Acceptable food products processed from underutilized crops

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Underutilized crops are rich in micronutrients but are only cultivated at subsistence level (1). Food processing technologies, particularly at household level, are challenging and often not applicable to traditional crops (2). Perishability and poor processing are among major constraints facing thier production in developing countries (3). Improved dietary diversity, diet modification and appropriate food processing technologies of micronutrient rich crops are among the long term strategies that could help eradicate or minimize micronutrient malnutrition (4). Processing of underutilized crops into acceptable food products can improve their exploitation. Snack foods like noodles, cookies and crackers are widely adapted for every day use, widely consumed throughout the world and their global consumption is second only to bread (5). This is because they are convenient, easy to cook, low cost and have relatively olng shelf-life (5). Therefore exploitation of the feed value potential of underutilised crops to process crackers, noodles and cookies could increase acceptability and reduce perishability thus increase marketability and consumption/utilisation in the long run. An informal experimental study design was used to evaluate preparation of acceptable food products comprising of crackers, noodles and cookies from cassava (*Manihot esculenta*), finger millet (*Eleusine coracana*), simsim (*Sesamum orientale L.*), and slenderleaf (*Crotalaria ochroleuca* and *C. brevidens*). Product acceptability was assessed using organoleptic tests evaluated by a panel of 76 judges. Disproportionate stratified random sampling was used to select 19 judges from each strata; age strata (<18yrs & >18yrs) and sex strata (men & women) totalling to 76 judges/panellists of 38 females and 38 males. Tests by sensory panels were conducted under controlled conditions using appropriate experimental designs, test methods and statistical analyses according to the International Standards Organization (ISO) (6,78,9). *Chi*-square test was used to analyze the acceptability of the crackers, noodles and cookies across the study groups. The products were highly accepted as over 50% of judges/panellists liked all the food products. This study brings forth acceptable food products prepared from selected underutilized crops. Promotion could lead to increased consumption and marketability of these products. The crackers, noodles and cookies should be promoted and marketed in order to increase consumption and utilization of underutilized crops.

Keywords: Underutilized crops; food products; food processing; food acceptability

1. Food Processing

Reasons for processing food include preservation for use in times of shortage, increase shelf life, removal of toxins, removal of antinutrients which improve digestibility and availability of minerals, and improvement of palatability; food fortification is also part of food processing (10 & 11). Food preparatory practices have changed over time, in East Africa, boiling and occasional roasting were the principal cooking techniques from 1930s to 1960s. These were superior to current practices favouring frying and deep-frying of foods (12). Besides the shift towards frying instead of boiling vegetables and other crops in urban areas, there seem to be no distinctive urban recipes (13). People tend to stick to food habits; thus, preparation techniques acquired in early childhood have a long-lasting influence even if people move from villages to towns (14). Contrary to the above assertions, methods of food processing have been developed over the centuries and are adopted to make the final product more attractive in flavour, appearance, taste and consistency. Besides these aspects of consumer preferences, several of the methods aim at making the food safe and wholesome and increase its shelf life. The common household practices of processing these foods include milling, germinating or sprouting, malting, fermentation and cooking. Each of these processes qualitatively modifies the nutritive value of the food (15). The shelf-life of minimally processed products is increased by pre-processing factors (crop varieties, pre-harvest factors, harvesting, maturity), processing factors (pre-cooling, trimming, washing, cleaning, disinfection, cutting, peeling, handling, dipping, drying, packaging) and distribution conditions (16). Techniques for processing combinations of selected neglected and underutilized crop species into food products have not been established.

An experimental study was carried out at Maseno University Nutrition Department foods laboratory at 65% humidity and 23^{o}C. Here food products (cookies, crackers and noodles) were prepared from underutilized crops which comprised of cassava roots, simsim seeds, fingermillet grains and slenderleaf vegetables. The food products were analyzed for food product acceptability (appearance, smell, taste, texture, and general acceptability) using Organoleptic tests. The underutilized food crops were procured at Luanda market located at 34^{o}36' East and 0^{o} North at an altitude of about 1530 meters above sea level. Same amount (500g) of each crop was procured from three different sellers at different locations of the market and mixed. The procured samples were cleaned and made free from dirt, foreign matter and other stubbles; this was followed by washing using distilled water after which processing was carried out for product preparation. Processing of raw material involved the following activities; fresh vegetable leaves were separated from

roots, washed under running double glass-distilled water. Vegetables were then blanched, drained completely and dried under shade**.**

1.1 Data Analysis

Qualitative and quantitative data analysis was performed using ANOVA with critical significance levels set at $P \leq 0.05$. Data on product acceptability was analyzed using Chi-square test by comparing proportions across the groups (stratum), and Kruskal-Wallis test for comparing differences in continuous data. Post-hoc Dunn's corrections for multiple comparisons were performed following Kruskal-Wallis tests. Acceptable attributes referred to the score values of 4 and 5 on the grading chart while 1, 2 and 3 were for unaccepted attributes.

2. Crop Processing for Product Formulation

2.1 Cassava (*Manihot esculenta*)

Dry cassava was procured and cleaned by picking dirt by hand. This was further washed under running double glass-distilled water to remove dirt then further dried in the open air under the sun. Dried cassava was milled into powder and sieved by a 0.5mm size sieve, then left in the open to release the toxic cyanide which is known to be volatile, in readiness for product processing.

2.2 Fingermillet (*Eleusine coracana*)

Fingermillet was cleaned by removing dirt by hand, this was further washed under running double glass-distilled water to remove dirt then further dried in the open air under the sun. Dried fingermillet was further processed by grilling in the oven to initiate cooking and to produce a characteristic scent. The dried and partially cooked millet was then milled into flour and sieved by a 0.5mm size sieve ready for product processing.

2.3 Simsim (*Sesamum orientale* L.)

Simsim was cleaned by removing dirt by hand further washed under running double glass-distilled water to remove dirt then further dried in the open air under the sun. Dried simism was processed by grilling till golden brown to improve colour and scent. This was followed by grinding then sieving by a 0.5mm size sieve in readiness for product processing.

2.4 Slenderleaf sp. (*Crotalaria ochroleuca* and *Crotalaria brevidens*)

Slenderleaf was destalked washed under running double glass-distilled water to remove surface soil contamination. Vegetables were rinsed three times to remove all the dirt. Each vegetable was processed separately (*ochroleuca* and *brevidens*). After washing, life processes were stopped by immediately blanching. The blanched vegetables were then dried were ground into powder using mortar and pestle and sieved by a 0.5mm size sieve.

The following procedure was followed in blanching the vegetables

1. A large pan half-full of double glass-distilled water was brought to rapid boiling.
2. Clean raw vegetables were put in a wire basket and gently lowered in the boiling water.
3. Once the water began to boil again, vegetables were left in for two minutes.
4. Vegetable basket was removed from the boiling water and plunged into ice-cold water for two minutes to stop the cooking process (over-blanching results into loss of nutrients, flavor and texture).
5. The blanched vegetables were drained and dried under shade until completely dry.

3. Food Products Processing

Formulated recipes followed standard procedures to process the food products according to inventions by (17). However, the wheat flour was not used in these products as cassava was used as a base ingredient and binding agent. This was also meant to break the monotony of using wheat in food product processing. Cassava was combined with slenderleaf to modify cookies, with fingermillet to modify noodles, and with simsim to modify crackers.

3.1 Cookies

Although wheat flour has traditionally been used to prepare cookies, there has been increased need to use other indigenous crops in cookie preparation. African breadfruit was in the past used in combination with wheat flour to prepare cookies (8). Composite sorghum, (yellow Kaura variety)-maize (white flint variety)-wheat flour cookies have been formulated and found to be acceptable in Nigeria (18). On the other hand (8) invented the use of cassava alone to process cassava cookies. This study omitted wheat flour in cookie processing and did not use cassava alone to prepare cookies, instead slenderleaf and cassava flour were combined and used to process cookies. This brings forth a new idea

of using a combination of cassava roots flour and slenderleaf vegetables to prepare cookies (cassava-slenderleaf cookies) besides wheat which has traditionally been used to prepare cookies.

3.1.1 The prepared Cassava-Slenderleaf Cookies

Ingredients

50g	Cassava flour
15g	*C. ochroleuca* powder
12g	*C. brevidens* powder
22g	Margarine
12g	Sugar
1 ¼ tbsp	Salt
50mls	Water

Net weight per serving = **6g**
Total net weight = **100g**

Preparation: The oven was heated to 175^{o}C, the flour, sugar and other dry ingredients were mixed thoroughly then margarine rubbed in to incorporate air. Mixing was continued as water was added till soft then pressed evenly onto bottom of a greased square pan. This was baked for 10 minutes at 175^{o}C. Cookies were then removed from oven and left to cool (19 & 17).
Characteristics: Greenish in colour, dry but easy to break, soft

3.2 Noodles

Attempts have been made to develop nutrient rich noodles by the addition of optimized proportions of wheat and fingermillet flour with other ingredients (20). In addition to these traditional foods, fingermillet is also processed to prepare popped, malted and fermented products like papads, noodles, soups, etc (21). Noodles can also be made from, rice, buckwheat, and starches derived from potato, sweet potato, and pulses, with corn starch as binding agent (22 & 23). Additionally (17), invented the use of cassava alone to prepare noodles. However, in this project noodles were prepared from a combination of fingermillet with cassava thus omitting wheat which is the traditionally known ingredient in processing of noodles. This could break the monotony of using wheat flour in noodle processing and also help promote the use of other underutilized crops like fingermillet in food product processing. This study has revealed the possibility to process noodles from a combination of fingermillet with cassava. Noodles may be used in pasta dish soups, stews, pasta and sauce dishes (19 & 17).

3.2.1 The prepared Cassava-Fingermillet Noodles

Ingredients

50g	Cassava flour
60g	Fingermillet flour
1tsp	Salt
2	Eggs
10mls	Water

Net weight per serving = **10g**
Total net weight = **100g**

Preparation: All dry ingredients were mixed in a bowl and a well made in the centre. Water was added little by little while mixing thoroughly after each addition. Water was added enough to form dough into a very light paste. It underwent kneading for about 10 minutes till smooth and elastic. The dough was then rolled into ¼ inch thin rectangle and cut cross wise into ⅛ inch strips for narrow noodles and ¼ inch strips for wide noodles. The strips were shaken out and placed on a clean dry towel to dry for about 2hrs. When cooking, immerse noodles in boiling water for 10 minutes or until they change from light brown to dark brown as the starch granules gelatinize.
Characteristics: Dark brown in colour, smooth to touch, dry but easy to break, soft after cooking

3.3 Crackers

An invention by (17), indicated the possibility of using cassava alone to prepare crackers. However, banana pulp, pumpkin pulp, mango pulp and mango peel flour have been used to process crackers (24). Results of this study prove that a combination of cassava and simsim can also be used to process crackers, thus including cassava and simsim among crops that can produce crackers.

3.3.1 The prepared Cassava-Simsim Crackers

Ingredients

50g	Cassava flour
50g	Simsim flour
10g	Sugar
10g	Margarine
14mls	Water
1g	Baking powder

Net weight per serving = **8g**
Total net weight = **120g**

Preparation: The oven was preheated to 175^{o}C while a large baking sheet was greased. The flours were then whisked together the flours. Margarine was then beaten together with sugar until light. The flour was then stirred in the flour mixture. Water was slowly poured in and stirred until dough was formed. On a well floured board, the dough was rolled to between ⅛ and ¼ inch thick. A knife was used to cut the dough into desired shapes, baked in the preheated oven for 10 minutes, then removed from oven.
Characteristics: Golden brown in colour, dry but easy to break, soft and crunchy

4. Sensory Analysis of the Modified Food Products through Organoleptc Tests

Tests using sensory panels were conducted under controlled conditions, using appropriate experimental designs, test methods and statistical analyses. A properly designed experimental area and appropriate experimental design, test method and statistical analysis were incorporated in the study (7). Methods mobilized by (6; 8; & 9) were used. The three modified products (cookies, crackers and noodles) were evaluated by a panel of 76 judges. Disproportional stratified random sampling was used to select 19 judges from each strata; age strata (<18yrs & >18yrs) and sex strata (men & women) totaling to 76 judges/panelists (38 females and 38 males). Before each test session panelists were given orientation about the procedure of sensory evaluation, their health status was also considered during selection to avoid those who are pregnant, suffering from colds, and with allergies that affect their sensitivity for the products. Each taster received a maximum of three foods in the session, rated each food as he/she finished it, and rinsed his/her mouth with clean water between samples in order to remove all traces of the previous sample. The sample food products were presented in identical containers with different codes, at the same time. The judges/panelists ranked the products on the basis of sensory visual appearance, taste, smell, texture and overall acceptability using a five point hedonic scale where numbers from 1 to 5 were assigned to the scale's five categories High numbers reflected preference, 5 was assigned the "like extremely"; 4 "like"; 3 "neither like nor dislike"; 2 "dislike"; and 1 "dislike extremely". Score distributions were also used to calculate means and percentages. The three food products comprising of cookies, noodles and crackers were subjected to sensory analysis to assess acceptability using organoleptic test. Products were regarded as acceptable if they had score values of 4 and 5 on the grading chart; on the other hand, 1, 2 and 3 scores were for unaccepted attributes therefore unacceptable products

4.1 Appearance Acceptability of the Modified Food Products

The appearance of crackers was most preferred by all the judges with insignificant differences in the liking of their appearance among judges, they were highly and equally liked by girls, women and boys, and least liked by men. Cookies followed closely in the liking of their appearance with insignificant differences among all the judges. However, they were highly liked by women and least liked by boys. Noodles appearance was the least liked among all the products with insignificant differences among the judges. However, the appearance of noodles was highly liked by girls and least liked by men as indicated in Table.1. Appearance is a very important parameter in judging properly baked biscuits that not only reflect the suitable raw material used for the preparation, but also provides information about the quality of the product (25). The high preference of the appearance of crackers and cookies by judges could therefore be

attributed to the baking processes of the two products as opposed to noodles which were not baked and their appearance was the least preferred among all the three modified food products. The appearance of crackers was most preferred than cookies even though both products were baked. This could be attributed to simsim which is bright in colour used in the preparation of crackers as opposed to slenderleaf which is dark green in colour, used in preparation of cookies. The least preference of noodles' appearance could be attributed to the use of fingermillet which is dark brown in colour. The brighter the colour of product, the higher the appearance acceptability and vice versa.

Table 1 Modified Food Product Acceptability among Study Participants.

Product Attribute	CATEGORY				*df* (χ^2)	P-*value*
	Girls (n=19)	Women (n=19)	Boys (n=19)	Men (n=19)		
Cookie Acceptability, n (%)						
Appearance	14 (73.7)	15 (78.9)	13 (68.4)	14 (73.7)	3 (0.543)	0.909
Taste	16 (84.2)	12 (63.2)	16 (84.2)	14 (73.7)	3 (3.203)	0.361
Smell	12 (63.2)	12 (63.2)	17 (89.5)	15 (78.9)	3 (4.886)	0.180
Texture	15 (78.9)	16 (84.2)	15 (78.9)	17 (89.5)	3 (1.021)	0.796
Cracker Acceptability, n (%)						
Appearance	18 (94.7)	18 (94.7)	18 (94.7)	16 (84.2)	3 (2.171)	0.538
Taste	19 (100)	18 (94.7)	19 (100)	18 (94.7)	3 (2.054)	0.561
Smell	19 (100)	15 (78.9)	15 (78.9)	18 (94.7)	3 (6.428)	0.093
Texture	16 (84.2)	15 (78.9)	14 (73.7)	17 (89.5)	3 (1.751)	0.626
Noodle Acceptability, n (%)						
Appearance	15 (78.9)	14 (73.7)	12 (63.2)	8 (42.1)	3 (6.606)	0.086
Taste	6 (31.6)	4 (21.1)	8 (42.1)	10 (52.6)	3 (4.524)	0.210
Smell	10 (52.6)	7 (36.8)	6 (31.6)	14 (73.7)	3 (8.164)	**0.043***
Texture	16 (84.2)	18 (94.7)	17 (89.5)	17 (89.5)	3 (1.118)	0.773
General Acceptability, n (%)						
Cookies	16 (84.2)	14 (73.7)	17 (89.5)	17 (89.5)	3 (2.375)	0.498
Crackers	19 (100)	19 100)	19 (100)	18 (94.7)	3 (3.040)	0.385
Noodles	15 (78.9)	11 (57.9)	15 (78.9)	18 (94.7)	3 (7.501)	0.058

†% Acceptability – calculated from a score of either 4 or 5 on a five- point hedonic scale, *- Significant

4.2 Taste Acceptability of the Prepared Food Products

Like appearance, the taste of crackers was the most liked by all the judges; they were most liked by girls and boys and least liked by women and men. However, there was insignificant difference in liking of the taste of crackers among the categories. This was followed closely by cookies whose liking for taste was higher among boys and girls and least liked by women while men were the second least. There was insignificant difference in the liking of the taste of cookies among the judges. The taste of noodles was least liked by all the judges, however, among the categories, men were the highest in liking, followed by boys, then girls while women least liked the taste of noodles. However there was no significant difference in their liking among the categories as shown in Table.1. Flavour is the main criteria that makes the product to be liked or disliked (25). Just like appearance, the taste of crackers was the most preferred by all the judges followed closely by cookies while noodles had their taste least preferred by all the judges. High preference of taste in crackers could be attributed to simsim whose taste could have been the contributing factor to its acceptability. This implies that the taste of simsim is most liked compared to slenderleaf and fingermillet used in preparation of cookies and noodles respectively.

4.3 Smell Acceptability of the Prepared Food Products

The smell of crackers was the most liked among all the judges, however, girls were the highest, followed closely by men, then women and boys who least liked the smell at the same percentage. There was no significant difference in the liking of smell of crackers among all judges. Acceptability of smell in cookies was second highest among all the products, however, boys recorded a higher percentage of liking followed closely by men, women and girls on the other hand least liked the smell of cookies but at the same percentage rate. There was no significant difference in the liking of the smell of crackers among all categories. The smell of noodles was the least liked among all the products with significant differences their smell acceptability among the judges. Men highly and significantly liked the smell of noodles, followed by girls, then by women, boys least liked the smell of noodles as indicated in Table.1. The sense of smell is considered to be more defined because an individual requires a relatively high concentration of tastant in order to perceive a taste solution (26). Smell acceptability was higher in crackers compared to cookies and least in noodles. This could be attributed to simsim used in processing crackers. If simsim was the reason for better taste in crackers as

shown in the flavour and taste results, it could have directly contributed to increased smell acceptability of crackers especially due to the fact that they were subjected to baking. Therefore high acceptability of flavor and taste results to increased liking of a product's smell.

4.4 Texture Acceptability of the Prepared Food Products

Despite noodles being the least liked in all the tested attributes, their texture was the most liked among all the products and among all the judges with no significant differences among categories. The liking of the noodles texture was higher among women, followed by men and boys who liked the texture equally while the girls least liked the texture of noodles. The texture of crackers was liked highest among men, followed by girls, then women and finally boys who least liked them. However, there was no significant difference in the liking of the texture of crackers among all the categories. Cookies on the other hand recorded highest texture liking among men, followed by boys and women who liked them equally, while girls least liked the texture of cookies. There was no significant difference in texture acceptability among categories as shown in Table.1. Upon food ingestion the sensors in the mouth detect food texture and consistency, which include mechanical properties (hardness, cohesiveness, adhesiveness, denseness & chewiness); geometrical properties (smooth, gritty, grainy, chalky & lumpy); and moisture properties (juicy, oily or greasy) (27). Although noodles were least preferred in all other attributes, their texture was most preferred among all products and all study participants. This could be attributed to processing procedures of extrusion and drying in the open used during the preparation of noodles as opposed to rolling and baking used in processing cookies and crackers.

4.5 General Acceptability of the Prepared Food Products

Cookies were liked by all judges and there were no significant differences in the liking for cookies among men, women, girls, and boys. However, men highly liked cookies compared to women. Over 68% of all the judges liked all the parameters for cookies (appearance, taste, smell and texture).

Crackers were highly liked by all the girls, women, boys and 94% of men. There was no significant difference in acceptability among the categories. Over 70% of all the judges liked all the parameters for crackers (appearance, taste, smell and texture).

Noodles were highly liked among men and least liked among women. However, there were no significant differences in acceptability among the categories. Generally all the three food products were highly liked by all participants.

Cookies were liked by most study participants thus indicated high acceptability. Generally the proportion of individuals who reported to like cookies was higher among male participants compared to female participants. On the other hand, crackers were highly liked all the girls, women and boys but a few men were undecided about their acceptability. Generally this indicated high acceptability for crackers. Noodles were highly liked by men participants compared to women. However, there was high acceptability of noodles. Generally all the modified food products were liked by all the study participants indicating high acceptability for the products as shown by the results in Table 1.

5. Summary

Although wheat has traditionally been used to prepare cookies, crackers and noodles, this study has demonstrated the possibility of using underutilized crops like fingermillet grains, simsim seeds and slenderleaf vegetables each combined with cassava roots to process noodles, crackers and cookies respectively. The use of these combinations of crops to prepare these food products have not been in existence and have not been documented before.

Baking increased preference for the appearance of cookies and crackers compared to noodles which were dried in the open and recorded least acceptability of appearance. Although both cookies and crackers were baked, the appearance of crackers was the most preferred compared to cookies; this could be due to simsim which is bright in colour used in the preparing crackers compared to slenderleaf which is dark green in colour used in the preparation of cookies. Noodles were the least preferred in terms of appearance and this could also be attributed to the use of fingermillet which is dark brown in colour in its preparation. High preference of taste in crackers could be attributed to simsim used in its formulation which could have contributed to a better tastes compared to slenderleaf and fingermillet used in the modification of cookies and noodles respectively. Smell preference was higher in crackers compared to cookies and least in noodles. This could be attributed to simsim used in cracker preparation. If simsim was the reason for better taste and flavor in crackers as indicated by the flavor/taste results, it could have directly contributed to better smell after crackers were baked. Therefore simsim contributes to the increased acceptability of food products in terms of taste, flavor and smell. Texture preference was higher for noodles among all the judges. This could be to processing procedures of extrusion and drying in the open used in the preparation of noodles as opposed to rolling and baking used in the preparation of cookies and crackers. Therefore extrusion and open drying raises texture acceptability of a food product.

6. Conclusions

1. Neglected and underutilized food crops like cassava, fingermillet, simsim and slenderleaf can be useful in processing food products like noodles, cookies and crackers.
2. Baking improves appearance acceptability of food products.
3. The brighter the color of ingredients used in preparing a food product, the higher the acceptability of product's appearance and vice versa.
4. Use of simsim in food product processing increases taste, appearance and smell acceptability of the end product compared to the use of slenderleaf and fingermillet
5. Extrusion and drying in the open increases preference of a product's texture as opposed to rolling and baking.
6. Among all the modified food products, crackers were highly acceptable followed by cookies and finally noodles. However, all products recorded high acceptability.

7. Recommendations

1. The use of selected underutilized food crops in preparation of food products should be promoted, marketed and recommended for use in food processing industries.
2. The modified cookies, crackers and noodles should be promoted and marketed in order to increase consumption and diet diversity.

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