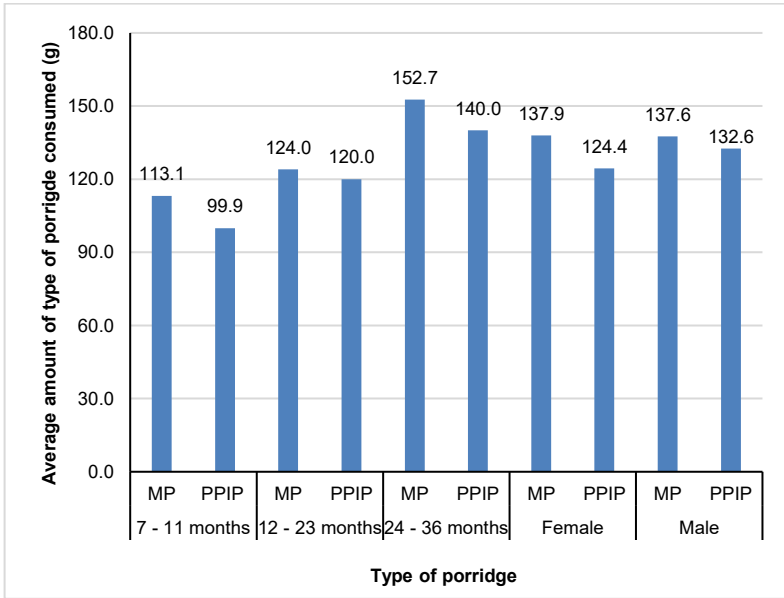
The means values with different superscript letters within a column are significantly different at (p<0.05).

The correlation loadings for PPIP samples indicate that component 1 was explained by 83% and 71% of variations of the X and Y axis (Fig. 3). The overall liking of the sample on Y-axis was related to colour, aroma, mouthfeel, and sweetness, which were closer to sample PPIP<sub>ofsp</sub><sup>r</sup> and PPIP<sub>ofsp</sub><sup>b</sup>. however, in the X-axis the overall liking was related to sweetness and mouthfeel for sample PPIP<sub>ofsp</sub><sup>r</sup> in the upper right hand; as well as colour and aroma for sample PPIP<sub>ofsp</sub><sup>b</sup> in the lower right hand. The variations in component 2 were explained by 10% and 19% of X and Y loadings, respectively that were related to samples PPIP<sub>pr</sub><sup>b</sup> and PPIP<sub>pr</sub><sup>r</sup> indicating little association between consumer liking and product attributes.



#### **4.5 Acceptance of PPIP among Children Aged 7- 36 Months**

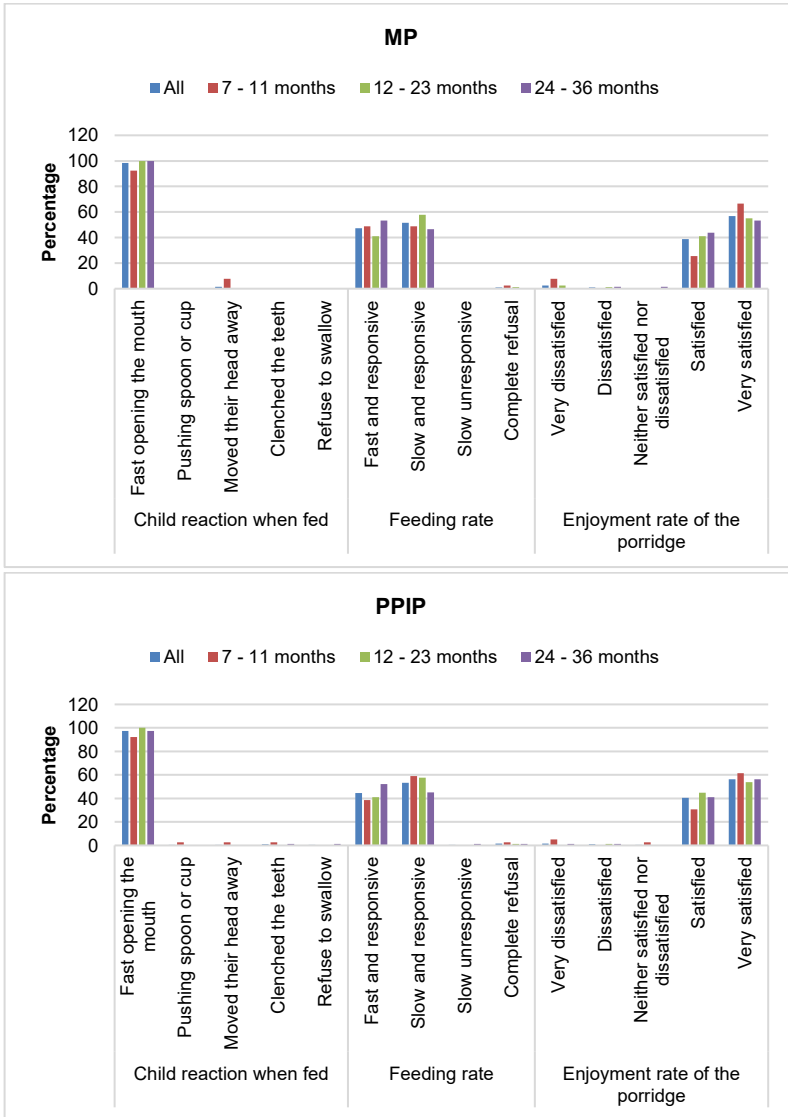
An average amount (g) of maize porridge (MP) consumed was  $137.7 \pm 48.4$  (SD), whereas that of pigeon peas-based porridge (PPIP) was  $128.3 \pm 47.1$  (SD). A Wilcoxon signed-rank test showed that the mean amount of maize porridge and PPIP consumed was not statistically significant difference. The average amount of maize porridge and PPIP consumed by children was significantly different between age groups (Fig. 4) at a p value  $< 0.05$ . The multiple comparison test indicated that the amount of maize porridge and PPIP consumed by children aged 7 - 11 months was significant difference from that consumed by children aged 12 - 23 months ( $P = 0.005$  (MP),  $p = 0.001$  (PPIP)) and those aged 24 - 36 months ( $P = 0.000$ ). Also, a significant difference was observed in amount of maize porridge consumed between children aged 12 - 23 months and 24 - 36 months. Children aged 24-36 months consume more porridge than the other age groups. There was no significant difference in amount of porridge consumed between children's gender for both maize porridge and PPIP.



**Figure 4: Average amount of porridge consumed by children among sex and age groups**

Majority of the children (88%) consumed amount of PPIP more than 50% of the amount of maize porridge consumed. Among them 75 (45%) of children were aged 12 - 23 months, 61(36%) were aged 24 - 36 months and 32 (19%) were aged 7 -11 months. In terms of those who consumed amount of PPIP less than 50% of the amount of maize porridge, eleven (50%) children were aged 24 - 36 months followed by 8 (36%) (7 -11 months) and 3 (13%) (12 - 23 months). Consumption by gender showed that child 83 (43%) and 85 (45%) were female and male children respectively, consumed amount of PPIP more than 50% of the amount of maize porridge consumed. About 15 (8%) of female children and 7 (4%) of male children consumed amount of PPIP less than 50% of the amount of maize porridge consumed.

In terms of child response to porridge, there was no significant difference in consuming the maize and pigeon peas-based porridge as well as feeding and enjoyment rate among children of all age groups at  $p < 0.05$ . More than 90% of children were quick in opening their mouth during feeding, responsive and satisfied with both kinds of porridge (Fig. 5).



**Figure 5: Observed child feeding responses to maize porridge (MP) and pigeon peas-based porridge (PPIP)**

## **5.0 Discussion**

### **5.1 Consumer Preferences for Noodles (PPBN) and Instant Porridge (PPIP)**

There was no statistical significance in ranking the PPBN samples in terms of colour, aroma, and mouthfeel in relation to consumers' education, marital status, and occupation. However, a significant difference was observed in ratings for aroma, mouthfeel, and softness of PPBN136 among female and male consumers. Female consumers had higher mean rating scores than their male counterpart. This could be due to the high sensitivity of females in rating food products compared to males which was attributed to gustatory function as reported earlier (Miyagi, 2017).

The differences were also observed in ratings for mouthfeel among different consumer age groups. The higher mean rating scores were observed among consumers aged above 49 years and those who were less than 15 years old. This could be due to differences in consumption behaviour between consumer groups, influenced by neuro-muscular activities that contribute to chewing behaviour. A mouthfeel was associated with the slippery of food in the mouth; hence chewing for a long time makes the taste and texture well perceived. Prolong chewing also makes the food softer and slippery. As age of the person advances the chewing ability decreases hence lengthening the process and consequently enhance the slippery feel for the food (Locker, 2002).

Despite gender and age differences, samples PPBN718, PPBN193 and PPBN136 were the most preferred in terms of colour aroma and mouthfeel. This was attributed to the type of ingredients used; samples PPBN718 and PPBN193 were composed of higher proportion of wheat flour (60%) compared to the other samples. Wheat flour dilutes the deep colour of pigeon flour and making the product resemble the colour of most the wheat-based noodles. Despite sample

PPBN136 having 64% of PP addition of OFSP flour makes its colour look similar with sample PPBN193 which has also composed of OFSP flour.

For pigeon peas-based instant porridge, the samples composed of orange fleshed sweet potato flour had higher mean intensity scores indicating that it is the most preferred one. Preference for the two samples (PPIP<sub>ofsp</sub><sup>r</sup> and PPIP<sub>ofsp</sub><sup>b</sup>) were also associated with colour, aroma, mouthfeel, and sweetness. This was due to the colour and aroma of OFSP which was light yellow compared to the samples composed of pumpkin flour (PPIP<sub>pr</sub><sup>b</sup> and PPIP<sub>pr</sub><sup>r</sup>). Pumpkin flour had a strong aroma that changed the grain taste for the blended flour. The developed porridge flour (PPIP<sub>pr</sub><sup>b</sup> and PPIP<sub>pr</sub><sup>r</sup>) blend had 26% of pumpkin flour compared to 15% of OFSP contained in samples PPIP<sub>ofsp</sub><sup>r</sup> and PPIP<sub>ofsp</sub><sup>b</sup>. This amount could be high enough to alter the taste of the instant porridge (PPIP) from the flour blend; consequently, samples PPIP<sub>pr</sub><sup>b</sup> and PPIP<sub>pr</sub><sup>r</sup> scored less in sensory attributes compared to samples PPIP<sub>ofsp</sub><sup>r</sup> and PPIP<sub>ofsp</sub><sup>b</sup>. It has been reported that food products blended with pumpkin had less preferred colour, reduced taste preference and low level of acceptability (Yuliantini *et al.*, 2020; Minarovičová *et al.*, 2017).

Regarding correlation loadings for sample PPIP<sub>ofsp</sub><sup>r</sup> was related to sweetness and mouthfeel whereas sample PPIP<sub>ofsp</sub><sup>b</sup> was associated with colour and aroma. Sample PPIP<sub>ofsp</sub><sup>r</sup> was composed of maize flour, roasted pigeon peas and OFSP flour. It was likely that the sweetness observed was associated with natural sugar available in OFSP. Similar findings were reported earlier (Ukom *et al.*, 2019) that sugar available in OFSP flour has great influence on acceptability of taste and flavour. The mouthfeel experienced by consumers was due to the coffee or chocolate taste feel available in the roasted pigeon peas. The roasted pigeon peas made the flour blend looks a little bit dull in colour

compared to the sample of PPIP<sub>ofsp</sub><sup>b</sup> which was composed of blanched pigeon peas. This made sample PPIP<sub>ofsp</sub><sup>r</sup>, to be highly associated with the preferred colour of the porridge. Sample PPIP<sub>ofsp</sub><sup>r</sup> was also highly associated with good aroma compared to sample PPIP<sub>ofsp</sub><sup>b</sup>. This could be due to the Maillard reaction that occurs during the roasting of PP. It has been reported that Maillard reaction influences the colour, texture and aroma of different foods products (Starowicz & Zieliński, 2019).

## **5.2 Children's Acceptability of Instant Porridge (PIIP) Sample**

The mean amount of instant porridge (PIIP) consumed by children was not significant different from the amount of maize porridge (MP) consumed. The average amount of porridge consumed by the children aged 7 - 24 months was higher than the recommended amount of 50 grams per serving for child aged 6 to 24 months (Buzigi *et al.*, 2020). The average amount of consumed porridge increased as age increased and significant differences were observed between children aged 7 - 11 months and the older ones.

This was due to an increase in body requirements associated with rapid growth. Children aged more than 12 months were the ones who consumed more amount of instant porridge (PIIP) than 50% of the amount of maize porridge. This may be attributed to child experience in porridge consumption, as children aged 7 to 11 months were still in the stage of adapting to new foods hence consumed less amount. There were no significant differences in the amount of maize porridge and PIIP consumed between children's gender. This was because being a male or female child does not influence the amount of food consumed in early childhood but as age increases the variation among them was notably (Ambikapathi *et al.*, 2022). According to a study conducted

to assess meal structure and food consumption away from home, the diet of children varies as age increases (Ambikapathi *et al.*, 2022). Feeding responses were not significantly different among children when fed maize porridge and PPIP. Most children were quick and responsive to the porridge given and were also satisfied. This was so evident since the mean amount of porridge consumed for both types did not differ significantly.

### **5.3 Conclusions and Recommendation**

The developed noodles (PPBN) and instant porridge (PPIP) are acceptable by all groups of consumers. Samples PPBN718 and PPIP<sub>ofsp</sub><sup>r</sup> are mostly preferred due to their colour, aroma and mouthfeel. The developed pigeon peas-based instant porridge was acceptable for consumption among children aged 7 - 36 months, as the majority of them consume more than 50% of the served amount of maize porridge. The developed noodles (PPBN718) and instant porridge (PPIP<sub>ofsp</sub><sup>r</sup>) if consumed frequently at the required amount, will help to improve iron, zinc and vitamin A status among children. It is recommended that consumers' preferences and acceptability tests should be considered during product development in order to come up with the best choice of product that will be acceptable among the intended consumers.

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## **Declaration of conflicting interests**

The authors declare that there is no conflict of interest.

**Author Contributions:** Z.S.M. countersigned on the design of the study, data collection, and performed the statistical analysis; as well as writing the first draft of the manuscript. Other author (C.N., K.K., K.M., C.R. and S.S.) critically reviewed and refined the manuscript and provided close supervision. All authors have read and agreed to the published version of the manuscript.

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**CHAPTER SIX****Consumer Willingness to Pay, Perceived Value and Drivers of Choice for Value-added Pigeon peas-based Noodles and Instant Porridge**

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**Abstract**

Willingness of consumer to purchase a food product depends on several factors that are related to food attributes, financial capabilities and cultural environment. Therefore, understanding consumers' perceived values and drivers for their willingness to pay is imperative for sustainability of the food industry. This study aimed to determine consumers' willingness to pay, perceived value and drivers of choice for value-added pigeon peas-based noodles (PPBN) and instant porridge (PIIP). A total of 107 consumers residing in Ruangwa and Nachingwea districts in Lindi region were involved. Stated Preference Method was used to collect the required information. The attribute for PPBN and PIIP were explained to consumers. The consumers in turn evaluated products' attributes by rating on a 5-point scale and proposed the price which they will pay for a product. SPSS software was used to analyse data. Mean, standard deviations, frequencies, Chi-square and Logit regression analysis were computed. The consumers' mean age was  $38.79 \pm 11.9$ (SD) years. Mean household food expenditure was  $13\ 625 \pm 1653.8$  (SD) Tanzanian Shillings (TZS)/week and  $25\ 176 \pm 5485.8$  (SD) TZS/week during harvesting and lean season, respectively. Consumers (52%) spent 2500 - 10 000 TZS/day on household foods. There was no significant difference in choosing sample PPBN718 and PPBN193 among the age group, sex, marital status, education, source of income, and amount of money spent per week. The colour, taste, and aroma of PPBN were perceived to be good with differences in mouthfeel scores among samples. Majority of consumers were willing to buy developed PPBN (86%) and PIIP (79%) at the median price of 2000 (IQR=1500, 2200) TZS and an average price of  $1610 \pm 546.44$  for 1000g of PPBN and PIIP respectively. The logit model was statistically significant ( $\chi^2$  27.402,  $p < 0.005$ ) whereas expenditure per day, package size, and price significantly contributed to the model as

drivers for the willingness to pay for developed noodles and instant porridge. Availability of preferred and acceptable value-added PPBN and PPIP, at an affordable price, will increase consumers' willingness to pay thus increase consumption of PPBN and PPIP.

**Keywords:** Consumer preference, perceived values, willingness to pay, pigeon peas-based noodles and instant porridge

## 1.0 Introduction

Willingness to pay is a behavioural intuition that has been decided after several augments about the valuation of the products (Tully & Winer, 2014). It provides information on price preferences that potential consumers will pay for the product of interest (Tully & Winer, 2014). It also depends on food choice motives that are influenced by socio-economic status as a drive for the purchasing decisions (Ali *et al.*, 2021; Alemu & Olsen, 2019). In the food industry, consumers will be willing to pay for a certain food product if it meets their desires. The desire for food is influenced by several factors including sensory attributes, occasion, family size, appearance, weight, the nutritional quality, socialization and cultural environment. According to a previous study, socialization and culture influences may lead to a buying decision for a food product (Hanf & Winter, 2017). For example, interaction with people in a certain social event such as a wedding ceremony may influence consumption of food that has never been eaten before. If the food has good taste can influence the consumer to purchase it for consumption. Despite knowing the extent of consumers' willingness to pay based on a set of attributes, desire for food also provides opportunity to understand consumers' attitudes and opinions regarding product attributes. This will act as evidence-based to inform product developers on the

feasibility of developing PPBN and PPIP that will bring radical changes in the business niche. It will also help to inform policy makers and other stakeholders the practicality of the developed product in our daily life, thus be able to take pigeon peas as a priority crop that will contribute on food and nutrition security sustainability.

Perceived value is concerned with consumer feeling and attitudes toward a certain food product based on a set of attributes (Zhang *et al.*, 2021). These are influenced by psychological factors that influence the decision to buy a product. A consumer decides on how much should be spent in purchasing food in order to maximize utility (Levin & Milgrom, 2004). Based on the random utility model (Gorton & Barjolle, 2013), the consumer will maximize utility at a low cost based on a set of attributes from a set of alternatives such as observable (price, income, size) and unobservable preferences (beliefs, behaviour, attitude). A consumer preference model (Weddepohl, 1970) considered four main elements in maximization of the product utility including available income to purchase a particular product, price of the product, taste and preference of consumer as well as a behavioural approximation. The product attribute model considers product attributes and the value of attributes individual consumer has (Gwin & Gwin, 2003). From the above models, consumers will purchase the product to satisfy their needs and wants based on the identified attributes. This can be determined by measuring their intentions to purchase which can be assessed from different perspectives including the value of food (Suzuki *et al.*, 2019), quality of the food (Xiao *et al.*, 2019; Mirabi *et al.*, 2015; Yeow *et al.*, 2013; Sobal *et al.*, 2006), knowledge about the product (Mirabi *et al.*, 2015; Hughner *et al.*, 2007), ability to purchase (Xiao *et al.*, 2019; Mirabi *et al.*, 2015; Yeow *et al.*, 2013), attitude towards the product of interest (Ueasangkomsate & Santiteerakul, 2016; Sethi *et al.*, 2014)

and the physical appearance of the food (Xiao *et al.*, 2019). Therefore, when developing a product, it is important to consider all these factors in order to increase product utility.

This article focuses on two samples of the developed value-added pigeon peas-based noodles (PPBN718 and PPBN193) and one sample of pigeon peas-based instant porridge (PPIP<sub>ofsp<sup>r</sup></sub>) which were the most preferred based on their colour, mouthfeel and aroma. However, valuation of the developed value-added noodles (PPBN) and instant porridge (PPIP) based on the consumer willingness to buy was not established. Hence it is important to establish the willingness to pay for developed products among consumers. Therefore, the study aimed at assessing (i) consumers' willingness to pay (ii) perceived value of PPBN and PPIP towards consumers' decision to buy and (iii) drivers for consumers' decision to buy the food product.

## **2.0 Methods and Study Approach**

### **2.1 Study Design, Location and Participants**

A cross-sectional consumer survey was conducted to assess the likelihood to buy the developed value-added pigeon peas-based noodles (PPBN) and instant porridge (PPIP). The study involved different consumers in Nachingwea and Ruangwa districts in Lindi region to determine the market potentials across different consumer categories. The study involved consumers who residing in hamlets of remote areas and those at the centre of the Mitumbati and Mibure villages as well as those residing at the centres of Nachingwea and Ruangwa districts. A total of 107 consumers aged above 20 years were involved.

## 2.2 Data Collection

Stated Preference Method was used to assess consumers' willingness to pay for the developed products whereas two samples of noodles (PPBN193, PPBN718) and one sample of porridge (PPIP<sub>ofsp</sub><sup>r</sup>) were subjected to the consumer for valuation. These samples were the most preferred by consumers as described in the previous chapter. The samples were presented to consumers and were asked to answer the questions on socio-demographic characteristics, willingness to buy, and price preference for the developed noodles (PPBN) and instant porridge (PPIP). In addition, information on preferred sample's (PPBN) attributes of interest, factors to consider in buying and price preference was collected.

The most preferred samples PPBN193, PPBN718 and PPIP<sub>ofsp</sub><sup>r</sup> were cooked and packed into containers and labelled with unique numbers. Sample PPBN193 and PPBN718 were cooked by boiling in water until well cooked, salt and sugar were added to the boiled noodles, mixed well and partially fried in cooking oil. Two samples of noodles (PPBN193, PPBN718) were displayed, and the specification of each attribute was described to the consumers before the actual evaluation of the product. Consumers were asked to evaluate the attributes by rating the choice of their preference and willingness to buy on a 5-point scale (1= definitely will not buy, 2 = will not buy, 3 = neither nor will buy, 4 = will buy and 5 = definitely will buy). Consumers were also requested to propose the price that they will be willing and not willing to buy the developed noodles. Food product utilities (price, weight, colour, aroma and mouthfeel) were used to create a market model that was used to determine factors that drive consumers towards purchase of the developed noodles. Similarly, a description of the instant porridge (PPIP<sub>ofsp</sub><sup>r</sup>) sample was provided to consumers. The porridge was prepared by mixing PPIP<sub>ofsp</sub><sup>r</sup> flour in hot water, and sugar and

milk were added. Thereafter, the porridge was boiled for five minutes and stored in the hot flask. The porridge was served in a disposable cup for testing and consumer were asked to rate their willingness to pay and suggest the price that they will be willing to pay for the product.

### **2.3 Estimation of the Production Cost of the Developed PPBN**

The cost of noodles was estimated by summing up the cost of ingredients used, manufacturing, packaging, labelling, marketing, and estimated profit. Since the actual manufacturing cost, packaging, labelling, marketing and estimated profit were not established during production, the computation was based on the assumption used earlier (Gilbert & Prusa, 2021) that manufacturing, profit, marketing and advertisement, packaging and labelling, will cost 55%, 20%, 4% and 15% of the cost of the ingredients respectively.

### **3.0 Data Analysis**

Data were analysed using SPSS version 25. Descriptive statistics (mean and standard deviation) were used to summarize continuous variables such as age, income expenditure and price preferences. Frequencies were used to summarize preference ratings of the samples, buying interest and factors to consider when buying developed noodles. A Chi-square test was computed to determine whether there was a relationship between two categorical variables (i.e., consumer characteristics, and noodles samples or instant porridge samples). A logit regression model was used to determine predictors that drive consumer willingness to pay for developed noodles and instant porridge. The dependent variable was consumer willingness to pay for the noodles (1=Yes, 0=No). Independent categorical data were converted to dummy variables before analysis (Table 1). Also, continuous variables such as age, price and expenditure per day were transformed into natural

logs to make them comparable. Logit regression was conducted to check whether the model fits well. The logit model was as follows:

$$WTP (P_i/1 - P_i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 \dots \beta_n X_n$$

Where  $P_i = 1$  if individual is willing to pay for a developed product and  $P_i = 0$  if individual is not willing to pay for a developed product,  $\beta$  = Parameter estimates,  $X_1$  = Age in years,  $X_2$  = Gender of the consumer,  $X_3$  = Education level,  $X_4$  = Marital status,  $X_5$  = Expenditure per day,  $X_6$  = Package size,  $X_7$  = Price of the product,  $X_8$  = Taste,  $X_9$  = Colour,  $X_{10}$  = mouthfeel and  $X_{11}$  = Aroma

**Table 1: Dummy variables used in the logit model  
(independent categorical data)**

| Variables      | Response choices   | Dummy variables   |
|----------------|--|---|
| Sex            | 1= Female, 2= Male   | 0=Female 1= Male  |
| Marital status | 1=Married, 2=Single/widowed/divorced   | 0=Married 1= Single                                       |
| Residence      | 1= Far from village centre<br>2= Village centre<br>3= District centre  | 0 =Village<br>1= Other residential area                   |
| Education      | no formal education<br>Primary school education<br>Secondary school education<br>College/ University education | 0 = Primary school education<br>1= Other education levels |
| Occupation     | 1=Farmer<br>2=Public servant<br>3=Self employed  | 0= Farmer<br>1= Other occupation                          |
| Package size   | 250g<br>500g<br>1000g  | 0= 500g package size<br>1= Other package size             |

|           |               |               |
|-----------|---------------|---------------|
| Colour    | 1=Yes<br>2=No | 1=Yes<br>0=No |
| Taste     | 1=Yes<br>2=No | 1=Yes<br>0=No |
| Aroma     | 1=Yes<br>2=No | 1=Yes<br>0=No |
| Mouthfeel | 1=Yes<br>2=No | 1=Yes<br>0=No |

## 4.0 Results

### 4.1 Consumer Characteristics

The mean age of consumers was  $38.79 \pm 11.9$  (SD) years. About 61% of the consumers were aged between 20 to 40 years, 78% were married, 64% had school primary education, and 69% were farmers (Table 2). The average household size was  $3.52 \pm 1.46$  (SD) people and 70% of households had 3 - 5 people. Average household expenditure for food was  $13\,625 \pm 1653.8$  (SD) TZS/week during harvesting season and  $25\,176 \pm 5485.8$  (SD) TZS/week during lean season. A day before the interview 52% of the consumers reported to have spent between 2500 and 10 000 TZS on household food while 31% of them reported to have spent amount less than 2500TZS (Table 2).

**Table 2: Characteristics of consumers who participated in the consumer survey.**

|   | <b>n = 107</b> | <b>%</b> |
|---|----------------|----------|
| <b>Area of residence</b>  |                |          |
| Far from the village  | 17             | 15.9     |
| Village centre  | 50             | 46.7     |
| District centre   | 40             | 37.4     |
| <b>Sex</b>  |                |          |
| Female  | 53             | 49.5     |
| Male  | 54             | 50.5     |
| <b>Age groups</b>   |                |          |
| 20 - 40 years   | 65             | 60.7     |
| 41 - 50 years   | 37             | 34.6     |
| More than 50 years  | 5              | 4.7      |
| <b>Marital status</b>   |                |          |
| Married   | 83             | 77.5     |
| Single/widowed/divorced   | 24             | 22.4     |
| <b>Education</b>  |                |          |
| No formal education   | 7              | 6.5      |
| Primary school  | 68             | 63.5     |
| Secondary school  | 12             | 11.2     |
| College/ University   | 20             | 18.7     |
| <b>Source of livelihood</b>   |                |          |
| Farming   | 74             | 69.2     |
| Public service  | 24             | 22.4     |
| Self-employment   | 9              | 8.4      |
| <b>Average amount of money spent a day before survey</b>            |                |          |
| Less than 2500/=  | 34             | 31.8     |
| 2500 – 10 000/=   | 56             | 52.3     |
| More than 10 000/=  | 17             | 15.9     |
| <b>Amount of money used a day before survey, compared to normal</b> |                |          |
| Very low  | 42             | 39.3     |
| Rather low  | 16             | 15.0     |
| Sufficient  | 26             | 24.3     |
| Rather high   | 12             | 11.2     |
| High  | 11             | 10.3     |

## 4.2 Preferences for the products

About 53% and 47% of consumers preferred samples PPBN193 and PPBN718 respectively. There was no significant difference in preference for the products between age groups ( $\chi^2 = 1.086$ ,  $p = 0.581$ ), sex ( $\chi^2 = 2.692$ ,  $p = 0.101$ ), marital status ( $\chi^2 = 0.010$ ,  $p = 0.920$ ), education ( $\chi^2 = 5.572$ ,  $p = 0.134$ ), source of income ( $\chi^2 = 5.895$ ,  $p = 0.052$ ) and amount of money spent per week ( $\chi^2 = 2.772$ ,  $p = 0.250$ ). About 92% and 94% of consumers choose samples PPBN718 and PPBN193 respectively, because the taste for the products was the most preferred (Fig. 1). There was a significant difference in the reason for their choices in terms of age, however, there was no significant difference in preference that was observed between sex, education level and marital status. More than 50% of consumers aged 20 - 40 years selected taste as a reason for their choice.

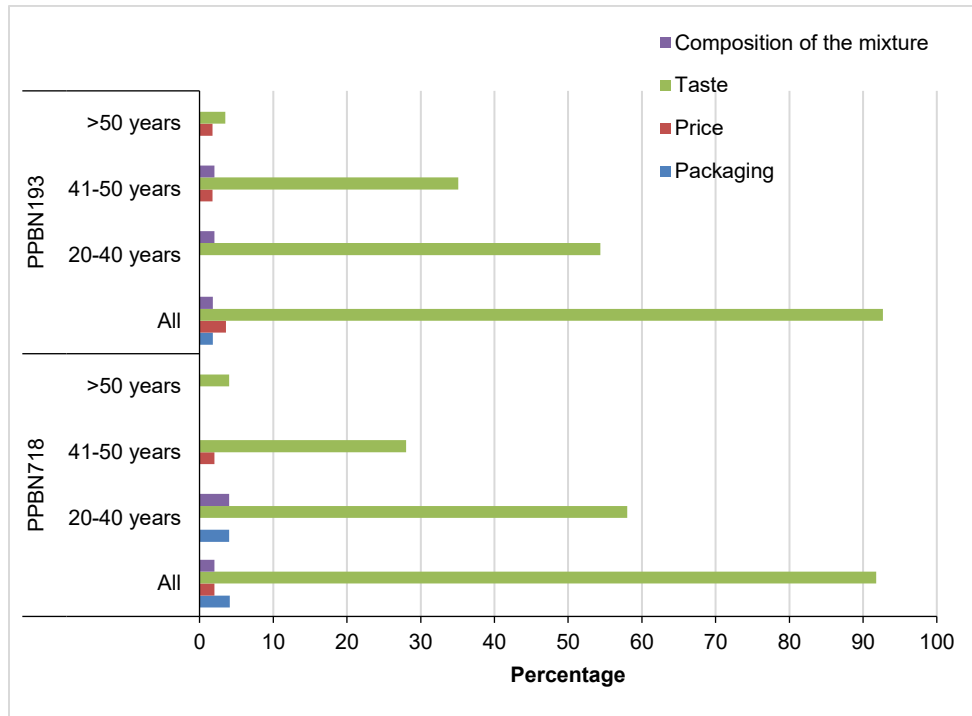


Figure 1: Reasons for choosing the noodles samples

### 4.3 Perceived Value

Table 3 indicates the perceived value of noodles. About 58% and 60% of the consumers' perceived that colour of noodles was good for samples PPBN718 and PPBN193 respectively. More than 70% of consumers also agreed that the taste and aroma of noodles were good for both samples. However, a significant difference was observed in mouthfeel between samples at  $p < 0.05$ . About 40% of consumers perceived that the mouthfeel of sample PPBN718 was not appealing while 48% of consumers perceived that the mouthfeel of sample PPBN193 was appealing. About 62% of consumers, who selected sample PPBN718, agreed that the existing price of noodles in the market was within their purchasing capacity and more than 50% of consumers reported that cooking noodles was simple and takes short time to prepare.

**Table 3: Perceived value of noodles samples**

| Perceived values   | Sample PPBN718    |                       |                | Sample PPBN193    |                          |                |
|--|-------------------|-----------------------|----------------|-------------------|--------------------------|----------------|
|  | Disagree<br>n (%) | I don't know<br>n (%) | Agree<br>n (%) | Disagree<br>n (%) | I don't<br>know<br>n (%) | Agree<br>n (%) |
| The colour of the noodles is not good                                | 29(58)            | 4(8)                  | 17(34)         | 34(59.6)          | 2(3.6)                   | 21(36.9)       |
| The taste of the noodles is good                                     | 3(6.0)            | 6(12.0)               | 41(82.0)       | 3(5.3)            | 5(8.8)                   | 49(86)         |
| The aroma of noodles is good   | 6(12.0)           | 7(14.0)               | 32(74.0)       | 3(5.3)            | 4(7.0)                   | 49(86)         |
| The mouthfeel of noodles is not appealing                            | 19(38.0)          | 11(22)                | 20(40.0)       | 28(49.1)          | 11(19)                   | 18(31.6)       |
| The price of noodles in the market is within the purchasing capacity | 9(18.0)           | 10(20.0)              | 31(62.0)       | 19(33.3)          | 7(12.3)                  | 28(51)         |
| Preparation of noodles before cooking is hard                        | 28(56.0)          | 13(26)                | 9(18)          | 34(59.6)          | 11(19.3)                 | 12(21.1)       |
| Cooking noodles takes too long time before is ready for consumption  | 28(56)            | 12(24)                | 10(20)         | 36(63.2)          | 10(17.6)                 | 11(19.3)       |

#### **4.4 Consumer Willingness to Pay for Developed Pigeon peas-based Noodles and Instant Porridge**

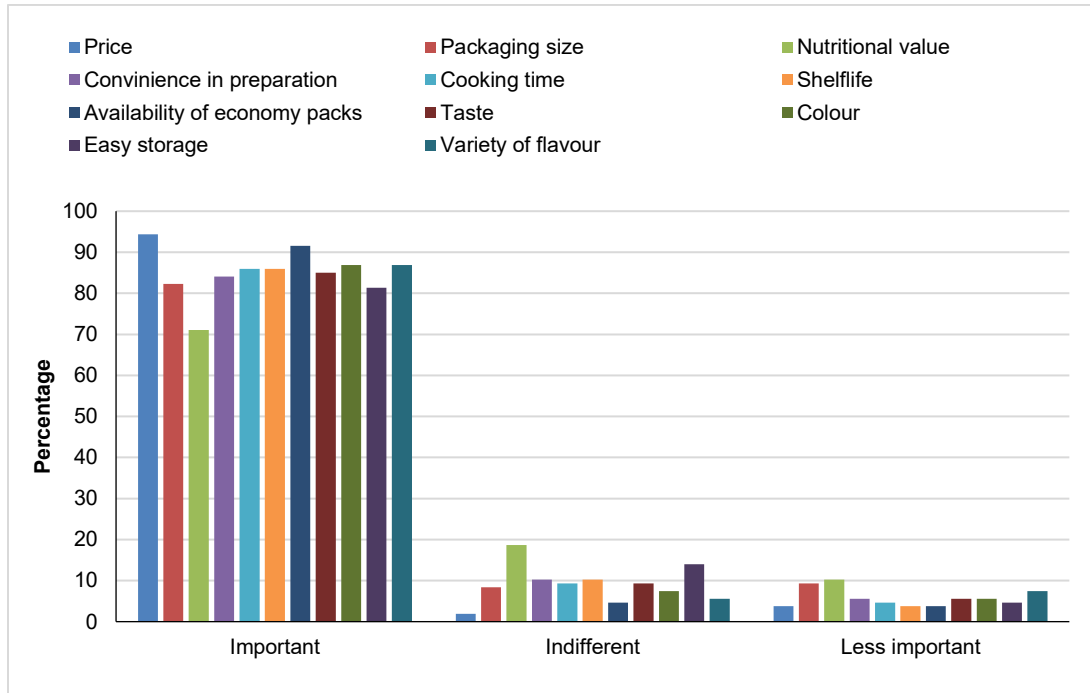
The majority of consumers reported that they are willing to buy the developed PPBN (86%) and PPIP (85%) (Table 4). Among them, 39% were from the village centres, 40% were female, 41% were aged 20 - 40 years, 67% were married, 62% had attained primary education, 60% were farmers and 47% were among those who have reported to spent 2500 – 10 000 TZS per day in household food.

It was noted from about 94% and 92% of consumers reported that price and availability of the small package size, respectively were among the key drivers that influence their buying decision (Fig. 2). Other key drivers were colour, availability of different varieties of flavour, cooking time, ability to stay longer without deterioration, convenience in preparation, taste and nutritional value.

**Table 4: Willingness to pay for developed noodles**

| Consumer characteristics | Definitely will not buy |    | Will not buy |    | Will buy |    | Definitely will buy |    |
|--------------------------|-------------------------|----|--------------|----|----------|----|---------------------|----|
|                          | n                       | %  | n            | %  | n        | %  | n                   | %  |
| PPBN                     | 14                      | 13 | 1            | 1  | 57       | 54 | 34                  | 32 |
| PPIP                     | 3                       | 3  | 13           | 12 | 27       | 25 | 64                  | 60 |
| <b>Area of residence</b> |                         |    |              |    |          |    |                     |    |
| Remote area              | 1                       | 1  | 0            | 0  | 12       | 11 | 4                   | 4  |
| Village centre           | 7                       | 7  | 1            | 1  | 31       | 29 | 11                  | 10 |
| District centre          | 6                       | 6  | 0            | 0  | 14       | 13 | 19                  | 18 |
| <b>Sex</b>               |                         |    |              |    |          |    |                     |    |
| Female                   | 8                       | 8  | 1            | 1  | 29       | 27 | 14                  | 13 |
| Male                     | 6                       | 6  | 0            | 0  | 28       | 26 | 20                  | 19 |
| <b>Age groups</b>        |                         |    |              |    |          |    |                     |    |
| 20 - 40 years            | 8                       | 8  | 0            | 0  | 35       | 33 | 21                  | 20 |
| 41 - 50 years            | 5                       | 5  | 1            | 1  | 19       | 18 | 12                  | 11 |
| More than 50 years       | 1                       | 1  | 0            | 0  | 3        | 3  | 1                   | 1  |
| <b>Marital status</b>    |                         |    |              |    |          |    |                     |    |
| Married                  | 11                      | 10 | 0            | 0  | 46       | 43 | 25                  | 24 |

| Consumer characteristics    | Definitely will not buy |   | Will not buy |   | Will buy |    | Definitely will buy |    |
|-----------------------------|-------------------------|---|--------------|---|----------|----|---------------------|----|
|                             | n                       | % | n            | % | n        | %  | n                   | %  |
| Single/widowed/divorced     | 3                       | 3 | 1            | 1 | 11       | 10 | 9                   | 8  |
| <b>Education</b>            |                         |   |              |   |          |    |                     |    |
| no formal education         | 0                       | 0 | 0            | 0 | 6        | 6  | 1                   | 1  |
| Primary school education    | 9                       | 8 | 1            | 1 | 46       | 44 | 19                  | 18 |
| Secondary school            | 2                       | 2 | 0            | 0 | 3        | 3  | 6                   | 6  |
| College/ University         | 3                       | 3 | 0            | 0 | 8        | 8  | 9                   | 8  |
| <b>Source of livelihood</b> |                         |   |              |   |          |    |                     |    |
| Farmer                      | 9                       | 8 | 1            | 1 | 45       | 42 | 19                  | 18 |
| Public servant              | 3                       | 3 | 0            | 0 | 10       | 9  | 11                  | 10 |
| Self-employed               | 2                       | 2 | 0            | 0 | 2        | 2  | 4                   | 4  |
| <b>Expenditure per day</b>  |                         |   |              |   |          |    |                     |    |
| less than 2500/=            | 2                       | 2 | 1            | 1 | 20       | 19 | 11                  | 10 |
| 2500 - 10000/=              | 5                       | 5 | 0            | 0 | 30       | 28 | 20                  | 19 |
| More than 10,000/=          | 7                       | 7 | 0            | 0 | 7        | 7  | 3                   | 3  |



**Figure 2: Drivers for buying decision**

Table 5 shows the lowest and highest price consumers will be willing or not willing to pay based on different package sizes for the products. For a package size of 1000 g, the median price consumers were willing to pay was Tanzanian shillings 2000 (IQR = 1500, 2200) TZS. On other hand, it was noted that the consumers will not buy PPBN if the median price will exceed 1500 (IQR = 800, 3000) TZS for 1000 g of noodles. Consumers were also being willing to pay for 1000g of the developed instant porridge (PPIP) at an average price of  $1610.28 \pm 546.84$  (SD) TZS.

**Table 5: Price preference for noodles**

| Package size (g) | Price will buy (TZS)  |                        |                     | Price will not buy (TZS) |                        |                    |
|------------------|-----------------------|------------------------|---------------------|--------------------------|------------------------|--------------------|
|                  | Lowest $\bar{x}$ (SD) | Highest $\bar{x}$ (SD) | Median (IQR*)       | Lowest $\bar{x}$ (SD)    | Highest $\bar{x}$ (SD) | Median (IQR)       |
| 250              | 554.21<br>(295.57)    | 842.52<br>(355.20)     | 600<br>(500,887.5)  | 274.02<br>(167.82)       | 1448.60<br>(767.85)    | 500<br>(250,1200)  |
| 500              | 1170.56<br>(397.45)   | 1633.64<br>(593.32)    | 1300<br>(1000,1600) | 568.22<br>(382.17)       | 2442.99<br>(748.75)    | 1450<br>(500,2500) |
| 1000             | 1623.36<br>(480.93)   | 2300.93<br>(1032.24)   | 2000<br>(1500,2200) | 762.15<br>(288.69)       | 3307.48<br>(1104.68)   | 1500<br>(800,3000) |

IQR\* = Interquartile range (25%,75%)

Results also indicated that the estimated price for samples PPBN718 and PPBN193 was 2071.92 TZS/kg and 3608.40 TZS/kg, respectively when the manufacturing cost was set at 55%, with addition of 20% profit, 15% packaging and 4% marketing (Table 6). The estimated cost of production of the developed instant porridge (PPIP) was 3317.00 TZS.

**Table 6: The estimated cost for production of developed noodles (PPBN) and instant porridge (PPIP)**

| <b>Cost items</b>                      | <b>PPBN718</b> | <b>PPBN193</b> | <b>PPIP</b>    |
|--|----------------|----------------|----------------|
| Ingredients                            | 1068.00        | 1860.00        | 1550.00        |
| Manufacturing (55%)                    | 587.40         | 1023.00        | 852.50         |
| Profit (40%)                           | 213.60         | 372            | 620.00         |
| Packaging and labelling (15%)          | 160.20         | 279            | 232.50         |
| Marketing (4%)                         | 42.72          | 74.4           | 62.00          |
| <b>Total production cost per 1000g</b> | <b>2071.92</b> | <b>3608.40</b> | <b>3317.00</b> |

The logit model was statistically significant, ( $\chi^2$  27.402,  $p < 0.005$ ). The Nagelkerke  $R^2$  explained 33.2% variability in willingness to pay for the developed products. Table 7 shows the coefficients estimates and the contribution of explanatory variables (e.g., age, sex, marital status, expenditure, education, package size, education) to outcome variable in the model. Expenditure per day, package size and price significantly contributed to the model. The odds ratio indicated that consumers' willingness to pay was less likely to happen for those who spent less than 2500 per day for household foods compared to those who spent more than 2500 TZS per day. The consumers who preferred package size of 500g were more willing to buy the developed PPBN than those who preferred package sizes of 250g and 1000 g. The decrease in the price was associated with increase in the likelihood that consumers will buy the developed noodles.

**Table 7: Contribution of each independent variable to the model**

| Variables         | $\beta$ | S.E.  | Sig.   | Exp( $\beta$ )<br>Odds<br>ratio | 95% C.I. |        |
|-------------------|---------|-------|--------|---------------------------------|----------|--------|
|                   |         |       |        |                                 | Lower    | Upper  |
| Constant          | 1.738   | 0.271 | 0.009  | 5.687                           | -        | -      |
| Age               | -2.595  | 1.406 | 0.065  | 0.075                           | 0.005    | 1.175  |
| Sex               | 0.724   | 0.713 | 0.310  | 2.062                           | 0.510    | 8.333  |
| Marital<br>status | -0.836  | 0.795 | 0.293  | 0.433                           | 0.091    | 2.056  |
| Occupation        | -1.876  | 1.670 | 0.261  | 0.153                           | 0.006    | 4.042  |
| Residence         | 1.531   | 1.010 | 0.129  | 4.624                           | 0.639    | 33.457 |
| Education         | 0.841   | 1.532 | 0.583  | 2.319                           | 0.115    | 46.696 |
| Expenditure       | -0.787  | 0.337 | 0.019* | 0.455                           | 0.235    | 0.881  |
| Package<br>size   | 2.418   | 1.066 | 0.023* | 11.226                          | 1.390    | 90.646 |
| Price             | -0.001  | 0.000 | 0.043* | 1.001                           | 1.000    | 1.002  |
| Colour            | -0.135  | 0.795 | 0.865  | 0.874                           | 0.184    | 4.154  |
| Mouthfeel         | -0.784  | 0.783 | 0.316  | 0.456                           | 0.098    | 2.117  |

## 5.0 Discussion

### 5.1 Preferences and Perceived Value of PPBN

Consumers' preferences for the two samples of noodles (PPBN193 and PPBN718) were not significantly different in terms of choice preferences by consumers. This might be due to a similar amount of pigeon peas used in their production. Also, addition of equal amounts of salt, water, sugar and cooking oil during the cooking of the noodles masked the actual taste of the two samples (PPBN193 and PPBN718). The main reason for consumers' choices was the taste of the noodles. Taste is among the main sensory attributes that influences consumers' liking of the food, hence plays an important role in food choice (Liem & Russell, 2019). Age differences were also observed to influence taste preferences. More than half of consumers aged 20 to 40

years selected taste as the main reason for their choices. Previous studies have indicated that taste sensitivity to sucrose decreases as an individual become older (Fukunaga *et al.*, 2005; Mojet *et al.*, 2001). This could be a reason for the observed difference as the two samples contained added sugar.

Similarly, for both samples the consumers perceived that taste, colour, and aroma of the noodles were good expect for mouthfeel. In this article, the mouthfeel refers to the feeling that remained in the mouth after chewing and swallowing the noodles. The difference observed between the samples was due to the composition of the ingredients used to prepare the noodles. Despite the two samples having pigeon peas and wheat flour, sample PPBN193 which was reported to have more appealing mouthfeel than sample PPBN718, also contained orange fleshed sweet potato flour. The addition of cooking oil in the cooked PPBN193 noodles retained the orange fleshed sweet potato taste, resulting into improved mouthfeel sensation. Similar findings were reported earlier that fat is a good flavour retainer that improves the mouthfeel of the foods (Korese *et al.*, 2021; Soria-Hernández *et al.*, 2015). Consumers perceived that the price of the commercial noodles found in the market is within their purchasing capacity and cooking of noodles is simple and takes short time to prepare.

## **5.2 Willingness to Buy the Developed Noodles (PPBN) and Instant Porridge (PIIP)**

The consumers were willing to pay for the developed products at a range of price preferences depending on the package size. The proposed price for sample PPBN718 was lower compared to the existing price of noodles products in the market which is 2,400 TZS/1000g. Based on the median price, consumers would be able to buy sample PPBN718 which is within their price preference. This was likely to happen when the expenditure per day would be greater than 2500TZS/day. The consumers who spent less money on purchase of food were less likely to purchase the noodles in the bigger pack size but were able to purchase those packed in the smallest size. Therefore, it is important to consider package of noodles in small sizes in order to increase range of choices to align with consumers' purchasing power. The estimated price of developed instant porridge was within the existing selling price of complementary porridge flour in the market which ranges from 2500 to 3500 TZS per 1000 grams of flour. Compared to the suggested price, the estimated price is high; hence the likelihood of refraining from buying is high. However, the nutrient composition of existing complementary porridge in the market may be different from the developed porridge flour. Also, the cooking time for existing complementary porridge in the market is longer than that of the developed instant porridge. The existing complementary porridge in the market needs at least 10 minutes (Marcel *et al.*, 2022; Zebdewos *et al.*, 2015) more than PPIP. The developed PPIP requires only 5 minutes for boiling to reduce microbial contamination that can be introduced during the milling and mixing time of the porridge. This is due to extrusion cooking technology used in production of PPIP flour. The ingredients were cooked before extruded, hence make it ready for consumption.

### **5.3 Drivers for Buying Decision for Developed Noodles (PPBN) and Instant Porridge (PPIP)**

The main key drivers for consumer buying decisions for PPBN were price, pack size, appearance (colour), convenience in preparation, taste, and varieties of flavour. For the instant porridge (PPIP) taste, price and nutritional value were the key drivers for consumers' buying decisions. Price of the existing noodles in the market range between 1000 and 1500 TZS for a package size of 500g. This price was reported to be within consumers purchasing capacities. Despite consumers' willingness to pay for the developed instant porridge, the proposed price is lower than the existing price of TZS 2500 – 3500 per 1000g for complementary porridge flour in the market. Studies have indicated that the higher the price of a product, the fewer the people who will buy it especially when there is an alternative products (Levrini & Dos Santos, 2021; Zhao *et al.*, 2021). On the other hand, sometimes low price has been associated with the quality of the product, that is the higher the price the good the quality of the product and vice versa (Levrini & Dos Santos, 2021). Hence, creating awareness among consumers on the nutrient content of the developed instant porridge is important in order to gain nutritional value for the money spent. Price was also associated with the package size or weight of the product. The smaller the package size, the lower price will be.

The colour of the value-added noodles (PPBN) was reported to be good by more than half of the consumers. This was due to the composition of the ingredients which made the PPBN sample have a colour (Ivory colour) similar to the reference noodles (Santa Lucia pasta). Colour is among the appearance properties of the food that influences buying decisions (Luo *et al.*, 2019). Colour was also associated with the flavour quality of the food product (Garber *et al.*, 2000). Since consumers were familiar with the colour of the noodles

available in the market, change in colour may result in the rejection of the new developed product. The ivory colour of the noodles influences consumers' willingness to buy pigeon peas-based noodles. If the noodles will have a grey colour consumer would associate them with poor quality related to the presence of moulds.

Taste of the value-added noodles (PPBN) and instant porridge (PPIP) samples were among the drivers of consumers towards buying decision. The preferred taste of noodles by the consumer may be associated with sweetness contributed by orange fleshed sweet potatoes. A similar reason was reported earlier (Tumuhimbise *et al.*, 2019). Cooking time and convenience to prepare was also among the drivers of buying decisions reported by more than three-quarters of the consumers. The developed noodles use about 10 minutes to cook and be ready for consumption as similar product in the market. In other hand instant porridge (PPIP) needs less than 7 minutes to have a cup of porridge whereas the complementary porridge flour in the market need more cooking time to be ready for consumption. Short cooking time saves energy, time, and increases labour productivity. Consumers also reported that the nutritional value of PPBN and PPIP was among the important drivers of their buying decision. This was due to awareness created on the importance of feeding children on nutritious food. Due to increase in number of people suffering from diet related disease, nutritional value of food has been reported to be among the factors that influence purchasing decisions (Udomkun *et al.*, 2018).

#### **5.4 Conclusion and Recommendations**

Consumers are willing to pay for the developed pigeon peas-based noodles (PPBN) and instant porridge (PPIP) that meet their preference. Both samples of noodles (PPBN193 and

PPBN718) are suitable for commercial production as there was no significant difference in consumer choices for the products. Colour, taste, aroma, mouthfeel, price, and cooking time are among the perceived value of the developed pigeon peas-based noodles. Price, pack size, appearance (colour), convenience in preparation, taste, and variety of flavour are the key drivers that determine consumers' willingness to purchase the value-added pigeon peas-based noodles. The estimated selling price for sample PPBN718 is lower than sample PPBN193, this increased likelihood of willingness to pay for sample PPBN718 than sample PPBN193. Taste, price and nutritional values of the instant porridge are the main drivers for consumer willingness to pay. Setting high, selling price for the products may affect consumers' willingness to purchase unless awareness of nutritional value of the developed instant porridge is created and well understood.

Several recommendations are made from this study: first, developers of noodles and instant porridge should pack the products in different sizes (such as 100g, 250g, 500g, 1000g) so that various consumers can afford based on their purchasing power. Second, quantification of the manufacturing cost, profit, packaging, labelling, and marketing of the value-added noodles and instant porridge should be done to establish the actual selling cost. Third, the promotion of developed noodles and instant porridge should be done to increase awareness and consumption.

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### **Declaration of conflicting interests**

The Author(s) declare(s) that there is no conflict of interest

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## **7.0 CHAPTER SEVEN**

### **GENERAL DISCUSSION**

#### **7.1 Introduction**

The overall objective of this study was to develop value-added pigeon peas-based products for recipe diversification, based on consumers and market requirements of people in Lindi region. This chapter summarizes the main findings generated from the research, limitation and discusses key methodological issues. Furthermore, the chapter covers discussion on implications of the developed value-added products for public health, policy and practice. The main findings have been presented based on publications (Chapter Two and Three) and manuscripts (Chapter Four to Six) generated from the four specific study objectives.

#### **7.2 Main Findings**

##### **7.2.1 Preferences and consumption of pigeon peas among rural households**

Traditionally, five existing recipes of pigeon peas are consumed in the study area with highest frequency of consumption during harvesting due to high availability. It was also observed that pigeon peas cooked as stew and boiled green pods were the most familiar and preferred. Despite of pigeon peas being among the major legume grown and frequently consumed in the area, the amount consumed especially during the lean season is 18 g/person/day and 20 g/person/day for all legumes. The consumed quantities are less than the recommended amount of 30 g/person per day for legumes (Mfikwa & Kilima, 2014). This could be due to seasonal availability of pigeon peas, inadequate storage and processing techniques to increase product values and inadequate knowledge on recipes that can be made from pigeon peas, which were observed during the study.

### **7.2.2 Identification and prioritization of pigeon peas-based products**

Consumers identified twelve recipes and ranked them in order of their preferences (Chapter Three). Pigeon peas-based noodles, flour, chapati and dhal were the most prioritized food products to be developed due to their perceived value, sensory attributes, and convenience. Noodles and chapati were perceived as convenient for preparation and having good taste. Chapati was also perceived to be reasonable in terms of portion size compared with an African donut of the same price. Furthermore, consumers also perceived pigeon peas flour as a key ingredient for easy production of different food products and diversification of the recipes. Dhal was consumed as a relish to diversify recipes because the product is readily available, familiar and has acceptable sensory attributes.

### **7.2.3 Development and profiling of affordable and nutritionally optimal pigeon peas-based products**

Eight and four samples of pigeon peas-based noodles and instant porridge respectively, were developed and evaluated for their sensory attributes by trained panellists. Orange fleshed sweet potato flour or pumpkin flour were added to increase amount of pro-vitamin A and improve sensory attributes on developed noodles and porridge flour. There was a significant increase in protein, iron, zinc and pro-vitamin A associated with increase in the amount of pigeon peas and/or orange fleshed sweet potato flour in the developed products compared to the wheat-based noodles and the normal porridge flour available in the market. This is attributed to higher amount of protein, iron and zinc in pigeon peas (Dako *et al.*, 2016; Ojwang *et al.*, 2021). Noodles' samples composed of large amount of pigeon peas and orange fleshed sweet potatoes flour (PPBN193) and

porridge flour with roasted pigeon peas (PPIP<sub>ofsp</sub><sup>r</sup>) had higher amount of iron content than other samples. Based on the linear programming formulation, developed pigeon peas-based porridge flour samples with added pumpkin flour had low pro-vitamin A content compared to those composed with orange fleshed sweet potatoes flour. As the amount of pigeon peas added in the developed products increases, levels of zinc content increases. This made noodles samples containing pigeon peas alone (PPBN462) to have higher amount of zinc content.

Quantitative Descriptive Analysis showed that samples of noodles with large amount of wheat flour (PPBN718 and PPBN193) and porridge flour with roasted pigeon peas (PPIP<sub>ofsp</sub><sup>r</sup>) had high intensities in colour, aroma and mouthfeel (Chapter Four). The colour of the samples observed to have higher intensities had appealing colour which is close to the colour of the ordinary noodles and porridge flour existing in the market. The porridge samples containing orange fleshed sweet potatoes (PPIP<sub>ofsp</sub><sup>r</sup>) had high intensities in sweetness and viscosity due to natural sweetness in sweet potatoes.

#### **7.2.4 Preferences and acceptability of developed value-added pigeon peas products**

The highest mean preference scores for colour, aroma and mouthfeel were observed in samples containing more than 60% of wheat flour (PPBN718, PPBN193) compared to other samples. Wheat flour dilutes the deep colour of pigeon peas flour hence making it resemble the colour of ordinary noodles in the market.

Despite of the fact that the developed porridge flour samples that the same proportion of ingredients, differences in processing method for pigeon peas contributed to preferences variation. Porridge flour sample composed of roasted pigeon peas (PPIP<sub>ofp</sub><sup>r</sup>) had preferred mouthfeel,

colour and aroma. Roasted pigeon peas had chocolate taste and aroma as well as with slightly dull in colour attributed to the Maillard reaction that occurs during the roasting. According to the literature Maillard reaction influence the colour, texture and aroma of different foods products (Starowicz & Zieliński, 2019). The same sample of porridge was tested for acceptance among children aged 7 - 36 months. The average amount of pigeon peas-based instant porridge consumed by children was similar to the equivalent amount of maize porridge consumed. This indicated that the developed porridge was acceptable among children as there were no differences in preference attributes between the two types of porridge. Also, the average amount of porridge consumed by the children aged 7 - 24 months was higher than the recommended amounts; implying that the porridge was preferred.

#### **7.2.5 Willingness to pay, perceived value and drivers of choice for the developed products**

Consumers were willing to pay for developed pigeon peas-based noodles (PPBN) and instant porridge (PPIP) at the median price of 2000 (IQR= TZS 1500, 2200) and an average price of TZS 1610 ± 546.44 for 1000 g of noodles and porridge, respectively. The estimated selling price for developed noodles was within the purchasing capacity, thus they are likely to buy the product. Willingness to pay for the products was less likely for the consumer who spent less than 2500 per day for household foods and those who prefer package sizes of 250 g and 1000 g. In case of developed PPIP flour the estimated price of TZS 3317/1000 g was beyond their purchasing capability. However, packing in small quantities and creating awareness among consumers on the quality of the porridge flour developed is increase likely to influence purchase the product.

Taste, colour and price were among the perceived value and key drivers for consumer willingness to pay of the developed

products. The earlier study reported that taste influences consumers' liking of the food, hence plays an important role in food choice (Liem & Russell, 2019). It has also been documented that colour is among the food properties that influences buying decisions (Luo *et al.*, 2019) and was associated with the flavour quality of the food product (Garber *et al.*, 2000). As the price decreases, likelihood for consumers to buy the developed products increases. Previous studies have indicated that the higher the price of a product, the fewer the people who will buy it especially when there is an alternative product (Levrini & Dos Santos, 2021; Zhao *et al.*, 2021).

### **7.3 Generalizability to other Settings**

Through this research or study, consumers in two villages in Lindi region who produce pigeon peas for household consumption and income generation were studied. Pigeon peas is a commonly legume consumed in the area in fresh and dried forms, hence consumers are more familiar with the natural and improved sensory attributes of the products compared with the areas where pigeon peas are not common or frequently consumed. The main study population involved adults (Chapter Five), and preference test involved consumers beyond this group. Youth and school age children were involved in testing the developed pigeon peas-based noodles and instant porridge. Furthermore, mothers of children aged 1-3 years were involved in testing the developed porridge samples and came up with one sample that was tested by their children. Although mothers/ caregivers provide a rational judgment on sensory attributes to test for acceptability of complementary foods, caregiver acceptability may not guarantee child's acceptability (Paul *et al.*, 2008). This is because under normal situation, children aged 1-3 years in rural communities are expected to be fed on porridge as one of the common meal, therefore acceptability test was also conducted with them. Adults

involved were relevant for the test due to past experience in consumption of pigeon peas. However, their culinary taste could be different to other adults in different area; results from this study should be generalized with caution due to differences in food cultural practices and habits. Geographical variation in food preference may exist, hence further studies are required in order to determine food preferences on the local situations. Despite of geographical variation of food preference, the developed pigeon peas-based products and other recipes can be promoted for consumption in other areas due to its nutritional value and sensory attributes.

#### **7.4 Drawbacks/ Limitations of the Study**

This study faced a number of limitations that have been taken into account in order to minimize errors and to increase reliability of the findings. The following were the limitations for this study

- i. Lack of laboratory analysis results for nutrient content of some of the ingredients such as orange fleshed sweet potato and pumpkin flour could have underestimated or overestimated the nutrient content of the developed pigeon peas-based products. Some nutrient contents of pigeon peas flour, orange fleshed sweet potato and pumpkin flour were missing in Tanzania Food Composition Table (TZ FCT) and as a result Kenya Food Composition Table and other sources were referred to (Chapter Four). The nutrient content of roasted and blanched pigeon peas was lacking in TZ FCT, hence results from previous studies on similar products were used (Chapter Four). This may affect the results for this study as nutrient contents of food tend to vary in terms of location and variety grown. In TZ FCT amount of nutrient reported was for raw orange sweet potato and pumpkin which was not processed into flour. This can influence nutrient content of formulated product as processing can

alter amount of nutrient available. Also, lack of protein content for orange fleshed sweet potatoes in TZ FCT leads into reliance on the results from previous study. Despite all these challenges, amount of OFSP flour added in the noodles (55 g) and porridge flour (200 g) is significant to provide at least 50% of recommended nutrient intake.

- ii. Actual cost for manufacturing the developed pigeon peas based products was not determined. Instead, the cost was estimated based on cost of the proportion of the ingredients used (55%). Similar technique had been used when actual cost was lacking (Gilbert & Prusa, 2021), although modifications were made to fit the study environment. A profit of 20% was assumed instead of 40% reported by Gilbert and colleague. The cost of store mark-up was not estimated as the study focused on assessing willingness to pay. Therefore, actual cost could have been underestimated or overestimated. Understanding of actual production cost is important as will give insight for economic evaluation and cost-effectiveness for the developed products.
- iii Systematic error due to selection bias can affect the rationality of the results as they may not be generalized. The selection bias could have been introduced in case knowledge of some consumers who participated in the stated preference test was low. Valuation of the developed product requires individuals who can understand the objective and significance of the process of rating products based on the product profile attribute. To reduce this error, random selection of consumers was conducted after listing those who complied with the required characteristics.

## **7.5 Methodological Considerations**

Several methodological approaches have been used to accomplish the study objectives. In this section issues on

sample size, approaches and methodology used are discussed. These choices are reflected upon and should be considered in interpretation of the results.

### **7.5.1 Sample size**

The number of study participants (consumers) varied by chapter due to the method for data collection used for each objective. Sample size calculation considered 95% confidence level, prevalence of outcome variable of 61%, effect size of 0.05, and attrition rate of 10%. Chapter Two and Three had 355 consumers compared to Chapter Four (25), Five (162) and Six (107). The established sample size is enough for adequate interpretation of the outcome variable. Sample size for preference test (Chapter Five) was small (162) to detect preference variability among consumers. Thus, this sample should be interpreted together with results of quantitative descriptive analysis and acceptance test. Further, the proportion of school age children (6%) and youth (9%) involved in the preference test is not adequate to get more preference variation due to high variability of individual preferences. Therefore, increasing number of panelists for preference tests ensured the statistical power of the tests, hence interpretation of the results should consider this age variation.

The sample size of 25 trained panelists for Quantitative Descriptive Analysis (Chapter Four) was adequate to reach consensus on developing a standardized language and scale to be used in evaluating intensity of the developed product attributes. The power of the test for QDA ranges from 5 to 14 panellists (Lawless and Hildegarde, 2010). Nevertheless, the results from QDA should not be considered as overall liking of the developed product rather should be interpreted together with preference test (Hedonic test).

### **7.5.2 Selection of study participants**

The main study participants were adults aged 19-60 years, however other consumers with different ages were involved based on the objectives and methodology used. Random sampling was used to select participants in Chapters Two, Three, Five and Six. Purposive sampling was used in Chapters Four, Five and Six. Rating of the developed noodles and porridge flour (Chapter Five) required individuals who could understand the described process. Therefore, the purposive sampling of consumers based on their understanding ability could have introduced selection bias. The selection bias could have occurred during preference test (Chapter Five) whereas consumers other than adults (school aged children and youth) were involved. School age children and youth were chosen for several reasons including differences in consumption behaviour that can influence household food choices. In most of the households, the foods preferred by children are the ones mostly prepared for consumption. Therefore, consideration of preferences of different age groups is important for sustainability use of the product developed. The selection bias may also occur during selection of consumers for the assessment of willingness to pay (Chapter Six) because socioeconomic status was among the contributing factors for their decision. Selection bias can affect the external validity of the results; hence the results from this study should be generalized with caution to other settings except for populations that have similar characteristics.

### **7.5.3 Methods and techniques used in the identification and prioritization of pigeon peas-based food to be developed**

Face to face interviews and focus group discussions were used in this study to get insight of the existing pigeon peas-based recipes and possible products to be developed based on consumer preferences. Garret Henry technique and

Pairwise comparison method were used to rank the identified product. These techniques indicate methodological significance in assigning and summarizing rank scores (Kou *et al.*, 2016; Zalkuwi *et al.*, 2015), of listed pigeon peas-based products that consumers preferred to be developed. Pairwise comparison method was used in ranking listed pigeon peas-based products in order of their preference in order to reduce domination of idea from the loudest person in the group during discussion. This method is the simplest type of interviews that weighs the importance of comparing two food products (i.e. binary choices). It is also considered as an effective decision tool in decision making where there are many alternatives (Kou *et al.*, 2016). Additionally, it uses individual knowledge and experiences to make binary comparison of their choices and bring them together in a comparison's matrix. However, its methodological approach was based on summation of pairs in the comparison matrix to obtain vector ratings which are known to be inconsistent and influence decision making (Zalkuwi *et al.*, 2015). In order to reach reasonable conclusion, this method should be combined with another technique.

Garret Henry technique was used to analyze the preferences of each product depending on attributes of interest. This technique includes weights obtained from the proportion of individual ranked scores (Kou *et al.*, 2016). It was used to arrange the position of each choice preference in a way that the same number can be assigned to different consumers on more than two pigeon peas-based products that have different rank scores. The weighted ranked scores were then compiled, and Garrett mean (GM) score for each pigeon peas-based product was determined. The GM score for each pigeon peas-based product was then ranked to determine the most preferred sample. This technique is suitable in preference study as it reduces biases by converting individual rankings using formula to establish orders of preference by merit given by the consumers.

#### **7.5.4 Use of Linear programming in product formulation and development**

Formulation of the developed noodles and instant porridge was done using linear programming to obtain the best combinations of the ingredients that meet at least 50% of daily nutritional requirements. Linear programming (LP) provides estimate of the nutrient content of the developed products and the extent to which the product will meet the nutritional requirement. It provides a room to decide the proportion of nutrient to be contributed on daily intake. It can also estimate the minimum cost of ingredients to meet nutritional requirement of selected group and establish the cheapest and possible formulation that meets a set of nutritional requirement of selected group (Raymond *et al.*, 2017; Sheibani *et al.*, 2018).

Linear programming has been used in several dietary studies including dietary inadequacies, food aid, dietary guidelines and several interventions. It has also been used in the formulation and optimization of local complementary foods of children (Briend *et al.*, 2003; Raymond *et al.*, 2017); high-energy, nutrient-dense food products for use during emergencies (Sheibani *et al.*, 2018), ready to use therapeutic foods, cost effective fortified food supplements (Briend *et al.*, 2001) and nutritionally adequate health promoting food baskets (Parlesak *et al.*, 2016). In all these studies Linear programming was considered as a successful and cost effective tool in design and formulation of foods that meet daily nutritional requirements. Despite of the fact that LP has been used in different studies, use of small number of food items or nutritional constraints can affect the results of the nutritional content of the product mix. It is recommended to have at least five nutritional constraints to have adequate estimated nutrient contents that meet the requirement (Van Doreen, 2018). In this study a combination of two to three food groups with four nutrition constraints and cost constraints

was used. This can lead into inadequacy of the estimated nutrient content of the developed product. Thus, it is important for the estimated nutrient content of the developed product to be interpreted based on laboratory analysis results but that was beyond the scope of this study. Lack of laboratory analysis results and nutrient composition in TZ FCT for pigeon peas flour, pumpkin flour, orange fresh sweet potato flour grown in the study area or in Tanzania could lead into either underestimation or overestimation of nutrient content of the developed product. Nevertheless, information on the nutrient composition of the mentioned ingredients was obtained from other studies that use similar ingredients and processing methods (Chapter Four). The varieties and processing methods used make the estimation of the nutrients to be appropriate for the formulation of the developed pigeon peas-based products but with limitations due to varying environment.

#### **7.5.6 Stated Preference Method to assess willingness to pay**

Stated Preference Method using structured questionnaire was used to assess consumer willingness to pay for the developed pigeon peas-based products. Through this method, consumers were asked how much money they were willing to pay (WTP) for different quantities of developed pigeon peas-based products. The answers were based on consumer perception on the product attributes. This may result into subjective estimations that can introduce imaginary response bias in estimating willingness to pay that may under or overstate the price preferences based on their preferred answers. Studies conducted earlier (List & Gallet, 2001; Murphy *et al.*, 2002; Broos & Lusk, 2010) reported about hypothetical bias associated with use of this method. The imaginary response biases can be reduced by using the method along with other methods such as revealed preference. Revealed preference used a comprehensive

attribute set, whereas consumers estimate the price they will buy the product based on the comprehensive set of product attributes identify and from what they observed in the real market. However, its collinearity nature of choices made it difficulties to be adopted in this study due to the nature of study participants and complexity of set of choices. To reduce imaginary response, each consumer was provided with products to taste for sensory attributes, choose one preferred sample and propose the price for it based on pack size (250 g, 500 g, and 1000 g).

### **7.5.7 Proportionate price estimation for the developed products**

Price estimation for the product developed was based on the estimated proportion of ingredients used and not actual cost. Hence. May results into over or underestimate the production and selling cost. It is important to have actual manufacturing cost so as to determine feasibility and profitability of the developed pigeon peas-based product and whether is within purchasing capacity of the consumers. A too low price contrary to the reality will affect the production capital and end up with making loss. Likewise, high price may lead into fewer customers who will afford to purchase the products, hence affecting business sustainability. Further study to determine actual production cost for the developed product is required.

## **7.6 Results in Perspective**

### **7.6.1 Public health implications**

Micronutrients deficiency is a serious public health problem, which affect growth and development of children (FAO *et al.*, 2022). The deficiencies reduce work capacity among adults and increases chances for getting diseases (Tulchinsky, 2010). Micronutrient deficiencies can be reduced through several interventions including dietary improvement via consumption of diversified foods. The developed pigeon

peas products are nutrient dense, thus their use increase food diversification by including two or three food groups in existing staple meals. Findings from this study are of particular relevance on public health as pigeon peas were incorporated with orange fleshed sweet potatoes and pumpkin to improve nutritional quality of existing noodles and instant porridge. Pigeon peas-based noodles and porridge flour are expected to contribute at least 50% of daily nutritional requirement for protein, vitamin A, zinc and iron upon consumption of 100 g. This offers sustainable means of improving zinc, iron and vitamin A content of plant-based household meals. Further, the dietary improvement using locally available foods is within capacity of resource poor households, thus sustainable towards increasing access to specific micronutrients of public health significance. It also diversifies recipes which can lead to increase in frequency of consumption of pigeon peas.

The use of pigeon peas also contributes to increasing protein content of developed porridge flour which is suitable for growth of infants and young children. Growth retardation and poor development are common health problems among young children due to inadequate nutrients intake exacerbated by low protein and energy content of commonly consumed complementary foods. Most of complementary foods in rural areas are composed of one or more cereal-based food such as maize, sorghum, finger millet which are inadequate in protein and micronutrients to meet the increased requirements among infants and young children. Therefore, inclusion of pigeon peas flour in complementary foods increases nutrients content of protein, zinc and iron. However, further research is required to assess the effectiveness of developed porridge on child growth.

Legumes including PP contain anti-nutrients which bind some nutrients and affect their absorption by the body (Kumar *et al.*, 2022; Mohan, 2016). The anti-nutrients can be

reduced by using different processing methods. In this study, pigeon peas were processed through different methods including roasting, soaking and dehulling that are expected to reduce anti-nutrients factors to acceptable extent. Further, extrusion cooking was used to process porridge flour hence increased the likelihood for reduction of anti-nutrients. Extrusion cooking and autoclaving have been reported to reduce anti-nutrients such as tannins in pulses (Kalpanadevi & Mohan, 2013). These methods not only reduce anti-nutrients but also improve the in-vitro protein digestibility of legumes (Kalpanadevi and Mohan, 2013; Siddhuraju & Becker, 2001; Shimelis & Rakshit, 2007). However, for effective results two or more methods should be used for desired reduction of anti-nutrients and improvement of protein quality of the legumes.

### **7.6.2 Implications for Practice**

Results of this research have shown that it is feasible to use pigeon peas in various recipes to prepare affordable and nutritious foods for home consumption and for commercial use to increase income. Other ingredients used with pigeon peas, such as orange fresh sweet potatoes, pumpkin and maize, are commonly grown crops at household level, thus can be source of affordable raw materials for the developed products. Processing Methods for pigeon peas (e.g., roasting or boiling, soaking, dehulling) are simple, affordable, and manageable at the household level. It is therefore possible to put into practice the skills for developing pigeon peas-based noodles and porridge flour at household level. Towards the end of the research project, training was conducted among the rural mothers to build their capacity in preparing and mixing ingredients for developed porridge at the household and milling the ingredients at the local milling machines at the same cost incurred in milling of maize flour. A similar training was conducted on preparation of noodles, which engaged males as trainees. Preparation of noodles requires

flour extrusion which has limitation since extruders are not available at the household level. This limitation has been reduced by Vegi Leg project to supply one of extruding machine in the study area which is operated by a formalized group of individuals who produce and sell the noodles at low cost. Furthermore, consumers in the study area are allowed to take their ingredients for extrusion and contribute token money just to cover for the cost of fuel and labor. Alternatively, consumers can buy extruding machine available market price of TZS 50,000/= which is sufficient to extrude 1 kg to 3 kg of the noodles per day. This kind of machine is manually operated, thus feasible in rural settings. Implementation of all these needs change in consumer behavior from their traditional practices. Consequently, increase of consumer preferences towards the developed products creates demand for raw materials as a result increase of production.

### **7.6.3 Policy Implications**

Improving household dietary intake or diets, and using informed policies, is extremely important. Decision makers need to inform about pigeon peas as one of the important food crops which need to be prioritized in the country because it is affordable and can be used to diversify and improve nutritional quality of foods. The crop is adaptive to the environment and with low production cost. Pigeon peas can be used in nutritional interventions related to dietary improvement. Pigeon peas flour can be mixed with flour from different crops such as maize, wheat flour, sorghum, and millet to make varieties food products. Results generated from this study contribute towards the development of relevant interventions to mitigate macro and micronutrients problems in the country as crucial aspects for policymaking. Tanzania National Nutritional Strategy (2011/12 - 2015/16) emphasizes on dietary improvement to reduce vitamin and mineral deficiencies through different interventions. One of

the interventions was to promote food preparation and processing technologies that increase bioavailability and absorption of vitamins and minerals. This study utilizes some of pigeon peas processing techniques to improve bioavailability of vitamins and minerals. The study further used readily available and affordable food crops to improve the nutritional quality of food consumed in the study area. Hence, it is important for nutrition stakeholders to consider this study as one of the practical applications in dietary improvement.

The National Multisectoral Nutrition Action Plan (2021/22 - 2025/26) emphasizes on home gardening for fruits and vegetables and keeping of small animals as one of the sensitive nutritional interventions. However, emphasis on use of pulses and its processed products is lacking. Right time has come for planners to emphasize on processing and modification of pulses (pigeon peas, soybean, bio-fortified beans) for incorporation into daily meal as a key intervention towards mitigation of protein energy malnutrition and micronutrient deficiencies. Processing of pigeon peas and other pulses increases diversification of foods and consequently increases consumption frequencies and improve nutrition status. Increased in consumption of pulses is one of global agenda towards achieving 2030 sustainable development as important aspect towards improving nutritional value of food and food security.

The school feeding programme within the Ministry of Education, Science and Technology should consider using processed pigeon peas in preparation of various meals and snacks for the children. These may include porridge flour, snacks such as bread, chapati, African donuts, and other foods provided and preferred by school children. Since most of the snacks such as African donuts, biscuits which are normally sold to school children are low in protein and

micronutrients, inclusion of pigeon peas would improve quality of diets consumed by the children.

The study is also in line with objective of the Tanzania National Agriculture Policy (2013) of improving agricultural processing through value addition of agricultural produce. Pigeon peas has been processed into flour and the flour has been used to improve the nutritional quality of the developed noodles and porridge flour. This output improves the nutritional value of food consumed, enhances utilization, and contributes into reduction of post-harvest losses of pigeon peas. The flour and pigeon peas-based products developed, can be commercialized, and sold widely in different areas. This will increase the marketing opportunities as one of the policy statements to be considered toward improving the livelihood of community members and alleviation of poverty.

This study also contributes to the Agricultural Marketing Policy (2008), with the objective of promoting and supporting value addition of agricultural products. The study utilized pigeon peas to add value of noodles and instant porridge consumed in the area. Despite the policy document explained about establishment of small-scale agro-processing businesses and rural agro-based industries, processing units for pigeon peas is lacking. Therefore, based on the significance of pigeon peas, results from this study inform policy makers on the need to establish processing units to be used for value addition of pigeon peas. Consequently, this will enhance consumption of diversified recipes, and increases supply chain of the crop and monetary value of the crop.

The findings from this study also provide opportunity for policy makers in health sector to consider the use of pigeon peas as potential food crop that can be used to improve quality of children diet. It could be of interest for nutritionists as the product developed will contribute in reduction of malnutrition in the country. This is in line with the Sustainable

Development Goal 2, target 2.2 which aims at ending all forms of malnutrition. Knowledge and skills on the importance of consuming the developed pigeon peas-based products, will increase awareness among consumers and promote consumption of nutritious foods. This is one of policy statement in Tanzania National Agriculture policy, Food and Nutrition security policy and other strategies or plan such as National multisectoral nutrition action plan.

All these together along with other interventions stipulated in different policies, government plans and strategies contribute to reduction of macro and micronutrient deficiencies in the country. It will also contribute to improving food security and create enabling environment for food supply.



## 8.0 CHAPTER EIGHT

### GENERAL CONCLUSION AND RECOMMENDATIONS

This chapter presents the conclusion and recommendations made from the study findings.

#### 8.1 General Conclusion

The main objective of this study was to develop value-added pigeon peas-based products for recipe diversification to meet consumers and the market requirements of people in Lindi region. Five pigeon peas-based recipes exist in the study area. Consumers prioritized pigeon peas-based noodles, flour, chapati and dhal as the most preferred food products to be developed due to their perceived value, sensory attributes and convenience. Pigeon peas-based noodles and porridge flour were developed through this study. Incorporating pigeon peas flour into noodles and maize porridge flour improves protein, iron and zinc content, diversifies pigeon peas recipes and increase availability of pigeon peas for household consumption. Developed pigeon peas-based noodles (PPBN) and instant porridge (PPIP) were preferred by majority of consumers. Colour, aroma and mouthfeel were the potential sensory attributes for consumers' preferences for the developed noodles and porridge flour. Multiple interrelated factors such as sensory attributes, price per portion size and familiarity about the product were important attributes to meet consumers' culinary tastes that are adequate, culturally acceptable and consumed sustainably. Consumers were willing to pay for the developed pigeon peas-based noodles and instant porridge and the key drivers for their purchasing decision were taste, colour and selling price.

## 8.2 Recommendations

Based on this research, the following are recommended

- i. Researchers and other stakeholders should promote consumption of the developed pigeon peas-based noodles and instant porridge to create awareness on significance of the products and consequently transform to changes in consumption preference and reshape food environments.
- ii. Small scale food processors should consider to use the pigeon peas flour in improving the nutrient content of developed foods that they develop and requiring nutrient enrichment provided b pigeon peas. This will contribute in improving nutrition status of the consumers and hence reduce malnutrition burden in the country.
- iii. Government should consider pigeon peas as a strategic crop and incorporate it in promotion strategies in order to improve food and nutrition security and promote the developed pigeon peas-based noodles and instant porridge for small scale commercialization.
- iv. Product developers should consider the aspects of pack size for developed products to meet consumers purchasing power for a positive effect on physical and economic access to the variety of pigeon peas-based products.
- v. In developing new products, the aspect of cost benefit analysis should be conducted while taking into account all the costs associated with manufacturing: packaging, labelling, distribution and marketing.

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## APPENDICES

## Appendix 1: Household questionnaire

## Section I: Basic and demographic information

| Basic information |  | BI                              |
|-------------------|--|---------------------------------|
| BI 01             | Name of the enumerator                       |                                 |
| BI01b             | Date of survey                               | ____/____/____<br>(DD/MM/YYYY)  |
| BI02a             | Vegi-Leg code - 6 digit code for participant |                                 |
| BI02b             | Name of interviewee                          |                                 |
| BI02c             | Birthdate (or Birth-year/Age) of interviewee | ____/____/____<br>(DD/MM/YYYY)  |
| BI02d             | Gender of interviewee                        | 1=female farmer, 2= male farmer |
| BI03a             | District name                                |                                 |
| BI03d             | Village name                                 |                                 |
| BI03c             | Hamlet name                                  |                                 |

## Section ii: Pigeon peas production and consumption

| A. Production and consumption of pigeon peas |  |             |              |  |   |   |
|--|--|-------------|--------------|--|---|---|
| PPC.01                                       | Did your household grow Pigeon peas in the past three years?   |             |              | 1= Yes<br>0= No  |   |   |
| PPC.02                                       | What do you do with the produced pigeon peas? ( <i>put √ in the respective box</i> )<br>1= consumption      2= selling    3= Both    4= Processed    88. Other (specify) |             |              |  |   |   |
| PPC.03                                       | How did you consume PPs?   |             |              |  |   |   |
|  | Variety  | As a relish | As main dish | Mixed with another food<br>1= Blended<br>2=Mixed whole PP seeds and other food<br>( <i>Mseto</i> ) | As snack<br>1= boiled green pods<br>“ <i>mandale/vikum bu</i> ”<br>2= fried balls of grinded PP<br>( <i>Bhajia</i> )<br>88= other (specify) | Roasted dried PPs and blended (Balahoa) |
|  | Local  |             |              |  |   |   |
|  | Improved   |             |              |  |   |   |

|        |   |  |  |   |
|--------|---|--|--|---|
| PPC.04 | If PPs not consumed what are the reasons?<br><br><i>(Circle appropriate answer, multiple responses allowed)</i> | 1. Scarcity/not available<br>2. High price<br>3. Poor taste<br>4. Poor preferences<br>5. Unpleasant smell<br>6. Longer preparation time<br>88. Other (specify) |  |   |
| PPC.05 | What kind of pigeon peas dish do you prefer?  |  |  |   |
| PPC.06 | Reason for preference   |  |  |   |
| PPC.07 | How frequently do you consume pigeon peas?  | <b><i>Type of dishes</i></b>   | <b><i>On season<br/>Number of days<br/>in the week</i></b> | <b><i>Off season<br/>Number of days<br/>in the week</i></b> |
|        |   | Relish   |  |   |
|        |   | Main dish  |  |   |
|        |   | Mixed with another food  |  |   |
|        |   | As snack (boiled green PPs with pods “ <i>mandale</i> ”)   |  |   |
|        |   | Roasted dried PPs and blended (Balahoa)  |  |   |
|        |   | Other (specify)  |  |   |

|               |  |  |               |
|---------------|--|--|---------------|
| PPC.8         | What factors usually influence your consumption?<br><i>(Circle appropriate answer, multiple responses allowed)</i> | 1=Availability<br>2=Affordability/price<br>3= nutrition Knowledge<br>4=Accessibility<br>5=Preparation time<br>6=Taste<br>7=Preference<br>88. other (specify) |               |
| PPC.9         | Who is the main consumer of pigeon peas in your household?   | <b>Household member</b>  | <b>Reason</b> |
|               |  | Father   |               |
|               |  | Mother   |               |
|               |  | Under five children  |               |
|               |  | Children   |               |
| Other specify |  |  |               |

### III: Processing, preparation, and preservation

|        |  |   |
|--------|--|---|
| PP.01  | How soon do you cook your green pigeon peas after picking them?  | 1= Within an hour of picking<br>2= After an hour to 12 hours<br>3= Stays overnight<br>4= Dry PP for future use<br>77. Not Applicable                                  |
| PP.02  | Do you process/dry/package pigeon peas for future use?   | 1= Yes<br>0= No ( <i>If no skip to PP.12</i> )  |
| PP. 03 | If yes, which method do you use for processing?<br>( <i>multiple response allowed</i> )                                    | 1= Sun drying (direct)<br>2= Boiling<br>3= Dehulling to get dhal<br>4= Heating and canning<br>5= Soaking<br>6= Blanching<br>77= Not Applicable<br>88. other (specify) |
| PP.04  | How do you process it? (try to probe for steps used in processing)   |   |
| PP.05  | How do you normally prepare and cook green pigeon peas for consumption? ( <i>describe steps and list all ingredients</i> ) |   |

|       |  |  |
|-------|--|--|
| PP.06 | How do you normally prepare and cook dried pigeon peas for consumption? ( <i>describe steps and list all ingredients</i> ) |  |
| PP.07 | If soaking was mentioned among the preparation methods indicate for how long is done.<br><br><i>If not skip to PP.39</i>   | 1= Less than 15 minutes<br>2= 15 to 30 minutes<br>3= 31 minutes to 1 hour<br>4= More than one hour               |
| PP.08 | What is the reason for soaking pigeon peas before cooking?   |  |
| PP.09 | If soaking is done, do you use soaked water to cook PP or discard them   | 1= Use of soaked water<br>2= Discard soaked water  |
| PP.10 | If cooked with soaked water, what is the reason for cooking with water which has been used for soaking?                    |  |
| PP.11 | If cooked without soaked water, what is the reason for discarding water?   |  |
| PP.12 | What method do you use to cook your pigeon peas?   | 1= Boiling<br>2= Steaming<br>3= Stir-Frying<br>4= Stewing<br>5= Roasted and boiling<br>88 = Other (specify)..... |
| PP.13 | When you cook PP, do you normally use magadi soda/bicarbonate/ashes?   | 1=Yes<br>0= No ( <i>If no skip to PP.22</i> )  |

|       |  |  |
|-------|--|--|
| PP.14 | If yes, what are the reasons for using magadi soda/bicarbonate/ashes                   |  |
| PP.15 | Do you wash pigeon peas before cooking?  | 1= Yes<br>0= No ( <i>if no skip to PP.24</i> )           |
| PP.16 | How do you wash them?  | 1. Washing on running water<br>2. Washing in a container |
| PP.17 | For how long does prepared/cooked pigeon peas can be stored without deterioration      |  |
| PP.18 | Do you think there are other ways of preparing pigeon peas to increase the shelf life? | 1= Yes<br>0= No ( <i>If no skip to PP.27</i> )           |
| PP.19 | If yes what do you think could be a best way to prepare it to increase shelf life?     |  |
| PP.20 | Do you think you would be willing to pay for processed PPs?                            | 1= Yes<br>0= No  |

**SECTION IV: KNOWLEDGE ATTITUDES, PERCEPTIONS AND PRACTICES ON FOOD PROCESSING, PRESERVATION AND UTILIZATION**

| <b>A. General knowledge attitudes, perceptions and practices (KAP)</b> |   |  |
|--|---|--|
| KAP.1  | Do you know why you should consume PPs concerning beneficial effects for your body?   | 1. Rich in protein<br>2. Rich in vitamins<br>3. Rich in iron<br>4. Rich in micronutrients<br>5. Rich in energy<br>6. Do not know |
| KAP.2  | What is the typical serving size of pigeon peas for adults' members of your household?<br><br><i>(One serving could be, for example, an orange or a handful of chopped carrots)</i> | 1=One<br>2= Two<br>3=Three<br>4= Four<br>5= Five<br>99= Do not know  |

|       |   |  |
|-------|---|--|
| KAP.3 | What is the most important consideration for you when you choose to eat pigeon peas?  | 1=Taste<br>2=Quantity<br>3=Availability<br>4=Price<br>5=Culture<br>6=Social<br>7= shelf life<br>8= Preference of household head<br>88. other (specify) |
| KAP.4 | How much do you agree with the following statements? Use the following rating scale to make your choices regarding pigeon peas. <i>1= Agree 2=neither agree nor disagree 3=disagree</i> |  |
| a.    | Pigeon peas are nutritious  |  |
| b.    | Pigeon peas has good taste  |  |
| c.    | The smell of pigeon peas is not appealing   |  |
| d.    | Markets for pigeon peas are available and accessible  |  |
| e.    | The price of dried pigeon peas is attractive  |  |
| f.    | The price of processed pigeon peas is good  |  |
| g.    | Processing pigeon peas can decrease the shelf life  |  |
| h.    | Storing processed pigeon peas in a tight close package will increase shell life   |  |

|       |   |            |        |         |      |       |
|-------|---|------------|--------|---------|------|-------|
| i.    | Storing pigeon peas in a well design package will attract customers   |            |        |         |      |       |
| j.    | Pigeon peas are used as gift to promote Tanzanian tradition   |            |        |         |      |       |
| k.    | Pigeon peas are important source of protein to your family  |            |        |         |      |       |
| l.    | Children are taught about the importance of consuming pigeon peas   |            |        |         |      |       |
| m.    | Pigeon peas are used as source of income  |            |        |         |      |       |
|       | Consumer acceptance<br>Use the following rating scale to make your choices. 1= Extremely acceptable; 2=Acceptable; 3=Neither acceptable<br>nor unacceptable; 4=Unacceptable<br>5=Extremely unacceptable |            |        |         |      |       |
|       | Dishes  | Attributes |        |         |      |       |
|       |   | Color      | Flavor | Texture | Size | Smell |
| CA.01 | Green pigeon peas boiled and eaten as snack ( <i>mandale</i> )  |            |        |         |      |       |
| CA.02 | Green pigeon peas cooked with oil and onion, tomato   |            |        |         |      |       |
| CA.03 | Green pigeon peas cooked with coconut milk and onion, tomato  |            |        |         |      |       |
| CA.04 | Pigeon peas mixed with other foods  |            |        |         |      |       |
| CA.05 | Dried pigeon peas roasted and blended and cooked with onion and oil ( <i>balahoa</i> )  |            |        |         |      |       |
| CA.06 | Dried pigeon peas cooked with oil and onion, tomato   |            |        |         |      |       |
| CA.07 | Dried pigeon peas cooked with coconut milk and onion, tomato  |            |        |         |      |       |
| CA.08 | Pigeon peas soup/broth boiled without oil   |            |        |         |      |       |
| CA.09 | Pigeon peas soup/broth boiled with oil  |            |        |         |      |       |

**Appendix 2: Quantitative Descriptive Analysis (QDA) questionnaire**

A: Panellist details

Name of panellist ..... Age..... Sex .....

Date: ..... Time .....

B: Product details

- 1. Code:
- 2. Sensory attributes

Please evaluate each coded sample in the order they are listed. Choose and circle appropriate number in a scale from 1 to 9, where 1 is low intensity and 9 is high intensity. How do you find the following characteristics for the developed noodles?

|            |   |   |   |   |   |   |   |   |   |               |
|------------|---|---|---|---|---|---|---|---|---|---------------|
| Sweetness  |   |   |   |   |   |   |   |   |   |               |
| Not sweet  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Very sweet    |
| Salt ness  |   |   |   |   |   |   |   |   |   |               |
| No salt    | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Very salt     |
| Mouth feel |   |   |   |   |   |   |   |   |   |               |
| Slippery   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Very slippery |
| Aroma      |   |   |   |   |   |   |   |   |   |               |
| Aromatic   | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Very Aromatic |

**Thank you**

**KEY**

NO--- Absence of both the sensory attribute and references.

YES--- Presence of both the sensory attribute and references.

**Appendix 3: Hedonic test questionnaire**

A: Panellist details

P No. .... Date: .....

Time: .....

Age: ..... Sex: .....

B: Consumer test

Please evaluate each of the eight (8) coded noodles. Indicate how much you like or dislike each sample attribute by putting the most appropriate number (9-1) in the column against each attribute.

9- Like extremely; 8-Like very much; 7- Like moderately; 6-Like slightly; 5-Neither like nor dislike; 4-Dislike slightly; 3- Dislike moderately; 2-Dislike very much; 1-Dislike extremely.

|                       | Sample codes |  |  |  |
|-----------------------|--------------|--|--|--|
| Attribute             |              |  |  |  |
| Colour                |              |  |  |  |
| Taste                 |              |  |  |  |
| Aroma                 |              |  |  |  |
| Mouth feel            |              |  |  |  |
| Softness              |              |  |  |  |
| Salt ness             |              |  |  |  |
| General acceptability |              |  |  |  |

## C: Additional questions related to consumption

1. Did you consume pigeon peas?
  - a. No
  - b. Yes
2. If yes in which form did you consume
  - a. Relish
  - b. Main dish
  - c. Snack
  - d. Mixed with other food
3. If yes which type of pigeon peas did you prefer
  - a. Green pigeon peas stew
  - b. Dried pigeon peas
4. How often do you eat/consume noodles?
  - a. Daily
  - b. Once in a week
  - c. Once in month
  - d. Seldom
5. Which sample do you prefer mostly? .....
6. Willingness to purchase
  - a. Yes
  - b. Nowhich product codes.....

**Appendix 4: Acceptance test questionnaire**

|             |              |
|-------------|--------------|
| Survey date | Enumerator   |
| District    | Village Name |
| Hamlet name | Centre Code  |

**Section I: Sociodemographic information**

|   |      |                              |                            |
|---|------|------------------------------|----------------------------|
|   |      | Mother/caregiver information |                            |
| Name                                      |      |                              | Age                        |
| Sex                                       |      |                              | Marital status             |
| Educational level                         |      |                              |                            |
| Occupation                                |      |                              |                            |
| How many under five children do you have? |      |                              |                            |
|   |      | Child information            |                            |
| Sno                                       | Name | Sex                          | Age in month/date of birth |
| 1   |      |                              |                            |
| 2   |      |                              |                            |
| 3   |      |                              |                            |
| 4   |      |                              |                            |

*If household has more than one child aged 6 – 36 months, each child should have a separate questionnaire from section II to IV*

**Section II: Breast feeding practices**

Now I would like to ask you about breast feeding

|      |   |   |
|------|---|---|
| BF.1 | Have you ever breastfed your child?   | 0. No<br>1. Yes   |
| BF.2 | Did you manage to breastfeed your youngest child exclusively for the first six months, without giving water, gripe water, fruit juice, porridge or any other foods besides mother's milk? | 0. No<br>1. Yes   |
| BF.3 | For how long do you normally breastfeed your children? (includes both current and who have stopped breastfeeding)   | 1= < 3months<br>2= 3-6 months<br>3= 6-12 months<br>4=12-18 months<br>5=18-24 months<br>99 =Don't know |
| BF.4 | At what age did you introduce your child to his/her first liquid/semi-solid/ solid food?  | 1= < 3months<br>2= 3-6 months<br>3= 6-8 months<br>99 =Don't know                                      |

### Section III: Feeding practices

Now I would like to ask you about complementary foods that normally feed your child during a day.

|                          |  |  |                                       |
|--------------------------|--|--|---------------------------------------|
| FP.1                     | During this period, how frequently do you normally feed your child? .....  |  |                                       |
| FP.2                     | During harvesting season (July to Nov), how frequently do you normally feed your child?<br>.....                       |  |                                       |
| FP.3                     | How many times did you feed your child yesterday? ..... (includes all foods, snacks, drinks)                           |  |                                       |
| FP.4                     | What did you feed your child yesterday?  |  |                                       |
|                          | Amount given   | Frequency of consumption   |                                       |
| Type of meal/food/drinks | 1. < ¼ cup/bowl<br>2. ¼ cup/bowl<br>3. ½ cup/bowl<br>4. ¾ cup/ bowl<br>5. 1 cup/bowl<br>6. > 1 cup/ bowl               | 1. Once<br>2. Two time a day<br>3. Three times a day<br>4. More than three times a day |                                       |
| FP.5                     | Does your child normally consume porridge?   |  | 0. No<br>1. Yes                       |
| FP.6                     | If yes, what kind of flour are you using to prepare porridge for your child (probe all types of flour/flour mix used)? | Tick all applied   | Rank in order of which is used mostly |

|      |   |  |  |
|------|---|--|--|
|      |   | 1. Maize   |  |
|      |   | 2. Sorghum   |  |
|      |   | 3. Finger millet   |  |
|      |   | 4. Soybean   |  |
|      |   | 5. Ground nuts   |  |
|      |   | 6. Cashew nuts   |  |
|      |   | 7. Sardines  |  |
|      |   | 8. Beans   |  |
|      |   | 99. Other(s) mention<br>.....  |  |
| FP.7 | Where did you get the porridge flour for your child? (source of porridge flour) | 1. Prepare at home<br>2. Purchase at the local market/shop<br>3. Purchase at the Locally made flour from food vendors<br>4. Given at health facility |  |
| FP.8 | If prepared at home, how did you prepare the porridge flour? Tick all applies   | 1. Sorting<br>2. Washing<br>3. Blanching<br>4. Roasting<br>5. Soaking<br>6. Fermentation   |  |

|       |  |   |
|-------|--|---|
|       |  | 7. Sprouting<br>8. Drying      Other(s) .....   |
| FP.9  | If you purchase porridge flour, how much did you pay per unit?<br>Weight of the flour ..... Price per unit ..... |   |
| FP.10 | How many times yesterday did you give your child porridge?   | 1. Once<br>2. Twice<br>3. Three times<br>4. More than three times   |
| FP.11 | During preparation/cooking porridge what ingredients do you normally add? Tick all applied                       | 1. Salt only<br>2. Sugar only<br>3. Sugar and salt<br>4. Milk<br>5. Margarine/cooking oil<br>6. Grinded oil seed flour (sesame, pumpkin etc.)<br>7. Other (s) specify |
| FP.12 | At which place did you normally sit when feeding your child?   | 1. Kitchen/cooking area<br>2. Sleeping area<br>3. Dinning/specific area for feeding<br>4. Outside the house<br>5. Other(s) specify                                    |

**Section IV: Consumption test – instant pigeon peas based- porridge.**

|  |               |                                     |                               |                |   |  |
|--|---------------|-------------------------------------|-------------------------------|----------------|---|--|
| Date .....   |               | Name of the child .....             |                               |                | Age .....   |  |
| Hamlet .....   |               | Center .....                        |                               |                |   |  |
| Did your child eat anything this morning?<br>0 = No<br>1 = Yes |               |                                     | What did she/he eat?<br>..... |                |   | Does your child feel sick today?<br>0 = No<br>1 = Yes  |
| Weight of utensil  | Amount served | Amount remained (utensil +porridge) | Start time for feeding        | Finishing time | Number of times child stops or pauses from eating (at least 2min/pause) | Observed behaviour during feeding<br>1= Fast opening of the mouth; 2 = Child crying<br>3 = Pushing spoon/cup; 4 =Moved their head away; 5= clamped the mouth shut or clenched the teeth; 6= Became agitated; 7= Spat out the food<br>8=Refuse to swallow |

|  |   |
|--|---|
| <i>Enjoyment rate<br/>(ask mother)</i>   | Do you feel the child is<br>1= Very dissatisfied 2 = Dissatisfied 3= Neither satisfied nor dissatisfied 4= Satisfied,5<br>=Very satisfied   |
| <i>Response</i>  | How does your child respond to feeding?<br>1= Fast and responsive 2= Slow and responsive 3= Slow unresponsive 4=Complete<br>refusal   |
| <i>Ask this question<br/>during the second<br/>and third day of<br/>acceptance test of<br/>PPIP:</i> | Did the child have any stomach discomfort resulting from consumption of yesterday's<br>porridge? 0=No; 1=yes<br>If yes what was it?<br>1. Stomach ache or too much gas/flatulence; 2. Diarrhea; 3. Vomiting ;4. Other(s)<br>mention ..... |
| <i>Additional<br/>porridge</i>   | Does the caregiver/mother ask for additional amount of porridge to the child? 0 = No;<br>1=Yes  |

### Appendix 5: Questionnaire on willingness to pay

#### Section I: Socio Economic information

|      |                |  |
|------|----------------|--|
| SE.1 | Sex            | 1= Female<br>2= Male   |
| SE.2 | Age            | Enter complete years<br>.....  |
| SE.3 | Marital status | 1=Married monogamous<br>2=Married Polygamous<br>3= widowed<br>4=Divorced<br>5=Single<br>6=Co-habited   |
| SE.4 | Education      | 1=No formal education<br>2=Primary school<br>education<br>3=Some primary school<br>4=Secondary school<br>5=Diploma/certificate<br>6=University |

|                   |  |  |           |
|-------------------|--|--|-----------|
| SE.5              | Source of livelihood/occupation                            | 1=Farmer<br>2=Employed in formal sector<br>3= Employed in informal sector (casual labor)<br>4=Business<br>5=Self employed<br>5=House wife / mother<br>88=Other<br>(specify)..... |           |
| SE.6              | On a typical week how much do you use to buy the following |  |           |
|                   | Expenditure  | Normal days  | Lean days |
|                   | Food for the household                                     |  |           |
|                   | Food for yourself if consume outside home                  |  |           |
|                   | School   |  |           |
|                   | Medication   |  |           |
|                   | Household assets/utensils                                  |  |           |
| Productive assets |  |  |           |

|      |  |             |           |
|------|--|-------------|-----------|
| SE.7 | On average how much do you spend per day   |             |           |
|      | Expenditure  | Normal days | Lean days |
|      | Food for the household   |             |           |
|      | Food for yourself if consume outside home  |             |           |
|      | School   |             |           |
|      | Medication   |             |           |
|      | Household assets/utensils  |             |           |
|      | Productive assets  |             |           |
| SE.8 | How much did your household spend yesterday?   |             |           |
| SE.9 | Compared to normal rate amount of money used yesterday<br>1. Very low<br>2. Rather low<br>3. Sufficient<br>4. Rather high<br>5. High |             |           |

**Section II: Knowledge, perception, consumption and buying behaviour of noodles.**

|       |  |   |
|-------|--|---|
| KPC.1 | Have you ever heard about noodles?<br>0=No 1=Yes   |   |
| KPC.2 | Have you tested/try noodles?   |   |
| KPC.3 | What makes you try to test it?<br>1= knowledge about the product 2= familiarity 3= advertisement/promotion 4= convenience 5= appearance 6= Peer influence<br>Other(s).....     |   |
| KPC.4 | What is the first thing that comes into your mind • when you here noodles?<br><i>Probe about ingredients of the noodles they buy (raw material)</i><br>.....<br>.....          |   |
| KPC.5 | How would you compare noodles with other foods made from grain legumes in the market/household? from a 3-point scale, how would you rate noodles? (Please circle your answer.) |   |
|       | Nutrient   | 1= less nutrient 2=I do not know 3= nutrient dense                |
|       | Preparation work   | 1= less preparation work 2= I don't know 3= more preparation work |
|       | Cooking time   | 1= shorter cooking 2= I don't know 3= longer cooking time         |

|       |   |  |
|-------|---|--|
|       | Taste   | 1= bad taste 2= I don't know 3= good taste   |
|       | Price   | 1= cheap price 2= I don't know 3= high price |
| KPC.6 | Did any member in your household consume noodles before?<br>1. No<br>2. Yes   |  |
| KPC.7 | Who consume noodles in your household? Tick all applies<br>1. Children<br>2. Women<br>3. Men  |  |
| KPC.8 | If no what is the main reason of not consuming?<br>1. Scarcity/not available<br>2. High price<br>3. Poor taste<br>4. Poor preferences<br>5. Unpleasant smell<br>6. Longer preparation time<br>88. Other (specify) |  |

|        |  |
|--------|--|
| KPC.9  | If consume, how often did you consume noodles?<br><ol style="list-style-type: none"><li>1. Daily</li><li>2. Once in a week</li><li>3. Once in month</li><li>4. Seldom</li></ol>  |
| KPC.10 | Where did you get noodles?<br><ol style="list-style-type: none"><li>1. Purchase at retail shops in the village</li><li>2. Purchase at district market</li><li>3. Purchase on common market/weekly/monthly markets</li><li>4. Prepare at home</li><li>5. Gift</li></ol> |
| KPC.11 | How often did you buy noodles?<br>1=Frequently (at least once per week)<br>2=Often (at least 3 times per month);<br>3= Sometimes (once in month)<br>4=Seldom (at least 1 x 6 months)<br>5=Never  |
| KPC.12 | What attributes are you considering when buying noodles?   |

| Attribute   | Response  |               |                                   |           |                |
|---|---|---------------|-----------------------------------|-----------|----------------|
|   | Strongly disagree   | Disagree      | Not sure                          | Agree     | Strongly agree |
| Price   |   |               |                                   |           |                |
| Weight  |   |               |                                   |           |                |
| Packaging   |   |               |                                   |           |                |
| Frequency of consumption                            |   |               |                                   |           |                |
| Number of people consuming noodles in the household |   |               |                                   |           |                |
| Other(s) .....                                      |   |               |                                   |           |                |
| KPC.13  | Please, indicate how the following attributes are important when you choose to buy noodles?<br>Use the following rating scale to make your choices. |               |                                   |           |                |
| Attributes  | Not very important  | Not Important | Neither important nor unimportant | Important | Very important |
| Price   |   |               |                                   |           |                |
| Weight  |   |               |                                   |           |                |
| Taste   |   |               |                                   |           |                |

|   |   |          |          |       |                |
|---|---|----------|----------|-------|----------------|
| Packaging   |   |          |          |       |                |
| Prestige  |   |          |          |       |                |
| Appearance  |   |          |          |       |                |
| Nutritional knowledge about the product                                   |   |          |          |       |                |
| Preference  |   |          |          |       |                |
| Availability  |   |          |          |       |                |
| KPC.14  | How could you rate the noodles in terms of nutritional quality? |          |          |       |                |
|   | Strongly disagree   | Disagree | Not sure | Agree | Strongly agree |
| Noodles we use to consume are made up with cereal based foods (rice/wheat |   |          |          |       |                |
| Noodles are rich in vitamins  |   |          |          |       |                |
| Noodles are rich in minerals  |   |          |          |       |                |
| Noodles are rich in protein   |   |          |          |       |                |

|                               |  |          |              |       |  |
|-------------------------------|--|----------|--------------|-------|--|
| Noodles are rich in Iron      |  |          |              |       |  |
| Noodles are rich in vitamin A |  |          |              |       |  |
| Noodles are rich in Zn        |  |          |              |       |  |
| KPC.15                        | How do you perceive the following noodles attributes                 | Disagree | I don't know | Agree |  |
| a.                            | The color of noodles is not good                                     |          |              |       |  |
| b.                            | The taste of noodles is good   |          |              |       |  |
| c.                            | The Aroma of noodles is good   |          |              |       |  |
| d.                            | The mouthfeel of noodles is not appealing                            |          |              |       |  |
| e.                            | The price of noodles in the market is within the purchasing capacity |          |              |       |  |
| f.                            | Preparation of noodles before cooking is hard                        |          |              |       |  |
| g.                            | Cooking of noodles take to a long time to be ready for consumption   |          |              |       |  |

### Section III: Choice experiment of developed Pigeon peas-based noodles

1. Please test the 2 samples of noodles, which one did you prefer mostly
  1. Sample A
  2. Sample B
2. What did you like most about the noodles tested?
  6. Packaging
  2. Price
  3. Taste
  4. Colour
  5. Composition of the mixture
  6. Smell

2. Based on the description, how interested would you be in buying this pigeon peas-based noodles if priced within your budget?

| Select one answer            | Reason for your choice |
|------------------------------|------------------------|
| 1. Not very interested       |                        |
| 2. Somehow disinterested     |                        |
| 3. Neither or nor interested |                        |
| 4. Somehow Interested        |                        |
| 5. Very interested           |                        |

3. Will you be willing to buy the selected type of noodles?
1. Definitely will not buy
  2. Will not buy
  3. Neither or nor will buy
  4. Will buy
  5. Definitely will buy

4. How important is each of the following considerations when you buy instant noodles?

|  | Very important | important | indifferent, | unimportant | very unimportant |
|--|----------------|-----------|--------------|-------------|------------------|
| Price  |                |           |              |             |                  |
| Packaging material                             |                |           |              |             |                  |
| Nutritional value                              |                |           |              |             |                  |
| Convenience in preparation                     |                |           |              |             |                  |
| Cooking time                                   |                |           |              |             |                  |
| shelf life                                     |                |           |              |             |                  |
| Availability of economy packs (packaging size) |                |           |              |             |                  |
| Good taste                                     |                |           |              |             |                  |
| Colour   |                |           |              |             |                  |
| Easy storage                                   |                |           |              |             |                  |
| Variety flavor                                 |                |           |              |             |                  |

5. Which price will be suitable to pay for the pigeon peas-based noodles?

| Quantity | Price range will buy |         | Price range will not buy |         |
|----------|----------------------|---------|--------------------------|---------|
|          | Lowest               | Highest | Lowest                   | Highest |
| 250g     |                      |         |                          |         |
| 500g     |                      |         |                          |         |
| 1000g    |                      |         |                          |         |

#### **Section IV: Willingness to buy for the developed Pigeon peas-based instant porridge**

1. Will you be willing to buy the selected type of instant porridge?
  1. Definitely will not buy
  2. Will not buy
  3. Neither or nor will buy
  4. Will buy
  5. Definitely will buy
2. Which price will be suitable to pay for 1000g of the pigeon peas-based instant porridge?

#### **Appendix 6: Checklist for Focus group discussion**

##### Section I: Background information

I would like to thank you all for coming and agreed to participate in this discussion. Before we start our discussion, I would like to have a self-introductory among members. I am interested to know your names, and how long have you lived in this community?

##### Section II: Crop production

1. Which legumes grow best in your area?
2. Which legumes are used as a source of income?  
Why?
3. Which legumes are mostly consumed and why
4. Now I would like to know more about pigeon peas as one of the crop grown in this area.
  - a. Where did you get seeds for pigeon peas?
  - b. Who participate on production of PPs (probe preparation of farm, weeding, harvesting, storage and marketing)
  - c. Does the production of pigeon peas change for the past 3 years? How does it change and what are the reasons for change?

##### Section III: Marketing (selling and buying)

1. In which form/stage do farmers sell pigeon peas?  
(probe for green pods, dried grains, process grains)

2. Who are main buyers of green pods?
3. Who are main buyers of dried grains?
4. What is the proportion of
  - a. Pigeon peas have been sold? (ask for sales figures for last three years)
5. Does the sales of
  - a. Pigeon peas change for the past 3 years?  
How does it change and what are the reasons for change?
6. How is the price determined?
7. How does the amount of pigeon peas traders/buyers change over the past three years? What is the reason for change?
8. What of pigeon peas quality do buyers prefer? Ask for
9. What are the market challenges for pigeon peas? (Probe for infrastructure, market conditions, challenges faced by sellers and buyers?)
10. Who are key actors of market of pigeon peas? Why?
  - a. What do you think are market opportunities for pigeon peas?
11. In your opinion what are best ways of increasing market opportunity for pigeon peas? (probe for possible products to be developed, the processing methods/techniques, raw materials to be used and consumer of the developed product, ask also for packaging material and size, marketing methods, existing regulations that promote or hinder marketing)
12. What are society attitudes towards new developed product? Start by ask if there was product developed earlier, what success and what are failure

Checklist for key informant interviews- District and village/ward extension officer  
Section I: Background information

1. What is your carrier/ occupation?
2. For how long have you been a... {Position} in this community?
3. Since you've started working as a [position] what important changes (if any) have you observed in this community?

Follow up depending on occupation →

- a) How have livelihoods / activities required as means of living changed?
  - b) How have markets changes?
  - c) How have the roles and responsibilities of women and men changed?
  - d) For all, Probe positive changes, negative changes
4. What do you think are the main drivers of these changes?
  5. How do you think these changes have affected the community?

#### Section II: Pigeon peas

5. What food crops grow best in this area?
6. What cash crops grow best in this area?
7. Which legumes grow best in your area?
8. Which legumes are used as a source of income?  
Why?
9. Which legumes are mostly consumed and why
10. What volume of pigeon peas has been produced in this area? (ask for production and yield figures for last three years)
11. Does the production of pigeon peas change for the past 3 years? How does it change and what are the reasons for change?  
(Probe also for indigenous vegetables that they collect)
12. Who are the key actors in the value chain and their relative importance?

13. What are the economics of pigeon peas production now and how might they be improved?
14. How efficient is the pigeon peas value chain?
15. In which form/stage do farmers sell pigeon peas? (probe for green pods, dried grains, process grains)
16. Who are main buyers of green pods?
17. Who are main buyers of dried grains?
18. What is the proportion of Pigeon peas have been sold? (ask for sales figures for last three years)
19. Do the sales of Pigeon peas change for the past 3 years? How does it change and what are the reasons for change?
20. How is the price determined? probe for
21. How does the amount of traders/buyers change over the past three years? What is the reason for change?
22. What quality do buyers prefer? Ask for
23. What are the market challenges? (Probe for infrastructure, market conditions, challenges faced by sellers and buyers?)
24. What do you think are market opportunities for PPs?
25. In your opinion what are best ways of increasing market opportunity for pigeon peas?
26. Who are key actors of market of pigeon peas? why?