Measuring Consumer Interest in Sorghum Composite Flours in Western Kenya

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Abstract- In western Kenya, sorghum (*Sorghum bicolor)* remains an important crop for rural food and nutrition security. Sorghum is a rich source of various phytochemicals including tannins, phenolic acids, anthocyanins and phytosterols which have the potential to significantly impact on human health. On the other hand, sorghum producing areas still experience periodic food deficits due to environmental changes and limited knowledge on diversity in utilization. This study investigated consumer interest in fortified sorghum flours and sorghum composite products. Results of consumer affective tests showed that tannin levels affected sensory characteristics of sorghum products i.e. low and free tannin levels would be preferred in sorghum products. Additionally, quality attributes such colour of high tannin varieties were more acceptable to consumers. After taste showed highest correlation with flavour (r=0.852), texture (r=0.692) and acceptability (r=0.774) for MKT-Red sorghum flour. Seredo, a low tannin variety showed high correlation between after taste and aroma (r=0.746), in flavour (r=0.747), texture (r=0.762) and overall acceptability (r=0.772). Results for composite products showed an average score of above 60% which was an indication of high acceptability of the products. Based on the potential benefits of sorghum, production and utilization should be prioritized to enhance household food and nutrition diversity.

Index Terms- Composite flour | Sensory evaluation | Sorghum | Tannins.

I. Introduction

Sorghum (*Sorghum bicolor* L. Moench) is the fifth most important cereal crop in the world after rice (*Oryza sativa*), barley (*Hordeum vulgare L.*), wheat (*Triticum aestivum*) and maize (*Zea mays*) [1,2]. It is a staple food crop for millions of the poorest and most food and nutrition insecure people in the semi-arid tropics of Asia and Africa [3]. The crop is agronomically suited to hot and dry agroecologies where other crops do not grow easily [3,4]. Sorghum is also characterized by an extensive root system, waxy bloom that reduces water loss, ability to stop growth in periods of drought and resume it when water stress is relieved and C4 photosynthesis [1,4,5]. These characteristics have made the crop adaptable to most arid and semi-arid regions of Kenya and therefore, has been accepted as an important hunger crop [4,6]. The crop performs well in areas between 500 metres and 1700 metres above sea level, with seasonal rainfall of 300 mm and above. In Kenya, it is grown in the often drought-prone marginal agricultural areas of Eastern region (1385m ASL, 76mm month^{-1}), Western region (1190m ASL, 130mm month^{-1}) and Coastal region (185m ASL, 87mm month^{-1}) [4].

In many parts of western Kenya, sorghum is an important food and feed crop and therefore, remains an important crop for rural food and nutrition security, income generation and food culture of the rural poor [5,7,8]. Amusala *et al.* (2012) [9] stated that grain yield of sorghum will decline by about 17% owing to climate change and this if not checked, environmental issues and drought in western Kenya may lead to decline in production and utilization of sorghum despite drought tolerant sorghum varieties having been developed and deployed. Since western Kenya still experiences food deficits, the production of the crop must be increased in order to ensure food and income security through the development of improved sorghum varieties and technologies [1,9].

Sorghum farming is mainly by small holder farmers who use low input levels and have limited access to new technologies. Farmers have always grown red sorghum varieties, but in small quantities and this has led to decline in sorghum yields to less than 1.0 t/ha, [5,7]. Decline in production, especially the popular landraces grown by farmers is attributed to perceptions of sorghum as a poor man's food of little nutritional value [10]. This negative perception has also frustrated governments effort to promote sorghum as a viable crop and commercially marketable food. As a result of low production, the market outlets for sorghum have stagnated [2]. Okuthe et al. (2013) [7] reported that prevalence of striga weeds, high soil acidity and competition from sugarcane and maize production also affects its farming and utilization. Since sorghum potential value is under-estimated and under-exploited, sorghum crop is in danger of continued decline in utilization as well as genetic erosion and disappearance. However, despite sorghum being neglected and regarded to be of low potential, it has one of the largest germ plasm collections, which could provide great opportunity for sustainable crop production, provide extra income for farmers, provide dietary diversity and enhance smallholder farm households nutritional wellbeing [10].

A wide variety of traditional fermented and non-fermented food products and recipes in western Kenya are based on sorghum namely and these include porridge, ugali, pilau and other traditional dishes where it is consumed with protein and vegetable sources [5,8,11]. Besides providing calories, sorghum has actual nutritional value in principle, due to its content of vitamins, both fat-soluble (D, E and K) and the B group, protein as well as minerals, such as iron, phosphorus and zinc[11]. In composition, sorghum compares favourably with other renowned cereals: it's protein content is similar to wheat but higher than maize and rice, while its essential amino acid profile is comparable to maize or wheat due to the limited content of threonine, arginine and lysine [4,11]. In particular, sorghum's main storage proteins kafirins (aqueous alcohol-soluble prolamins) are devoid of lysine amino acid, thus, the abundance of kafirins in a given sorghum variety has a direct negative impact on its nutritional value [11,12] In contrast, sorghum proteins contain a relatively high proportion of leucine, in particular compared to isoleucine, which determines an unfavourable leucine/isoleucine balance [13]. Due to its lack of gluten, sorghum whole grains could be considered a suitable complementary diet for people with coeliac disease [14]. Iron content of sorghum is lower than millet but is higher than wheat, maize and rice [12]. Duncan et al. (2013) [4] stated that sorghum has high levels of iron (>70 ppm) and zinc (> 50 ppm) hence may be used to reduce micronutrient malnutrition.

Despite sorghum having some vital nutrients, its nutritional value is compromised to a certain extent by its contents i.e. low protein digestibility and activity of antinutrients: phenolic compounds, mainly condensed tannins, and phytic acid. The low digestibility of sorghum in comparison to other cereals is presumably due to the proteins high cross linking and kafirins location primarily on the periphery of the protein bodies [11,15]. Close packing of starch granules and protein bodies in the endosperm also lowers protein digestibility. The implication of such a close association between starch and protein may be that the starch, especially when gelatinised after cooking, could reduce the accessibility of proteolytic enzymes to the protein bodies and therefore reduce protein digestibility [13].The antinutrients groups of tannins and phytates interact negatively with the bio-accessibility of essential nutrients in the digestive tract, particularly iron and zinc; moreover, tannins further reduce the digestibility of sorghum's proteins. Tannins are also able to bind human gut enzymes involved in cereal digestion. The general mechanism involves formation of insoluble complexes at physiological pH, due to the ability of phytic acid and tannins to bind proteins and divalent cations [1,13,15]. Consequently, the anti-nutrients elicit an unbalanced intake of essential elements as well as reduce the availability of amino acids and metabolized energy. In contrast, these antinutrients may also have potential positive impacts; tannins may act as antioxidant scavengers of free radicals, thus contributing to the prevention of chronic pathologies such as cancer and cardiovascular diseases. Similarly, phytates acts as anti-oxidants by binding iron ions in solution, and thereby prevent ferric irons from participating to the generation of the hydroxyl radical as well as reduction in bioavailability of heavy metals like cadmium and lead [11]. Sorghum has also gained industrial relevance where the grains are used to manufacture wax , starch, wax, starch, syrup, alcohol, dextrose agar, edible oils and gluten feed [8] while sorghum stalks are used as dry season fodder and fencing materials [7].

Although more attention should be devoted to the beneficial effects of antinutrients, however, in western Kenya, the high intake of tannins in traditional cultivars grown and the consequent impaired bioavailability of essential elements and proteins may cause health disorders especially in pregnancy and early childhood. Consequently, enhancing nutritional value of sorghum through food to food fortification to enhance absorption and acceptability may improve the nutritional status of vulnerable groups of a population. Therefore, this study sought to measure consumer interest in sorghum fortified products through affective tests.

II. METHODS AND MATERIALS

Sorghum selection

Five types of sorghum that are popularly used to make porridge were procured from both research centre Kenya Agricultural and Livestock Research Organization (KALRO) and smallholder farmers from western Kenya and these represented grains with a wide range of tannins. Characterization of the sorghum varieties according to their tannin levels was done using the bleach test as described in Khoddami et al. (2017) [16]. Quantification of tannin levels in the sorghum grain varieties was based on standards described by Awika & Rooney (2004) whereby tannin contents in dry weights ranged between 10.0-68.0 mg/g and 0.5-3.8 mg/g for high and low tannin varieties respectively. The sorghum grain varieties were milled to produce sorghum flour and thereafter coded as follows, E1-High tannin sorghum, E97-Low tannin sorghum, MKT-RED-high tannin sorghum, SEREDO-low tannin sorghum, T30b-1 No tannin sorghum.

Product categories for evaluation

In this study, two categories of products were evaluated i.e. porridge made from the 5-types of sorghum characterized by their tannin levels and 6–bakery products made from sorghum composite flour (T30b-1-free tannin variety). Porridges were evaluated by 110 consumers drawn from both urban and rural areas of the study site while composite flour products were evaluated by thirty (30) trained panelists comprising of students and staff in the school of Agriculture, University of Eldoret but were from western Kenya region as shown in Figure 1.

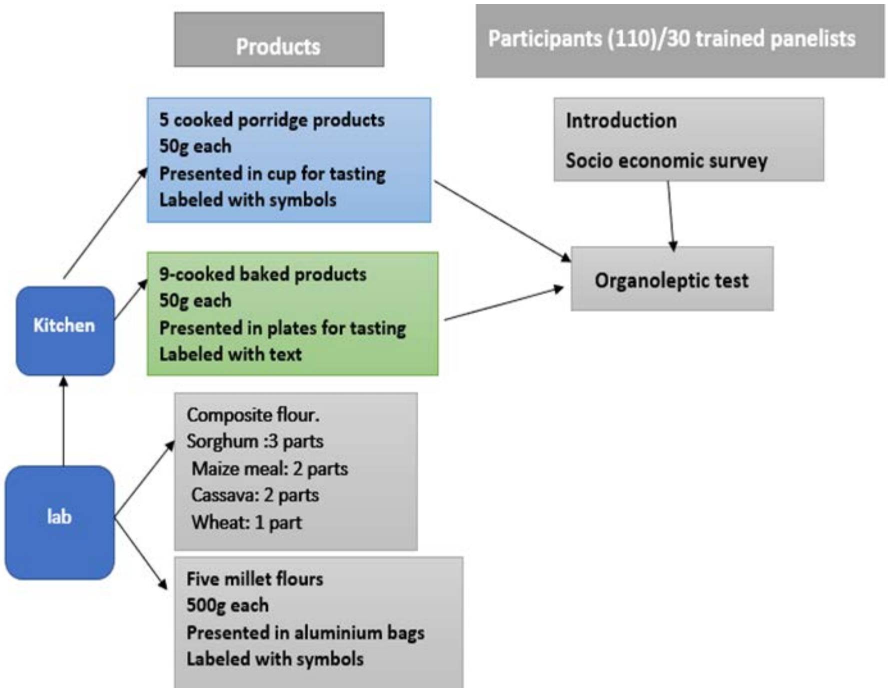

Figure 1. Study design

Preparation of sorghum flour

Each sorghum grain type was milled in a laboratory grinding mill to make sorghum flour that was immediately packed in batches of 1kg in aluminium laminated packages and stored in plastic buckets at room temperature (25± 5°C) until use.

Composite flour

A composite flour was made out of sorghum (T30b-1-free tannin variety) comprising of sorghum: maize meal: cassava: wheat in the ratio of 3:2:2:1. This composite flour was utilized in the preparation of six bakery products namely; sorghum cakes, scones, chapati, biscuits, doughnuts and zimbare. Minimal ingredients were added for purposes of cost effectiveness. Sugar and fat levels were lower than for conventional recipes. They had higher ratios of sorghum than other cereal grains since it is the staple cereal of small holder farmers in the regions.

Preparation of sorghum porridge

The conventional porridges were prepared for sensory evaluation based on the selected sorghum grain varieties. 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 (2 L) 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). The porridge. Once ready, the porridge was held in coded thermos vacuum flask and then served to consumers within 10 min interval. Four batches of porridges (20 porridges) were prepared and evaluated each day.

Selection of site and participants for sorghum porridge evaluation

The study was conducted at western Kenya which extends between 0° 30′N and 34°30′E. The study covered two regions namely; Matayos, an urban zone and Koyonzo, a rural zone. Western region forms part of the extensive basin around Lake Victoria. It consists of mainly of faulted plateaus marked by escarpments that descend gently from the Kenya Highlands to the lakeshore. The target population were consumers of sorghum from both the rural and urban zones within the two regions. The inclusion criteria included men and women who consume or use sorghum products in their homes or places of work and at least 18 years of age. And for evaluation of sorghum porridges, 110 consumers men and women were used. In collaboration with the relevant administration, a list of adult women and men was drawn, and 55 names were randomly drawn from each zone with an extra ten (10) as reserve. The selected participants were contacted and invited to participate in the study on specific dates. Actual evaluation and experiment took place in a large hall with enumerators seated at individual tables to conduct sensory evaluation with one consumer at a time. Porridge was prepared on a separate kitchen and participants were invited into the hall, in small groups or individually. They were registered, and the procedure briefly explained to them, they were then asked to give their informed consent. Invited participants who did not show up were replaced by those in the reserve list in the order they were drawn.

Sensory evaluation of sorghum porridge

The widely used 5-point hedonic scale for evaluating sensory characteristics such as colour, taste, flavour and texture was used to evaluate sorghum porridge [17]. The prepared porridge was kept in coded thermos vacuum flask. Each participant was provided with hot porridge samples (50 g) 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 or 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 taste, appearance, flavour, overall acceptability, aroma and texture. The tests were conducted double blind; neither the participants nor the enumerators knew the tannin levels in the porridges. Evaluation was done over a 2-day period (1-day per site).

Sensory evaluation of composite products

Sensory evaluation of products made from composite flour was done by a trained panelists of 12-people of western Kenya origin in the food processing laboratory, University of Eldoret. The trained panelists evaluated the food on a 9-point hedonic scale (1= very extremely disliked and 9= very extremely highly) scale based on sensory attributes of colour, texture, taste, flavour and acceptability. Two evaluation sessions were conducted per day over a 2-day period involving 6 panelists per day. A randomized complete block design was used whereby during each session, all six samples were randomly presented to each panelist. To avoid fatigue, panelists first evaluated a set of 3-samples, followed by a ten (10) minutes break before evaluating a second set of 3 samples. Each sample was presented as pieces on a transparent plastic plate, identified with three-digit codes. Panelists assessed the samples while seated in individual sensory booths under red light. Red light in the tasting area was used to mask the colour of the porridges for the panellists in order to concentrate on aroma, texture and flavour properties. Each panelist was also provided with a glass of water to rinse the palate before and between tasting of samples.

Data Analysis

Data were analyzed using Microsoft Excel 2010 and SPSS software (v. 16, SPSS Inc., Chicago, IL, USA) to derive mean differences and standard deviation of the quality attributes. ANOVA test was used to determine the differences between means of rural and urban respondents. Differences were significant for the sensory evaluation of porridge when the p-value < 0.05. Pearson correlation coefficients were generated to quantify the level of association between sensory attributes and characterized sorghum varieties. Results for composite products evaluation were reported as means and standard deviations.

III. RESULTS AND DISCUSSION

Consumer characteristics

Both men and women were represented well in the sample. More than half of the participants (53.6%) were women and the average age was 35.7 years ranging from 19 to 57 years. Two thirds of the participants had received formal education however, socio economic indicators like family size and income level were not asked during the study.

Sensory evaluation of sorghum flour porridges.

Table 1 presents results from the mean sensory scores of porridges from sorghum flour with different tannin levels. The ANOVA test of differences between means showed that rural respondents scored higher means for after taste in high tannin and free tannin varieties of sorghum while urban respondents showed no preference between low/free and high tannin varieties even though the means scores were high in the range of 3.4-4.0 respectively. A similar trend was also observed in scores for flavour in both categories of respondents thus an indication that taste influences flavour and overall acceptability. A similar result was obtained by Timu et al. (2014) [18] on the role of varietal attributes on adoption of improved sorghum seed varieties whereby consumption attributes like taste was scored high by rural farmers in Kenya upon consumption of local sorghum varieties (reddish in colour). A review by Drewnowski and Gomez-Carneros (2000) [19] on possible causes of bitterness (after taste) in cereal grains revealed that bitterness may be due to trace quantities of low molecular weight phenolic compounds such as flavonoids, microbial metabolites, rancid oils, and hydrolysed proteins. The sorghum flour which had high tannin contents (>10.0mg/g dry weight) presumably had higher amounts of flavonoids (condensed tannins), hence leading to high scores in after taste. However, high scores by both urban and rural respondents for after taste in free tannin sorghum porridge suggests the presence of other phenolic compounds in sorghum flour. Kebakile et al. (2008) [20] reported that bran infusion from tannin free sorghum with variable phenolic compounds after milling were slightly bitter and astringent and this was attributed to catechin and procyanidin B1, the common monomer and dimer, respectively, in sorghum.

With regard to appearance, both rural and urban consumers showed no preference between high and low/free tannin sorghums suggesting that the reddish colour of high tannin sorghum varieties is not a discriminating factor in selection. With regard to aroma, rural respondents scored highly for porridge made from low/free tannin (with mean score value of 4.5) thus, an indication of high preference while the score for high/low tannin variety porridges ranged between 3.5-4.0, thus an indication of no preference. On the other hand, urban respondents with a higher mean score value (>4.0) for all the sorghum varieties showed no preference for aroma. The differences between means indicate that for both rural and urban respondents, low tannin and no tannin varieties scored higher means in acceptability, an indication that during further food processing, low and free-tannin sorghum varieties will be suitable in the development of composite flours as well as adoption by the community members.

	ANOVA	E1 High tannin Sorghum	E97 Low tannin Sorghum	MKT-RED High tannin Sorghum	SEREDO Low tannin Sorghum	T30b-1 No tannin Sorghum
Rural						
After taste	***	3.5^{ab} ± 0.2	3.0^{b}± 0.2	3.7^{a} ± 0.2	3.1^{b} ± 0.1	4.1^{b}± 0.1
Appearance	NS	4.1^{c} ± 0.1	4.0^{bc} ± 0.2	3.7^{c} ± 0.2	4.0^{b} ± 0.1	4.6^{a} ± 0.1
Flavour	NS	2.9^{a} ± 0.2	3.4^{b} ± 0.1	3.7^{a} ± 0.1	4.3^{b} ± 0.1	4.5^{b} ± 0.1
Aroma	***	3.5^{ab} ± 0.1	3.6^{b} ± 0.1	3.6^{b} ± 0.1	4.0^{ab} ± 0.1	4.5^{a}± 0.1
Acceptability	***	3.5^{ab} ± 0.1	3.6^{ab} ± 0.1	3.4^{a} ± 0.2	4.1^{ab} ± 0.1	4.4^{b} ± 0.1
Urban						
After taste	*	3.7^{ab} ± 0.1	3.9^{b} ± 0.1	3.4^{a} ± 0.1	4.0^{b} ± 0.1	4.0^{b} ± 0.1
Appearance	***	4.4^{c} ± 0.1	4.2^{bc} ± 0.1	4.4^{c} ± 0.1	4.0^{b} ± 0.1	3.5^{a} ± 0.1
Flavour	***	3.4^{a} ± 0.1	3.9^{b} ± 0.1	3.2^{a} ± 0.2	4.1^{b} ± 0.1	4.1^{b} ± 0.1
Aroma	NS	4.2^{ab} ± 0.1	4.3^{b} ± 0.1	4.4^{b} ± 0.1	4.1^{ab} ± 0.1	4.0^{a} ± 0.0
Acceptability	NS	3.8^{ab} ± 0.1	4.0^{b} ± 0.1	3.6^{a} ± 0.1	4.0^{ab} ± 0.1	4.1^{b} ± 0.1

Table 1. Sensory profiling of sorghum flours with different tannin levels used for porridge.

*** P-value < 0.001, * P-value < 0.05, NS-=not significant, Mean values with different superscript in the same column are significant.

Correlation between sensory attributes of sorghum porridges and demographic data.

Table 2 shows the correlation between sensory attributes of porridge made from the different sorghum varieties and demographic data (age and gender). Gender and age did not show any significant relationship with consumer rating of other sensory attributes. This is in agreement with Aboubacar et al. (1999) [21] study conducted in Niger on important sensory attributes affecting consumer acceptance of sorghum porridge which indicated that appearance and colour were less important in affecting consumer acceptance. Phenolics in sorghum grain contribute to the bitterness and astringency of sorghum, therefore, it is noteworthy that all the sorghum cultivars (tannin and tannin-free) are perceived as bitter and astringent at least to some extent thereby contributing to after taste upon consumption. Correlation coefficients for after taste was significant for overall acceptability of E1 ($r = 0.552$, $p<0.0001$) and flavour ($r = 0.648$, $p<0.0001$), texture ($r = 0.603$, $p<0.0001$) and overall accessibility ($r = 0.768$, $p<0.0001$) for E97. Significant correlation was also observed between after taste and flavour ($r=0.648$, $p<0.0001$) and texture ($r=0.603$, $p<0.0001$) of E97. After taste was positively correlated with overall acceptability of all the sorghum varieties indicating that it was a vital parameter in consumer selection and adoption of the sorghum varieties.

Table 2: Pearson correlation coefficient between sensory attributes of sorghum porridge and demographics

Numbers in parenthesis represent p-values for correlations made.
Significant differences ($p < 0.05$) are designated by bold text.

Products	Variables	Appearance	Aroma	Flavour	Texture	Overall acceptability	After taste
E1	Age	0.171(0.211)	-0.091(0.510)	-0.135(0.323)	0.062(0.653)	-0.003(0.998)	0.135(0.327)
	Gender	0.061(0.657)	0.167(0.223)	0.029(0.835)	-0.066(0.632)	-0.136(0.323)	0.227(0.040)
	After taste	0.188(0.169)	0.220(0.106)	0.423(0.001)	0.472(0.003)	**0.552(<0.0001)**	1
E97	Age	-0.072(0.603)	-0.045(0.742)	0.120(0.383)	0.036(0.791)	-0.015(0.915)	-0.016(0.231)
	Gender	0.3464(0.802)	-0.162(0.235)	-0.142(0.030)	-0.230(0.030)	-0.187(0.172)	-0.218(0.110)
	After taste	0.161(0.241)	0.255(0.060)	**0.648(<0.0001)**	**0.603(<0.0001)**	**0.768(<0.0001)**	1
T30b-1	Age	-0.188(0.173)	-0.153(0.269)	-0.171(0.215)	-0.039(0.778)	**0.736(<0.0001)**	-0.277(0.043)
	Gender	0.063(0.653)	0.1635(0.238)	0.172(0.216)	-0.037(0.791)	0.453(0.006)	0.117(0.399)
	After taste	0.336(0.013)	**0.596(<0.0001)**	**0.691(<0.0001)**	**0.697(<0.0001)**	0.263(0.055)	1
Seredo	Age	0.194(0.159)	0.085(0.543)	0.010(0.937)	0.141(0.309)	0.007(0.959)	0.095(0.517)
	Gender	-0.032(0.818)	-0.027(0.845)	-0.134(0.339)	-0.026(0.055)	-0.243(0.076)	-0.243(0.07)
	After taste	0.482(0.002)	**0.746(<0.0001)**	**0.747(<0.0001)**	**0.762(<0.0001)**	**0.772(<0.0001)**	1
MKT-Red	Age	0.034(0.806)	-0.188(0.173)	0.006(0.963)	-0.022(0.087)	-0.094(0.049)	0.035(0.799)
	Gender	-0.111(0.422)	0.171(0.216)	-0.232(0.009)	-0.193(0.162)	-0.158(0.254)	-0.308(0.024)
	After taste	0.306(0.002)	0.306(0.007)	**0.852(<0.0001)**	**0.692(<0.0001)**	**0.774(<0.0001)**	1

E1=High tannin sorghum, E97=low tannin, MKT=Red-high tannin, Seredo=low tannin, T30b-1=free tannin sorghum.

Porridge made from T30b-1 recorded a significant correlation for after taste with aroma ($r = 0.596$, $p < 0.0001$), flavour (0.691, $p < 0.0001$) and texture ($r=0.697$, $p < 0.0001$) however, there was a weak correlation between after taste and overall acceptability ($r=0.263$, $p=0.055$) therefore, after taste is not a sensory parameter in determining its adoption for utilization. Age and overall acceptability recorded a negative correlation ($r=-0.736$, $p<0.0001$) for the same product. It was however, not possible to determine the rationale behind the negative correlation for this low tannin sorghum because it was not specific to a particular age group. Significant and positive correlation were observed between after taste and aroma ($r=0.746$, $p<0.0001$), flavour ($r=0.747$ $p<0.0001$), texture ($r=0.762$, $p<0.0001$) and overall acceptability ($r=0.772$, $p<0.0001$) for Seredo variety while MKT-Red recorded high and significant correlation between after taste and flavour ($r=0.852$, $p<0.0001$), texture ($r=0.692$, $p<0.0001$) and overall acceptability ($r=0.774$, $p<0.0001$).

The difference in texture of the sorghum varieties (Seredo and MKT-Red) was attributed to the characteristics of the endosperm i.e. MKT_Red, a high tannin variety, had a soft endosperm texture hence were bitter, chewy while Seredo, a low/free tannin variety had relatively hard endosperm hence were perceived to were perceived to be soft and sweet [22]. Chiremba et al. (2009) [23] also observed a soft floury texture on high tannin variety sorghum Significant correlation of flavour and after tastes ($r=0.852$, $p<0.0001$) for MKT-Red variety is an indicator of consumer preference for the traditional red cultivar. Positive correlation between after taste and aroma profile of T30b-1 and Seredo were attributed to distinctive aroma of raw seeds which is dominant in common cereal search [24]. For high tannin varieties of sorghum porridge E1 and MKT_Red, the positive correlation observed between after taste and overall acceptability as well as high sensory mean scores of above 3.5 (Table 1) was attributed familiarity and regular consumption of local varieties hence consumers. Several studies have linked consumer preference to familiarity. Stallberg-White and Pliner (1999) [25] found that most familiar flavours are usually also the most preferred by consumers.

Sensory evaluation of composite products

Table 3 presents results from the mean sensory scores from sorghum flour composites. Most of the panelist rated the colour of the six products between 6 and 7 on the hedonic scale ('Like moderately' and 'Like very much') resulting in a mean score of above 6. The degree of liking for the colour of sorghum composites products decreased from 7.33 in sorghum cake to 6.15 in sorghum doughnuts. Colour as an attribute during sensory evaluation is an important parameter in judging whether a composite is properly baked. It also provides information about the formulation and quality of the product. High preference for colour by the panelists on these products may be due to Maillard reaction between reducing sugars and proteins resulting into appealing brown colour [24,26]. The degree of liking texture was high for sorghum zimbare (mean score of 7.42) and sorghum cake (mean score of 7.28) with lowest preference recorded for sorghum chapati and doughnuts at a mean score of 6.16 and 6.17 respectively. The panelists preference for texture could be caused by high gluten content in the composite flour. Added gluten provides a stronger network in the dough, increasing gas volume and retention thus resulting in more firmness [27].

Table 3. Sensory acceptability of composite products

Product	Colour	Texture	Taste	Flavour	General acceptability
Sorghum cake	7.33±1.4	7.28±1.2	6.80±1.9	6.50±1.8	6.94±0.3
Sorghum scones	6.18±1.7	6.19±1.8	5.75±2.1	4.78±1.9	6.10±1.5
Sorghum chapati	6.15±1.7	6.16±1.6	5.70±2.0	4.76±1.8	6.15±1.7
Sorghum biscuits	6.53±2.0	7.20±0.8	6.40±2.1	6.80±2.0	6.70±1.2
Sorghum doughnuts	6.15±1.7	6.17±1.8	5.74±2.1	4.76±1.9	5.60±1.6
Sorghum zimbare	6.97 ± 1.0	7.42 ± 0.5	7.11 ± 0.1	6.65 ± 0.7	7.28 ± 0.9

N.B. Mean and standard deviations from duplicate analysis are reported

Taste/ flavour of sorghum chapati and sorghum doughnuts were generally accepted with a mid-mean ranking, and this was attributed to their perception as compared to the commonly consumed wheat products. Generally, the scores for flavour and taste attributes were lower than for the scores for the other attributes and therefore this may mean that taste and flavour had a greater influence on the quality and acceptability of the products than other sensory attributes. The overall score for taste was above average and this probably influenced overall acceptability as taste is an essential parameter related to acceptability. Sugar and fat was used in the preparation of some of the products and the changes in taste and flavour is attributed to the added ingredients which gelatinized starch upon heating as well as the Maillard browning end reaction product melanoidin [24]. Sorghum zimbare, which is a fermented traditional food had the highest acceptability mean score of 7.28 indicating consumer preference of fermented culinary characteristics while sorghum doughnuts had the lowest score on 5.60 due to preference of the commonly eaten breads. The high scores for the overall acceptability of sorghum composite products could be due to the familiarity of taste, aroma and colour as the panelists were regular consumers of sorghum.

IV. CONCLUSION

Sorghum characterization on tannin levels have great effects on sensory characteristics of the porridge. The study showed that low tannin or tannin-free sorghum types would be preferred in sorghum foods, however, quality attributes such as colour of high tannin varieties were acceptable to consumers. Rural and urban consumers showed some differences in preferences due to the differences that they place in food and its contextual significance. For urban consumers, accepting a new variation of a product may take a longer time whereas the rural consumer may be excited about product that is likely being introduced for the first time. Sorghum products are highly likely to be accepted and should be popularized and adapted by smallholder sorghum farm households as well as urban consumers to enhance food, nutrition and dietary diversity.

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