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Sensory evaluation and consumer acceptability of Snack Value-Added Rice Products in Eldoret Town, Kenya

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Abstract
Farmers in developing countries are greatly affected by post-harvest losses due to poor handling techniques, over maturation, poor storage conditions, infestation by pests and fungal infections. This explains the high rates of micronutrient malnutrition in Kenya with more than half of the morbidity and mortality cases among children being attributed to micronutrient deficiencies. This study aimed at determining consumer acceptability of snack value added rice products in Kenya. The experimental research design was used to conduct consumer tasting and sensory evaluation of the rice composite flours AT1, AT2, AT3, AT4, AT5 and AT6 and baked products from the value-added rice composite (VARCs) rice cookies-CT1, crackles-CT2, rice cake-CT3, doughnuts-CT4, & rice pancakes (plain)-CT5. Significant levels was set at p<0.05. Food to food fortification was used to composite the milled rice cereal with pumpkins, carrots, baobab and grain amaranth. Sensory characteristics were derived from five variations of porridge made from the rice composites. An untrained panel of sixty people made a distinct preference among the five porridge products, in terms of appearance, aroma, taste, flavor, texture andoverall acceptability. AT4 was ranked the highest with a mean value of 20.5% followed by AT5 and AT1 of 19.2%. AT3 had the least preferred appearance with 11.0%. Consumers gave different scores to the composite bakery products for the different attributes indicating that the flours were distinguishable. CT3 was scored higher for all the attributes (p<0.05). CT4 and CT2 were scored lowest for all the attributes which were not statistically different from the base product-CT5 (p>0.05). Scores for CT1 were higher for aroma (p=0.018), taste (p=0.018) and flavor (p=0.002) while its scores for appearance, texture and overall acceptability were not statistically different from the base product CT5 (all p >0.05). Value added rice products were generally acceptable among respondents since they serve as nutritious products, and the consumers' likelihood to adopt and pay for them. These products are also valuable variation for household nutrition.

Key words: Consumers, Value-added rice products, Composites

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I. INTRODUCTION

Rice (*Oryza sativa*) is a staple cereal for almost half of the world's human population. During the last decade, the world rice production has increased by 28% (Seck&Diagne, 2012) mainly due to the increase in production of rice in the developing countries. In Kenya it is grown in large scale in Mwea and Ahero irrigation schemes and in small-scale quantities in other irrigation scheme like Tana and Pekerra irrigation schemes (MoALF, 2017). Almost half of the Kenyan population consumes rice as a staple food. However, producers incur losses during planting, harvesting and after harvesting. Post-harvest loss can be defined as the reduction in both quantity and quality of food produced from the time of harvest to the point it is consumed (MoALF, 2017). Ministry of Agriculture, Kenya indicates that quality losses include those that can affect the nutrient/caloric composition, the acceptability and the edibility of a given product while quantity losses refer to those that result in loss of the amount of a product. In rice production, the term post-harvest refers to the reduction in the amount of edible rice grain due to the reduction of availability, edibility, wholesomeness or quality that prevents rice grain from being consumed by people. According to FAO, (2010), neglected and underutilized crops such as pumpkins, carrots, baobab and grain amaranth are rich in micronutrients and therefore can be used to develop nutrient dense food products which are not only good for their nutritional value but also their commercial value. Therefore, if we expand their utilization, there may be an incentive for farmers to grow and cultivate them on a large scale, thus enhancing their income

II. MATERIALS AND METHODS

Ingredients

Different ingredients were obtained from the Kenyan local market to make composites. The samples are summarized in Table 1.

Table 1: Overview of ingredients

Ingredients	Source	Quantity (Kgs)
Rice	Mwea	5
Carrots	Sogomo market	4
Pumpkins	Sogomo market	5
Baobab	Coastal Kenya	5
Grain Amaranth	Eldoret town Market	5
Wheat flour	Dola company	2
Milk	Brookside	2 litre
Butter	Pwani oils	1
Maize	Sogomo market	2
Sorghum	Sogomo market	2

Preparation of value-added rice flour (VARF)

Preparation of carrot and pumpkin flours

Pumpkins and carrots were grated and washed with deionized water and blanched at 75˚C for 5 minutes (Pongjanta, Naulbunrang, &Kawngdang, 2006; Kikafunda, Abenakyo, &Lukwago, 2006).Blanching helps inactivate the enzymes, retain the color and prevent cooking of the pumpkins (Noreña&Rigon, 2018). The grated pumpkin and carrot were then dried using KleinsDehy-Tray (JUA Technologies International, USA) at 75℃ for 6 hours to retain the heat sensitive vitamins-Vitamin A. They were milled using a small laboratory grinder (Bountiful International, USA) to obtain the pumpkin flour and carrot flour. The flours were sieved and immediately packaged in airtight plastic containers and stored in a cool and dry place at room temperatures (20-25˚C) until use (Nahemiah, Nkama, Badau, &Idakwo, 2017; Pongjanta et al., 2006).

Preparation of grain amaranth flour

The grain amaranth was weighed and sorted to separate from the chaff. They were then washed with deionized water and dried using KleinsDehy-Tray (JUA Technologies International, USA) at 75 ℃ for 8 hours to ensure complete removal of the moisture(Sindhuja, Sudha, & Rahim, 2005). The grains were then milled using a small laboratory grinder (Bountiful International, USA) to obtain the grain amaranth flour which was immediately stored in airtight containers at room temperature (20-25˚C) (Nahemiah et al., 2017)**.**

Preparation of rice flour

Locally sourced rice grains were weighed, washed, dried and milled using a grinder (Bountiful International, USA) to get the rice powder which was then sieved and stored in airtight containers at room temperature (Nahemiah et al., 2017; FFTC, 2004).

Preparation of baobab flour

Baobab was obtained locally from Markiti market, Mombasa- Kenya. It was deseeded to get the powder, and then sieved to obtain the fine baobab powder.

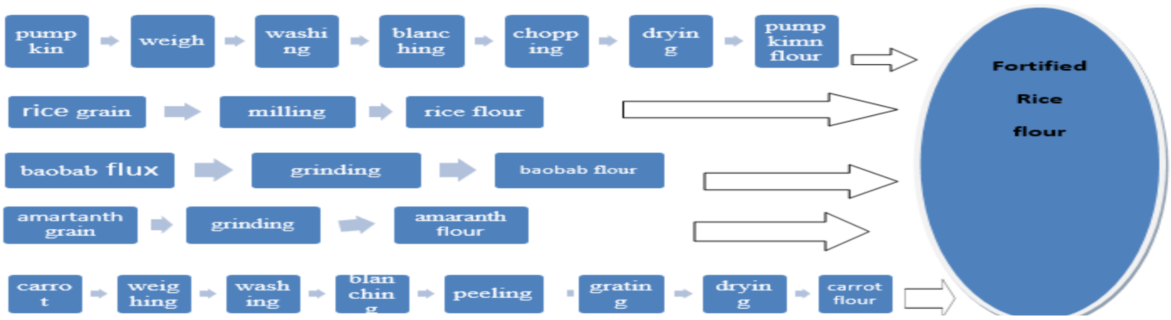

Figure 1: Flow chart for preparation of VARF

Flour variation composites

After processing the flours, four variations of food to food composites were prepared with a variation in the rice, maize and sorghum cereals used (whereas 100% rice flour was the control).Table 2 shows the percentage of ingredients per sample which were immediately packed in batches of 1kg in aluminum laminated packages and stored in plastic buckets at room temperature (25±5°C) until use. The composite had different flour compositions as shown in Table 2. Sample AT5 was made as a reference sample.

Table 2: Composition of composite samples

INGREDIENTS	Samples (%)				
	AT1 AT5		AT2	AT3	AT4
Rice	70	45.5	35	23.3	100
Maize	_	24.5	35	23.3	_
Sorghum	_	_	_	23.3	_
Pumpkin	7.5	7.5	7.5	7.5	_
Carrots	7.5	7.5	7.5	7.5	_
Baobab	5	5	5	5	_
Amaranth	10	10	10	10	_
Total	100	100	100	100	100

Preparation of porridge for sensory evaluation

The conventional porridges were prepared for sensory evaluation based on the VARF flours variations. The cooking process entailed mixing 350 mL ambient temperature water with flour to form slurry. The slurry was then poured to 850 mL of boiling water in a small (2L) saucepan with stirring to avoid lump formation. The mixture was then brought to boil with vigorous stirring and then simmered at low heat (hot plate) for 30 min with occasional stirring. For each tasting, 5- porridge samples were cooked in a batch, allowing for a 5-min interval between cooking cycles (between samples). Once ready, the porridge was held in coded thermos vacuum flask and then served to consumers within 10 min interval (Oladeji et al., 2016).Five batches of porridges were prepared and evaluated.

Production of composite products for affective tests

This composite flour was utilized in the preparation of 5 bakery products namely; cakes, crackles, rice pancakes, cookies and doughnuts. Minimal ingredients were added for purposes of cost effectiveness. Sugar and fat levels were lower than for conventional recipes.

Consumer sensory analysis

An untrained panel comprising of sixty (60) people was used for consumer preference evaluation. The 5-point hedonic scale for evaluating sensory characteristics such as color, taste, flavor and texture was used to evaluate VARCs porridges. The prepared porridge was kept in coded thermos vacuum flask. Each participant was provided with hot porridge samples (50g) in a 100 ml coded disposable cup. The 5-porridges were provided simultaneously on tray in systematic random order and each participant was asked to taste and evaluate each product in the established order on the 5-point scale (1-dislike very much, 2-dislike, 3-neither like nor dislike, 4-like, 5-like very much). Water was also availed to each participant to rinse the palates before testing the next sample. The sensory attributes used were after appearance, aroma, taste, flavor, texture and overall acceptability. The tests were conducted double blind; neither the participants nor the enumerators knew the ingredients' in the porridges. Evaluation of bakery products also followed a similar procedure. Evaluation was done over a 2-day period.

Ethical approval

The researcher sought permission from the University of Eldoret authority to conduct the study in the same university. The consent procedure involved the subjects being informed about the purpose of the study and their rights to confidentiality of information collected.

Data analysis

Sensory evaluation data was subjected to statistical analysis using SPSS software (v. 22, SPSS Inc., Chicago, IL, USA). Correlation analysis and multiple regression analysis was used to test the hypothesis. Duncan's Multiple Range Test (DMRT) was performed to determine the effects of variables and determine the differences between mean values.

III. RESULTS AND DISCUSSION

Sensory evaluation of products made from the value-added rice composites

Figure 2 shows that consumers generally appreciated the different products and made significant distinction among them. In terms of appearance, AT4 was ranked the highest with a mean value of 20.5% followed by AT5 and AT1 of 19.2%. AT3 had the least preferred appearance with 11.0%. The aromas of AT5 followed by AT4 were the most preferred with 22% and 16% respectively. AT3 had the least preferred aroma with 12%. The taste for AT4 and AT5 was the best with 26% and 18% respectively. AT1 had the least preferred taste with 11%. The flavor for AT5 followed by AT2 were the most liked with 22% and 21% of the respondents respectively. AT2 was the least preferred flavor by10 % of the respondents. The textures for AT5 and AT2 were the most preferred by 34% and 21% of the panelists respectively. AT3 had the least preferred texture among 12% of the panelists. In terms of overall acceptability, AT1 was the most acceptable product followed by AT4 scoring 34% and 33% respectively. AT3 was the least acceptable witha mean score of 15%.

Figure 2: Consumer sensory evaluation on a 5- point Likert scale, for parameters, appearance, aroma, taste, flavor, texture and overall acceptability. (X-axis represents percentage of respondents).

Analysis of variance was carried out to determine the differences between the consumer choices of the respective products as shown in Table 3. In terms of appearance, AT4 was the most preferred with a mean value of 3.74 followed by AT1 with a mean value of 3.71. Although the appearance score for AT5 was the least preferred with a mean value of 3.33, a significant difference in terms of appearance was observed between AT1 and AT5 while there was no significant differences between AT1 and AT4, and AT2, AT3 and AT5 ($p<0.005$).

Table 3: Analysis of products scores for appearance, aroma, taste, texture, flavor and overall acceptability one-way ANOVA

Treatment	Attribute					
	Appearance	Aroma	Taste	Flavor	Texture	Overall acceptability
AT1	3.71 ± 0.920^{a}	3.64 ± 1.032^{a}	3.33 ± 1.028^{a}	3.44 ± 1.067^{a}	3.66 ± 1.003^{a}	3.97 ± 1.000^{a}
AT2	$3.53\pm0.944^{a,b}$	3.62 ± 0.937^{a}	3.55 ± 0.972^{a}	3.52 ± 0.944^{a}	3.68 ± 0.814^{a}	3.82 ± 0.839^{a}
AT3	$3.52\pm0.944^{a,b}$	3.66 ± 0.803^{a}	3.53 ± 1.042^{a}	3.70 ± 0.908^{a}	3.74 ± 0.800^{a}	3.74 ± 0.800^{a}
AT4	3.74 ± 1.000^{a}	3.68 ± 0.896^{a}	3.66 ± 1.083^{a}	3.70 ± 0.982^{a}	4.25 ± 0.928^{a}	4.01 ± 0.874^{a}
AT5	3.33 ± 1.281^{b}	3.64 ± 1.110^{a}	3.45 ± 1.191^{a}	3.53 ± 1.144^{a}	3.78 ± 1.181^{a}	3.70 ± 0.967^{a}

Values with the same superscript are not different, (p value <0.05)

Similar results were recorded by Saleh, Zhang, Chen, & Shen, (2013). AT4 had sorghum which might have influenced the color of the porridge hence its appearance being the most preferred.In terms of aroma, AT4 and AT3 had the best aroma with a mean value of 3.68 and 3.66 respectively, AT2 had the least preferred aroma with a mean value of 3.62 however, there was no significance difference observed between the samples, i.e. AT1, AT2, AT3 AT4 and AT5 ($p<0.005$). The tastes of AT4 followed by AT2 were the most liked with a mean value of 3.66 and 3.55 respectively. AT1 had the least preferred taste with a mean value of 3.33 (Table 3). No significant difference was observed between the samples ($p<0.005$). The results were consistent with Saleh et al., (2013) who suggested that millet in the product might have influenced the taste of the product.

In terms of flavor no significant difference was observed between the samples, the findings were consistent with Oladeji et al., (2016). The porridge was composed of different flours, and this might have influenced the taste. AT4 and AT3 had the best flavor with a mean value of 3.7 followed by AT5 which had a mean of 3.5. The flavor in AT1 was least preferred with a mean value of 3.44 (Table 3). The products were almost similar since there was no significant difference observed between the samples. The texture of AT4 was most preferred with a mean value of 4.25 followed by AT5 which had a mean of 3.8 (Table 3). These findings were consistent with those observed by (Ndagire, Muyonga, Manju, &Nakimbugwe, 2015). AT1 had the least preferred texture with a mean of 3.66. The texture of AT2 and AT3 were disliked probably because of the high composition of maize which despite the flour being finely milled, and sieved, it had some large irregular shaped particles which might have passed through the sieve and were detectable in the mouth (Tortoe et al., 2014). No significant difference observed between AT1, AT2 AT3 AT4 and AT5 ($p <0.005$).

In terms of overall acceptability, AT4 was the most acceptable product with a mean value of 4.01 followed by AT1 which had a mean value of 3.9. Kikafunda et al., (2006) reported comparable results, due to its taste and texture, figure millet is highly influential, and it probably influenced the overall acceptability of AT4 since it had finger millet in its initial formulation. AT5 was the least accepted product with a mean value of 3.70 (Table 3). AT5 had rice flour in the initial formulation; therefore, its porridge was just white in color due to rice color which might have influenced its overall acceptability. Similar results were recorded by Tortoe et al., (2014) who found out that color is a correlating factor to overall acceptability in meat.

Affective test of the value-added rice products

Baked products were made from the VARCs, the products were coded as; rice cookies-CT1, Crackles-CT2, Rice cake-CT3, Doughnuts-CT4, & Rice pancakes (plain)-CT5 and were then evaluated by 60 untrained panelists as shown in Table 4.

Table 4: Analysis of products scores for appearance, aroma, taste, texture, flavor and overall acceptability one-way ANOVA

Treatments	Attributes					
	Appearance	Aroma	Taste	Flavor	Texture	Overall acceptability
CT1	4.08±0.696[a]	4.20±0.576[b]	4.45±0.675[a,b]	4.37±0.712[a,b]	4.23±0.673[b]	4.28±0.163[a]
CT2	4.07±0.800[a]	4.07±0.710[b,c]	4.25±0.756[b,c]	4.23±0.722[b,c]	4.20±0.798[b]	4.25±0.632[a]
CT3	4.55±0.534[a]	4.62±0.555[a]	4.62±0.555[a]	4.52±0.624[a]	4.67±0.542[a]	4.65±0.481[a]
CT4	4.03±0.688[a]	3.82±0.676[c]	3.92±0.720[d]	4.02±0.833[c]	3.98±0.701[b]	4.03±0.581[a]
CT5	4.12±0.715[a]	3.97±0.780[b,c]	4.13±0.83[c,d]	3.97±0.76[c]	4.08±0.829[b]	4.14±0.681[a]

Values with the same superscript in the same column are the same (p<0.05)

Treatment CT3 scored higher in all attributes (p <0.05). CT4 and CT2 scored relatively lower in all the attributes (p<0.05). There was no significant difference between all the products (CT1, CT2, CT3, CT4 and CT5) in terms of appearance. There was no significant difference noted between CT5 and CT2. However, a significant difference was noted between CT1, CT3 and CT4 in their aromas. A significant difference existed between all the products in terms of taste. For the product's flavor; there was no significant difference between CT4 and CT5 (Table 4).

A significant difference was noted between CT1, CT2 and CT3, the same products were also different from CT4 and CT5.In terms of texture, there was no significant difference between CT1, CT2, CT4 and CT5, a significant difference existed between the other products and CT3 There was no significant difference between CT1, CT2, CT3, CT4 and CT5 in the overall acceptability (Table 4).

Table 5:Analysis of consumer scores for different attributes and overall acceptability using regression ordinal with random effects (CT5 as the base product, plain rice flour pancakes).

Group	Var.	Appearance			Aroma			Taste			Flavor			Texture			Overall acceptability		
Prod.		Esti.	SE.	P-value	Esti.	SESE	P-value	Esti.	SESE	P-value	Esti.	SES	P-value	Esti.	SESE	P-value	Esti	SES	P-value
	CT1	-0.191	0.358	0.594	0.587	0.357	**0.018**	0.844	0.357	**0.018**	1.078	0.353	**0.002**	0.298	0.349	0.394	0.545	0.369	0.140
	CT2	-0.025	0.357	0.944	0.271	0.357	0.407	0.293	0.353	0.407	0.688	0.349	0.049	0.322	0.349	0.356	0.383	0.372	0.303
	CT3	1.183	0.365	**0.001**	1.967	0.379	**0.000**	1.365	0.370	**0.000**	1.490	0.362	**0.000**	1.698	0.379	**0.00**	1.670	0.382	**0.000**
	CT4	-0.286	0.358	0.425	-0.475	0.357	0.183	-0.718	0.356	**0.044**	0.154	0.346	0.657	-0.329	0.349	0.346	-0.439	0.379	0.247
Age		-0.039	0.018	**0.032**	-0.032	0.018	0.074	-0.033	0.018	0.066	0.003	0.018	0.860	-0.041	0.018	**0.024**	-0.014	0.019	0.451
N participants		60			60			60			60			60			60		
-2 log likelihood		351.6			325.6			353.2			353.5			353.9			295.8		
Note: the estimated coefficients are log-odds ratios; they represent a comparison of the 4 composite products with base product CT5, plain rice pancake. Dependent variables are hedonic score is the score for sensory evaluation (on a scale from 1 = dislike very much, to 5 = like very much) for the five sensory characteristics.																			

Consumers gave different scores to the composite bakery products for the different attributes indicating that the flours were distinguishable (Table 5). CT3 was scored higher for all the attributes (p<0.05). CT4 and CT2 were scored lowest for all the attributes which were not statistically different from the base product-CT5 (p>0.05). Scores for CT1 were higher for aroma (p=0.018), taste (p=0.018) and flavor (p=0.002) while its scores for appearance, texture and overall acceptability were not statistically different from the base product CT5 (all p >0.05) (Table 5).

Differences in appearance scores for the products probably were due to Maillard browning a reaction between the protein and the carbohydrates. Cooking affects the color of the resulting products (Oladeji et al., 2016). Comparable findings were recorded by Tamanna& Mahmood, (2015) who reported that color affects choice. Mohammed, Ahmed, &Senge, (2012) reported that value addition of a product increases the nutritional value and influences the eating quality, the flavor, the taste, aroma and appearance of cooked products. Sivakanthan, Nithyanantharajah, Vasantharuba, &Sandrasegarampillai, (2010) reported that baking influences the flavor of a product due to presence of flavorings. CT3 was a cake which was baked using sugar and artificial straw berry flavors and this might have attributed it having the most preferred taste and overall acceptability. Tamanna& Mahmood, (2015) findings reported that gelatinization temperature influences the texture of a product. CT3 was a cake baked at 250^0C for 45 minutes. This increased the gelatinization temperature and might have influenced the texture of the end product. In terms of overall acceptability, CT3 was the most preferred product followed by CT1 with an estimate of 1.670 and 0.545 respectively. CT4 was the least preferred product with an estimate of -0.439.

IV. CONCLUSION

Consumers expressed their interest in value added rice products. Almost two thirds (63.3%) and more than half (58.3%) of the respondents were very willing to pay for the products and were ready to adopt them in their menus respectively. Therefore, more efforts should go towards value addition of rice and to curb post-harvest losses incurred by rice grain farmers as well as African indigenous crops such as pumpkins. This will result to an improved food security state in Kenya and reduce malnutrition levels. It will also diversify the uses of rice and lead to diversified forms of rice products consumed in Kenya.

Compliance with ethical standards

Conflict of interest:The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Research involving human participants: Written informed consents were obtained from each participating individuals.

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