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Nutritional quality of fritters produced from fresh cassava roots, high-quality cassava and soy flour blends, and consumer preferences

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Abstract: Fritters are flour-based snacks made from wheat flour, but a cheaper alternative is needed in a developing economy, such as Zambia, owing to the high cost of wheat. This study aimed at evaluating fritters produced from different sources: fresh cassava roots, high-quality cassava flour (HQCF), and a composite (80:20) of HQCF and high-quality soy flour (HQSF) using 100% wheat flour as the control. The nutritional and anti-nutritional properties were analyzed with standard laboratory methods. A structured questionnaire was used to analyze consumer preferences. There were significant ($P < 0.05$) differences in the proximate parameters of the fritters samples. In HQCF fritters, amylose increased by 12.26%, sugar by 11.12%, and starch by 27.91%. There were no significant ($P > 0.05$) differences in the antinutritional properties among cassava and wheat fritters except for the composite cassava–soybean fritters. Among respondents from Kaoma, Kasama, and Serenje, the sensory characteristics showed no significant ($P > 0.05$) differences

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PUBLIC INTEREST STATEMENT

Fritters are a ubiquitous widely available snack found in the street corners of Zambia, especially in busy locations like markets. Both young people and adult enjoy snacking on it almost daily. The sole ingredient in the production of fritters is wheat, which is an import commodity and as such, perceived as expensive. Moreover, the utilisation of local content is also not encouraged. Thus, an excellent substitute for wheat is cassava flour which is locally produced from fresh cassava roots cultivated in the country. This study has helped contribute to knowledge by coming up with a recipe made up of two locally sourced raw materials (***cassava and soybean)*** to develop a delicious and healthy snack, thereby reducing the cost of production for the popular snack and boosting the economy of Zambia.

for appearance and aroma of all the fritters samples. The results showed that HQCF fortified with HQSF could be used as a cheaper alternative to wheat flour in the production of nutritious and acceptable fritters.

Subjects: Food and Nutrition; Food Chemistry

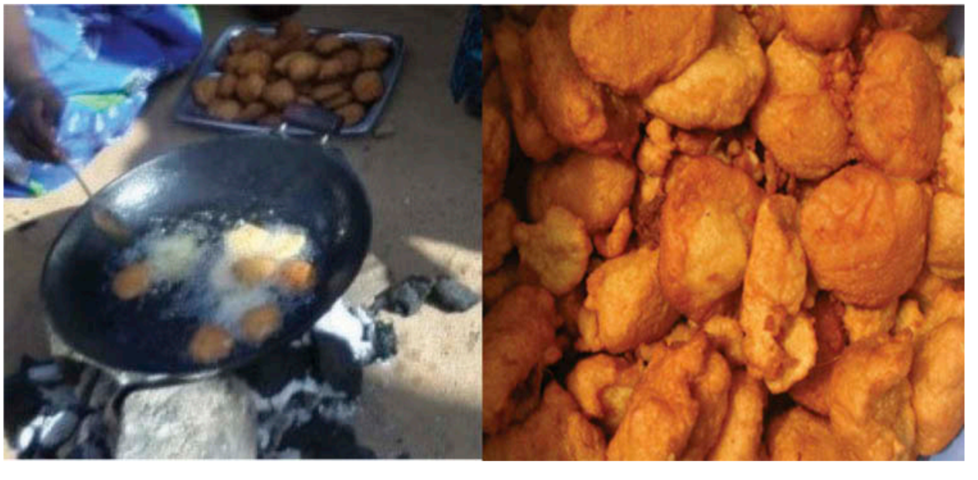
Keywords: Fritters; sensory attributes; proximate composition; consumer preference

1. Introduction

Zambia is well known for *vitumbuwa*, otherwise known as fritters, one of the cheapest delicious snacks that anyone can buy by the roadside or in markets. Their essential characteristics are ease of production and affordability. Wheat flour is the primary ingredient, but wheat (*Triticum aestivum*) is not a tropical crop; it is an imported commodity, brought in at high cost to meet increasing demand. According to FAO (2015), Zambia's annual wheat production stood at 241,231 tonnes. The recent Crop Forecast Survey in Zambia revealed a sharp drop in production from 309,000 tonnes in 2015 to 279,329 tonnes in 2017 despite yearly increases in demand (Indaba Agricultural Policy Research Institute [IAPRI], 2017). Thus, there has been continuous importation of 27,000 tonnes since the first quarter of 2017 to meet local demand. Wheat contains gluten and glutenin, which gives it unique properties for baking, although it may contain antinutritional factors such as phytate and tannins if not correctly processed (Gunashree, Kumar, Roobini, & Venkateswaran, 2014; Hussain, Uddin, & Aziz, 2011; Kavitha & Parimalavalli, 2014; Steve, 2012).

Cassava (*Manihot esculenta* Crantz), a tropical crop with a high level of carbohydrates; most varieties exhibit high starch content, which makes it prominent among polysaccharide-bearing crops (David, 2006). The economic influence of cassava research and extension in Malawi and Zambia from 1990 to 2008 was estimated after the introduction of varieties tolerant to diseases and drought. Farmers did not embrace them, mainly because they were not satisfied with their sensory attributes compared with the preferred local types. However, over time, researchers have introduced several varieties with higher yields and improved sensory and industrial traits (Alene, Khataza, Chibwana, Ntawuruhunga, & Moyo, 2013). According to Prochnik et al. (2012), research in breeding programs that have kept nutrition in mind, while studying the genes involved in disease resistance, has brought about tremendous improvements in releasing disease-resistant varieties available to farmers. Sayre et al. (2011) revealed how important it is for an African populace to accept the bio-fortified cassava, which is resistant to viral diseases. Several legislative efforts have been put into improving the yield, such as making funding available for research purposes to release improved varieties to farmers at little or no cost, even varieties that thrive in areas of poor agronomic conditions. Though some varieties contain cyanide, much effort has been put into

Figure 1. Preparation of Fritters.



breeding for the development of varieties with reduced cyanogenic potential (CNP). Also, some genetic engineering and improved processing methods are reducing cyanide toxicity problems (Lambri, Fumi, Roda, & De Faveri, 2013). Another significant stride is the use of biomarkers to screen the first-generation genotypes with low CNP. Cassava does not contain the proteins that make wheat a preferred primary ingredient, but the physicochemical properties of starch are suitable for supplementing wheat flour in bread-making without compromising its sensory attributes (Eduardo, Svanberg, Oliveira, & Ahrné, 2013; Komlaga, Glover-Amengor, Dziedzoave, & Hagan, 2012). Cassava processing and utilisation in Zambia are still rudimentary and focused on traditional products such as *Bwabi* and *Kapesula*. For that reason, there are few cassava-based products in the country (Alamu, Ntawuruhunga, Chibwe, Mukuka, & Chiona, 2019).

Soybean (*Glycine max*) is another major crop grown in the tropics, sub-tropics, and temperate zone (Alamu, Gondwe, Mdziniso, & Maziya-Dixon, 2018). In addition to its ability to thrive in diverse environments, it is a healthy food with good protein content and low levels of saturated fat (Alekel et al., 2000; Messina, 2010). The Food and Drug Administration (FDA) reported that 25 g/day of soybean protein could reduce the risk of coronary heart disease. The UK Joint Health Claims Initiative (JHCI) reconfirmed the assertion with a similar claim (Richardson, 2003). Recent studies reported new, improved varieties evaluated for compositional differences and their applications in product development for improved nutrition (Alamu et al., 2018).

Sensory evaluation (sensory analysis) is the process of evaluating products using the five senses; it evokes, measures, reports, and interprets responses to products as perceived by the senses of sight, smell, touch, taste, and hearing (Sidel & Stone, 1993). The consumer prefers and purchases nutrition, convenience, image, and functionality in food. Therefore, new products must be similar to the older product and provide all the same responses.

Lyimo, Gimbi, and Shayo (2007) evaluated the nutritional value of different composite flours: (cocoyam-wheat- soybean (50:20:30), cassava-wheat-soybean (50:20:30), and sweet potato-wheat-soybean (50:25:25), and found the combination of cassava, wheat, and soybean had the most carbohydrate but the least protein because cassava is known to have a low protein content. The blending of composite flours of roots and tubers up to 50% with cereals and legumes provides good sources of carbohydrates and an alternative and cheap source of energy (Adepoju & Oyewole, 2013). It was also established that cassava flour could replace wheat flour in producing excellent composite bread, also suitable weaning mixtures when fortified with cereals such as maize to ensure food security (Adepoju & Oyewole, 2013). According to (Eddy, Udofia, & Eyo, 2007), the substitution of cassava flour for 20% wheat flour showed no adverse effects on the sensory and organoleptic properties of the bread. They further stated that foods with the inclusion of cassava flour at 10 and 20% were not significantly different in most sensory attributes from those made with 100% wheat flour. Wheat-cassava bread with 10 and 20% inclusion of cassava flour rated higher in aroma, color, flavour, general acceptability, and preference than bread with 100% wheat flour. Several research materials archived by the Federal Institute for Industrial Research, Oshodi (FIIRO) in Lagos, reported successful incorporation of cassava flour into wheat flour for bread making at different levels of substitution. The most acceptable was 10–15%; for confectioneries and other baked goods, 15–20% was acceptable (Dankwa, Liu, & Pu, 2017; Owusu, Owusu-Sekyere, Donkor, Darkwaah, & Adomako-Boateng, 2017).

Hyacinthe, Bedel, Constant, Soumaila, and Patrice (2018) worked on the sensory acceptability of sweetened and non-sweetened fritters made with 100% wheat as the control and different compositions of taro to wheat flour and found both versions were acceptable. However, preference was higher for sweet fritters, and a decline in sensory acceptability was observed for fritters made from the composite flour at 12% taro and 88% wheat.

Thus, this study aimed at evaluating fritters produced from fresh cassava roots, HQCF, and cassava-soybean composite flour (80:20) compared with products from wheat flour (100%) for nutritional properties, consumer preference, and willingness to purchase (WTP) these products in Kaoma, Kasama, Mansa, and Serenje districts of Western, Northern, Luapula, and Central provinces, respectively, in Zambia.

2. Materials and methods

2.1. Materials

Wheat flour from hard wheat (*Triticum aestivum*) was purchased from a supermarket in Zambia, Fresh roots (Mweru variety), cassava flour, and soybean grain were obtained from IITA, Zambia.

2.2. Processing of cassava roots into flour

Freshly harvested roots were washed and peeled, then grated or chopped into slices or chips. These were sun-dried on concrete floors on trays or in artificial dryers (rotary, bins, fixed bed, or flash dryers). The dried chips were milled, and the flour was sieved using a 1mm sieve to obtain fine flour, which was finally packaged and stored (Abass et al., 2014; Falade & Akingbala, 2008; Iwe et al., 2017; Shittu, Alimi, Wahab, Sanni, & Abass, 2016; Simonyan, 2014).

2.3. Processing of soybean grain into flour

Alamu et al. (2018) described the method used in the assessment of nutritional characteristics of products developed using soybean (*Glycine max (L.) Merr.*) pipeline and improved varieties.

2.4. Processing of fresh tubers into the mash

The unit operations involved was done, according to (Sajeev, Nanda, & Sherriff, 2013).

2.5. Preparation of fritters

Four types were made using; fresh root (100% cassava mash mixed with other ingredients), cassava flour (100% HQCF), 100% wheat flour and HQCF (100% cassava flour) mixed with HQSF (100% soy flour) in percent ratio of 80 to 20% as described by Alamu et al. (2018). All categories were prepared according to the method of Alamu, Popoola, and Maziya-Dixon (2018) (Fgure 1). Table 1 explains the varying quantities of other ingredients.

Dough mixing and frying were done, according to Alamu et al. (2018). Time varied slightly across all product types; average frying time (min) was as follows; 101: 2.40, 102: 2.51, 103: 4.20, and 104: 3.48 in 2 liters of refined vegetable oil at a temperature between 170 and 175 °C. The weight of the dough before frying (15g) was reduced after frying due to removal of moisture to an average

Table 1. Recipes for fritter preparation

Ingredients	Type and Quantity			
	Cassava-root fritters(g)	Cassava flour fritters(g)	Wheat fritters(g)	Cass-soy fritters(g)
Dewatered cassava root	224.0	0	0	0
HQCF	0	224.0	0	179.20
Wheat flour	0	0	224.0	0
Soy flour	0	0	0	44.80
Eggs	100	100	100	100
Onion	30	0	0	0
Salt	3.0	4.0	4.0	4.0
Sugar	0	15	15	15
Baking powder	0	3.8	3.8	3.8
Water	0	158.20	42.36	134.56

Table 2. Product sample codes

Product	Code	Description
Fritters	101	100% fresh cassava roots
	102	100% HQCF
	103	100% wheat
	104	80%:20% HQCF: HQSF

HQCF = High-quality cassava flour; HQSF = High-quality soybean flour

weight of 12.76g for product 101, 14.23g for 102, 13.93g for 103, and 14.06g for 104. Table 2 shows the coding for all products.

2.6. Chemical composition analysis

The four products were analysed for proximate compositions; moisture, ash, fat, total sugars, starch, and amylose, anti-nutritional composition; functional parameter; bulk density, and pH (Alamu et al., 2018; AOAC, 2005). All analyses were run in duplicate.

2.7. Consumer preferences

The survey was conducted in three camps/districts in each of the four major cassava growing districts (Kaoma, Kasama, Mansa, and Serenje). The areas were selected based on consumption levels and accessibility. Thirty-five respondents per camp were randomly chosen to give a total of 105 respondents providing 430 respondents for the whole survey. The data were collected using a structured questionnaire administered to each respondent with the help of trained enumerators. The respondents were informed about the nature of the study. Subject participation was voluntary with informed consent sought from each of the respondents.

The cassava products were coded with three-digit numbers, and participants were presented with the samples at random to minimise positional error. Participants rated the appearance, aroma, texture, taste, and general acceptability of each of the samples on a 5-point hedonic scale ranging from 1 (I dislike it very much) to 5 (I like it very much). Consumption intent was measured on a 6-point scale ranging from 1 (I would often eat it) to 6 (I would eat it if forced). The respondents were asked to indicate which of the samples they preferred, and if they were willing, how much they were willing to pay for one piece (Gupta & Pandey, 2015).

2.8. Data analysis

The data generated on the proximate, functional, and antinutritional properties were statistically analysed using IBM SPSS statistical software (Version 21). The data about preference and willingness to consume were subjected to Analysis of Variance (ANOVA) at a 95% level of significance. The differences between means were considered to be significant at $p < 0.05$ using the Duncan multiple range test.

3. Results and discussion

3.1. Proximate composition

The results from the proximate analysis of products from fresh cassava roots, HQCF, and cassava-soybean composite flour showed significant ($P < 0.05$) differences in the content of moisture, ash, fat, amylose, sugars, and starch (Table 3). The moisture content ranged from 3.63% to 5.50%, with the highest value in product 104 and the lowest in 103. The high moisture content could be attributed to the inclusion of soybean flour (Akinwale, Shittu, Adebowale, Adewuyi, & Abass, 2017; Chinma, Ariahu, & Abu, 2013); low moisture content can be an advantage during storage at ambient temperatures (Butt, Nasir, Akhtar, & Sharif, 2004). Soluski (1962) showed that products with low moisture content could have a longer shelf life. The ash content across the products ranged from 1.58% in product 101 to 3.67% in 103. The

Table 3. Proximate composition of different fritters

Parameter	101	102	103	104
%Moisture	5.37 ± 0.06^{f}	4.19 ± 0.14^{e}	3.63 ± 0.05^{d}	5.50 ± 0.26^{f}
%Ash	3.67 ± 0.07^{f}	2.09 ± 0.03^{d}	1.58 ± 0.10	2.82 ± 0.07^{e}
%Fat	15.85 ± 0.18^{c}	8.91 ± 0.17^{b}	8.39 ± 0.43^{b}	8.57 ± 0.48^{b}
%Amylose	13.54 ± 0.00^{j}	17.76 ± 0.11^{m}	15.82 ± 0.08^{l}	14.52 ± 0.08^{k}
%Sugar	8.70 ± 0.04^{b}	10.09 ± 0.07^{c}	9.08 ± 0.09^{b}	9.93 ± 0.04^{c}
%Starch	61.83 ± 4.71^{ab}	87.80 ± 1.62^{e}	68.64 ± 0.17^{bcd}	64.63 ± 3.11^{abc}

Values in the columns with the same letters are not significantly different at $P < 0.05$
Value is the mean ± standard deviation
The analysis runs in duplicate

Table 4. Antinutritional and functional properties of Fritters

^{a}Parameters	101	102	103	104
Tannin(mg/g)	0.41 ± 0.07^{ab}	0.26 ± 0.05^{a}	0.20 ± 0.04^{a}	0.83 ± 0.05^{c}
%Phytate	0.13 ± 0.03^{a}	0.13 ± 0.04^{a}	0.27 ± 0.03^{a}	0.94 ± 0.30^{cd}
pH value	6.53 ± 0.02^{e}	6.75 ± 0.04^{f}	6.61 ± 0.05^{e}	6.80 ± 0.01^{f}
Bulk density (g/ml)	0.86 ± 0.03^{f}	0.77 ± 0.00^{cde}	0.78 ± 0.01^{cdef}	0.83 ± 0.01^{ef}

Values in the columns with the same letters are not significantly different at $P < 0.05$
Value is the mean ± standard deviation
The analysis run in duplicate

high ash content could be attributed to the fibrous nature of fresh roots (Montagnac, Davis, & Tanumihardjo, 2009). Though crude fibre does not contribute nutrients, it adds bulk to food, thus facilitating bowel movements (peristalsis) and preventing many gastrointestinal diseases in man. The fat content ranged from 8.39% in product 101 to 15.85% in 103. The high-fat content in product 101 could be due to the oil uptake from the high moisture level in the fresh cassava root matrix. Stephen, Shakila, Jeyasekaran, and Sukumar (2010) reported that fresh tuna fish during processing would take up as much as 50% of the frying oil, following the same trend. The other products had no significant differences as far as the fat content was concerned. Nasiri, Mohebbi, Yazdi, and Khodaparast (2012) found that soybean flour was an active ingredient in the reduction of fat content in fried snacks. Product 102 contained the most amylose, and 101 contained the least. The increase will be beneficial to consumers because several types of research have established the relationship between resistant starch and amylose. It is responsible for the slow release of glucose into the bloodstream and thus lowers insulin levels in humans by being digested more slowly than amylopectin. Therefore, more extended periods will be needed before the next meals (Eleazu, 2016; Kabir et al., 1998). Diets with high amylose content are thus likely to be beneficial for many members of society, particularly those with obesity or hyperinsulinemia (Behall & Howe, 1995). Recent studies indicate that amylose is vital in reducing the glycemic and insulin impact of foods (Behall & Scholfield, 2005) and in increasing the body's fat-burning ability which may help to maintain a healthy weight (Higgins et al., 2004). The sugar content ranged from 8.70% in product 101 to 10.09% in 102. The primary source of sweetness and the energy in fritters is reducing Sugars and the increased sugar content is essential to improve its taste and flavour (Taira, 1990). The primary attribute of cassava is starch as reported by various studies and contributed to the increase in the starch content in product 102 (Afoakwa, Budu, Asiedu, Chiwona-Karltun, & Nyirenda, 2011; Apea-Bah, Oduro, Ellis, & Safo-Kantanka, 2011; Nwosu, Owuamanam, Omeire, & Eke, 2014; Oladunmoye, Aworh, Maziya-Dixon, Erukainure, & Elemo, 2014).

3.2. Anti-nutritional and functional properties
The products showed significant ($P < 0.05$) differences in antinutritional and functional properties (Table 4). The tannin content ranged between 0.20 and 0.83 mg/g, with product code 103 having the lowest while 104 had the highest due to the inclusion of soybean flour. Tannins adversely affect the utilisation of proteins in animal and human diets owing to their ability to bind with and precipitate proteins (Pushparaj & Urooj, 2011) especially in pulses (Khandelwal, Udipi, & Ghugre, 2010). Tannins also inhibit important digestive enzyme activities (Barrett, Farhadi, & Smith, 2018) but are excellent antioxidants. The phytate content ranged from 0.13 to 0.94%, with products 101 and 102 having the lowest while 104 recorded the highest. There was no significant difference among the fritters except for product 104 that showed a significant difference ($P < 0.05$) from others. Phytic acid is associated with mineral complexing, mostly with zinc, calcium, and iron. It deactivates digestive enzymes and induces a reduction in the bioavailability of minerals and proteins in foods (Wu, Ashton, Simic, Fang, & Johnson, 2018). The tannin and phytate content in all the fritters were below the acceptable limit recommended by the WHO. The increment in pH (between 6.53 and 6.80) could be due to the inclusion of soybean. According to the findings of Thingom and Chhetry (2011) on nutritional analysis of fermented soybean, the pH value of raw soybean was 6.8. The bulk density is an important parameter that determines the ease of packaging and transportation of particulate foods (Shittu, Sanni, Awonorin, Maziya-Dixon, & Dixon, 2007); it ranged from 0.77 to > 0.86 g/ml.

3.3. Characteristics of survey respondents and consumption frequency
Table 5 represents some selected characteristics of participants in the consumer survey across four locations. Over 50% of the participants were males. Females had a higher consumption frequency (2.61) than males (2.55).

3.4. Preference for sensory attributes across the locations
Preference is primarily an economic concept. Significant influences on choice are prejudice, religious principles, group conformance, “status value,” and snobbery, in addition to the quality of food. People have options, no matter how illogical they may appear; therefore, the parameters are difficult to determine in newly developed products (Sim & Tam, 2001). Appearance ranged between 4.28 and 4.80 across the districts and is an essential sensory attribute to enhance acceptability (Table 6). More females in Kaoma (4.66) than men in Mansa (4.3) preferred the appearance attribute (Table 7). The aroma is another vital parameter of food (Iwe, 2002). The

Table 5. Respondents’ characteristics

Variables	Location				
	Kaoma (n = 448)	**Kasam (n = 416)**	**Mansa (n = 412)**	**Serenje (n = 428)**	**Total (n = 1704)**
Gender					
Female	224(50%)	244(58.65%)	196(47.57%)	152(35.51%)	816(47.89%)
Male	224(50%)	172(41.35%)	216(52.43)	276(64.49%)	888(52.11%)
Frequency of Consumption					
Product type		**Mean ± Std**	**CV**		
101	M	2.55 ± 1.02	39.93		
	F	2.61 ± 1.03	39.36		
102	M	2.55 ± 1.02	39.93		
	F	2.61 ± 1.03	39.36		
103	M	2.55 ± 1.02	39.93		
	F	2.61 ± 1.03	39.36		
104	M	2.55 ± 1.02	39.93		
	F	2.61 ± 1.03	39.36		

Table 6. Consumer preference for sensory attributes across the locations

District	Product code	Appearance		Aroma		Taste		Texture	
		Mean ±Std	CV	Mean ±Std	CV	Mean ±Std	CV	Mean ±Std	CV
Kaoma (N = 112)	101	4.66 ± 0.74	15.92	4.49 ± 0.98	21.76	4.29 ± 1.03	23.93	4.29 ± 1.03	23.94
	102	4.50 ± 0.86	19.10	4.33 ± 0.92	21.34	4.17 ± 0.92	22.04	4.21 ± 0.89	21.21
	103	4.60 ± 0.81	17.63	4.36 ± 0.94	21.53	4.32 ± 0.85	19.76	4.32 ± 0.82	18.95
	104	4.76 ± 0.51	10.65	4.47 ± 0.85	18.97	4.29 ± 0.96	22.46	4.35 ± 0.93	21.32
	Overall Mean	4.63 ± 0.75[a]	16.11	4.41 ± 0.92[b]	20.91	4.27 ± 0.94[a]	22.07	4.29 ± 0.92[a]	21.39
Kasama (N = 104)	101	4.34 ± 0.96	22.17	4.68 ± 0.66	14.04	3.85 ± 1.19	30.91	3.81 ± 1.21	31.71
	102	4.70 ± 0.70	14.78	4.56 ± 0.81	17.78	4.51 ± 0.79	17.48	4.52 ± 0.81	17.97
	103	4.80 ± 0.53	11.01	4.59 ± 0.81	17.61	4.58 ± 0.80	17.41	4.50 ± 0.78	17.24
	104	4.57 ± 0.86	18.75	4.43 ± 0.93	21.03	4.26 ± 0.95	22.19	4.26 ± 0.98	22.9
	Overall Mean	4.6 ± 0.79[a]	17.26	4.56 ± 0.81[a]	17.74	4.3 ± 0.98[a]	22.87	4.27 ± 1[a]	23.33
Mansa (N = 103)	101	4.46 ± 0.75	16.86	4.91 ± 0.28	5.78	4.51 ± 0.84	18.58	4.54 ± 0.71	15.65
	102	4.42 ± 0.65	14.71	4.26 ± 0.59	13.92	4.12 ± 0.69	16.77	4.05 ± 0.71	17.42
	103	4.39 ± 0.82	18.67	4.06 ± 0.71	17.53	3.94 ± 0.80	20.35	3.96 ± 0.77	19.34
	104	4.28 ± 0.75	17.43	4.21 ± 0.74	17.47	4.04 ± 0.80	19.89	4.07 ± 0.85	21.01
	Overall Mean	4.39 ± 0.74[b]	16.97	4.36 ± 0.69[b]	15.8	4.15 ± 0.81[a]	19.57	4.16 ± 0.79[a]	19.07
Serenje (N = 107)	101	4.60 ± 0.67	14.59	4.63 ± 0.62	13.45	4.34 ± 0.80	18.45	4.36 ± 0.77	17.63
	102	4.35 ± 0.91	20.99	4.18 ± 0.95	22.74	4.18 ± 0.92	22.01	4.19 ± 0.96	23
	103	4.65 ± 0.66	14.19	4.45 ± 0.74	16.69	4.32 ± 0.80	18.44	4.29 ± 0.85	19.74
	104	4.54 ± 0.73	16.08	4.38 ± 0.80	18.18	4.29 ± 0.82	19.22	4.27 ± 0.90	20.98
	Overall Mean	4.54 ± 0.76[a]	16.68	4.41 ± 0.8[b]	18.15	4.28 ± 0.84[a]	19.53	4.28 ± 0.87[a]	20.36

Table 7. Preference for sensory attributes of different fritters by gender

District	Gender	Appearance		Aroma		Taste		Texture	
		Mean±Std	CV	Mean±Std	CV	Mean±Std	CV	Mean±Std	CV
Kaoma	F	4.66 ± 0.67	14.38	4.39 ± 0.92	20.87	4.24 ± 0.94	22.05	4.24 ± 0.92	21.81
	M	4.6 ± 0.81	17.71	4.43 ± 0.93	20.99	4.3 ± 0.95	22.12	4.34 ± 0.91	20.94
Kasama	F	4.64 ± 0.79	17.06	4.56 ± 0.88	19.31	4.4 ± 1.00	22.71	4.32 ± 1.04	23.99
	M	4.55 ± 0.80	17.53	4.58 ± 0.70	15.32	4.16 ± 0.95	22.74	4.2 ± 0.93	22.26
Mansa	F	4.48 ± 0.74	16.51	4.46 ± 0.67	14.94	4.12 ± 0.81	19.73	4.16 ± 0.79	19.03
	M	4.3 ± 0.74	17.17	4.27 ± 0.70	16.33	4.18 ± 0.81	19.44	4.15 ± 0.80	19.15
Serenje	F	4.4 ± 0.84	19.08	4.25 ± 0.89	21.02	4.21 ± 0.87	20.75	4.26 ± 0.90	21.21
	M	4.61 ± 0.70	15.13	4.5 ± 0.73	16.26	4.32 ± 0.81	18.83	4.28 ± 0.85	19.91

Value is the mean ± standard deviation; Analysis runs in duplicate

Table 8. Analysis of variance (ANOVA) for cassava fritters

Source	DF	Appearance MS	Aroma MS	Taste MS	Texture MS
District	3	4.8693***	3.3256**	1.8080	1.6307
Products	3	1.1283	10.8075***	0.3599	0.0882
Gender	1	0.5731	0.2599	0.0025	0.0010
Error	1696	0.5769	0.6419	0.8059	0.8077

***means significant at $P < 0.001$, ** means significant at $P < 0.01$

Table 9. Correlation between sensory attributes of fritters and Willingness to pay (WTP)

Attribute	R-value
Appearance	0.1364***
Aroma	0.17265***
Taste	0.24905***
Texture	0.22384***

***means significant at $P < 0.001$, ** means significant at $P < 0.01$, * means significant at $P < 0.05$

fragrance from food excites the taste buds, making the system ready to accept the product. “Poor” smell may cause outright rejection of food before being tasted. Table 6 showed that aroma ranged between 4.06 and 4.91 across the districts. Table 8 showed that the district had a highly significant ($P < 0.01$) effect on appearance while variety had the most positively significant effect ($P < 0.001$) on the aroma. The results in Table 7 show that the preference for aroma by gender ranged between 4.25 and 4.58, with both the lowest preference ratings (in Kaoma) and the highest (in Kasama) being female. Additionally, the district had a highly significant effect on appearance. The sensory attributes of taste and texture did not show any significant effect ($P < 0.05$) on preference across the districts (Table 7).

3.5. Preference for sensory attributes by gender

The appearance was the attribute most preferred among men in Kaoma (4.6) (Table 7) and the least favored among men in Mansa (4.3). Among the men of Kasama (4.58) aroma were the most favored attribute and the least preferred for women in Serenje (4.25) District. The men in Kaoma (4.34) preferred the taste, although it was the attribute least preferred by women in Mansa (4.12). Men of Kaoma District had more preference for texture, and men in Mansa preferred it the least. From these results, it has been shown that fritters produced from cassava-soybean composite flour had the highest preference in Kaoma; fritters from HQCF was most preferred in Kasama; in Mansa and Serenje, products from fresh cassava roots were preferred to those made from wheat.

3.6. Analysis of variance for cassava fritters

The Analysis of Variance (ANOVA) showed that district had a highly significant effect ($P < 0.001$) on appearance and aroma while types of fritters had an exceptionally high and significant effect ($P < 0.001$) on the aroma. It could be inferred that preference based on appearance and aroma are district-dependent, and aroma is a critical sensory property to differentiate the types of products. The finding is in agreement with Alamu et al. (2018) that reported the respondents across the three locations found a significant difference ($P < 0.05$) in terms of appearance and color of both product samples investigated (80:20 wheat: soy and 100% wheat).

3.7. Correlation between attributes and willingness to pay

Table 9 represents a weak but sigificant ($P<0.05$) positive linear relationship between sensory characteristics and consumers’ willingness to pay (WTP), and this implies that WTP is dependent on sensory properties. However, taste and texture showed higher correlation coefficients than apperance and aroma. This implies that taste and texture drive the consumers' WTP. This is in agreement with Alamu et al.(2018) that identified taste and texture as important drivers of fritters acceptability.

4. Conclusion

The following were conclusions from the study: fritters produced from cassava-soybean composite flour had the highest preference in Kaoma; those from 100% HQCF were the most preferred in Kasama; those from fresh cassava roots were preferred to wheat fritters in Mansa and Serenje. The preference for specific fritters is district- or region-dependent, and this could be due to cultural differences. This study has helped to establish that it is possible to make healthy, nutritious and acceptable fritters with cassava in Zambia. However, public enlightenment on the nutritional benefits of products made from cassava - soybean composite flour (such as fritters) could help to improve levels of protein-energy malnutrition (PEM) across the regions, especially in Kasama, Mansa, and Serenje districts.

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Conflict of interest
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