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Full Length Research Paper

Effect of different cassava varieties (*Manihotesculenta*) and substitution levels in baking of wheat-cassava composite bread on physical properties and sensory characteristics

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ABSTRACT

The ever increasing worldwide cost of wheat flour used in the baking and confectionery industries has necessitated the search for alternative cheaper flour from the locally available crops. Cassava (*Manihotesculenta*)is one of such crops that have been identified because its flour has great potential to be utilized as a partial substitution of wheat flour. This study investigated the effect of different varieties and flour substitution levels of cassava with wheat flour in baking of wheat-cassava composite bread and bench-marked with attributes of common wheat bread on the market. Three cassava varieties; MH95/0183, MH95/0193 and *Selele* were used in the wheat-cassava flour blending at different ratios; 95:5, 90:10, 85:15, 80:20, 75:25 and 70:30 whereas the bread from baker's flour was used as the control. Baking was done using Pup –loaf method. The proximate composition of the flour blends and alveograph properties; length (dough extensibility), height (dough strength) and W (Deformation energy) of the dough blends were determined. The specific volume and form ratio of the breads was calculated and the sensory evaluation of bread was carried out using 25 semi-trained panelists. The study found out that the proximate components of the blended breads reduced with increase in cassava substitution for all the cassava varieties. Composite flour with MH95/0183 were found to have better alveograph properties while composite bread with *Selele* had the highest specific volume and form ratio and sensory properties. Bread made from 5%, 10% and 15% cassava flour didn't have significantly different (P<0.05)sensory properties from the control. The external loaf characteristics were the major factors the panelist used to rate the acceptability of the bread. Results of this study show that cassava flour can be used in the reconstitution of bread so as to reduce costs.

Key words: Cassava, Bread, Varieties, Substitution level, Sensory evaluation

INTRODUCTION

Bread is a fermented baked product that is made mainly from wheat and is widely consumed as part of breakfast and other meals. It is an important staple food in both developing and developed countries and is rich in most of nutrients such as carbohydrate, protein, fibre, vitamins and minerals. The most common types of bread in Kenya is white bread made from wheat flour which has been processed and the bran removed and whole grain bread commonly known as brown bread made from whole grain wheat without the removal of bran.

Due to the increasing population, industrialization and changes in food habits, the demand for wheat-based products has increased especially in the developing countries. However, bread and other baked products are expensive because they are produced using wheat (Ohimain, 2015) which is mostly imported due to climatic reasons; it does not grow well in the tropical regions. Kenya only produces 40% of its national requirement for wheat (Economic Review of Agriculture, 2010) leaving a deficit of about 60% which has to meet with expensive imports of wheat which is paid in foreign exchange

Abbreviations

KEBS- Kenya Bureau of Standards PCA- Principle Component Analysis
NIR- Near Infra-Red

costing the government about 5.85 billion shillings per annum (Annon, 1997). Due to the increased costs associated with imported wheat the use of other flours from locally grown crops which are cheaper is being studied (Ijah *et al.,* 2014). Such crops include maize, sorghum, millet, sweet potatoes and cassava.Out of these, cassava has more potential to be used as an alternative to wheat in terms of agronomic aspects and flour properties. Unlike wheat and other flour yielding crops, cassava requires low inputs like water, fertilizer and labor. The flour yield is high and cheap to extract compared to the other crops because it has few impurities. Other advantages include flexibility in planting and harvesting time, tolerance to drought conditions giving reasonable yields where other crops do not grow well.

In Kenya cassava is grown at the Coast, Eastern, Nyanza and Western regions and mainly used as a staple food and the surplus is sold at the local markets. Cassava has a great potential of being used in many industries like the food industry especially the bakery industry as a partial substitution to wheat. However, this has not been successfully done in Kenya because there has not been sufficient research on the utilization of cassava flour in the confectionery industry. Currently there are many different cassava varieties that have been bred which are disease resistance, drought resistance, low cyanide content and high yielding (Obiero *et al*., 2007). However, these cassava varieties have not been successfully screened for their functional properties and whether there are differences between the different varieties when used for baking bread.

The aim of the study was to determine the effect of cassava varieties on the physical properties of bread and the maximum substitution level of wheat with cassava and consumer acceptability of the composite bread through sensory evaluation.

MATERIALS AND METHODS

Study site

The cassava varieties namely; MH95/0183, MH95/0193 and S*elele* were obtained from Migori County in Kenya (0^{o}40S 34^{o}50E). Migori county experiences two seasons of rain with an average rainfall of 1200 mm annually and a temperature range of 21^{o}C to 35^{o} C. Wheat flour (Bakers flour) was purchased from Eldoret millers in Nakuru town. The laboratory analysis was done in Kenya Agricultural and Livestock Research Organization (KALRO) Njoro.

Sampling and preparation of cassava flour

The three cassava varieties were obtained from one farmer and harvested at 12 months after planting. In order to produce good quality cassava flour, healthy cassava roots with no bruises and cracks were processed immediately after harvesting i.e. within 24 hours into flour. After processing the flour it was packaged into polythene bags and transported to Kenya Agricultural and Livestock Research Organization (KALRO)Njoro for analysis.

Cassava flour was processed using a method described by (Dziedzoave *et al.,* 2003).The cassava roots were peeled by hand then washed with portable water. The washed tubers were grated using a motorized cassava grater to disintegrate cassava tissues. The mash was pressed to remove excess water then sundried to a moisture content of about 13% dry weight basis and milledinto flour using a hammer mill. The milled flour was sifted using a sieve fitted with a 250 µm screen to remove as much fiber as possible in order to obtain fine flour with uniform particles size.

Experimental design and formulation of composite wheat-cassava flour

Nineteen different samples of composite flour were prepared using baker's flour and cassava flour from the three varieties using different ratiosof baker's: cassava flour as follows; Baker's flour: cassava flour, 100%: 0, 95%: 5%, 90: 10%, 85%: 15%, 80%: 20%, 75%: 25%, 70%: 30% with 100% baker's flour serving as the control. The composite flourswere then packaged in polythene paper bags to await analysis.

The experiment was done using a Completely Randomized Design in 3×6 factorial arrangement where three varieties of cassava were substituted with bakers' flour at six levels as shown above. The experiment was carried out in three replications.

Wheat-cassava flour proximate composition and alveograph analysis

The composition of the composite flours (protein, gluten, moisture content and water absorption) was measured using Near Infra Red (NIR) grain analyzer model 1241.The different blends of baker's flour and cassava flour were subjected to analysis length (dough extensibility), height (dough strength) and W (deformation energy) using Alveograph MA (Chopin, Tripetteet Renaud, France).The height is the force required to blow the bubble of the dough. Deformation energy is the area under the curve and is a factor of dough strength and extensibility

Bread production by Pup-loaf method

The different composite flours formulated above were used to make the different bread samples of 100 grams weight using the Pup loaf method (AACC, 1993). The other ingredients added to the composite flour at different percentage of the weight of the bread were as follows; sugar 4%, salt 1%, shortening 3%, milk powder 3%, malted barley 0.2%.The amount of water used to prepare the dough was determined using Brabendar Farino graph. The ingredients were then mixed for 3 minutes using a dough mixer. The dough was rounded and placed into a fermentation cabinet at 30^{o}C and 85% relative humidity for 105 minutes. First punch was done by passing the dough through a sheeter then folding twice and returning to the fermentation cabinet for 50 minutes. The second punch was done and the dough returned into the fermentation cabinet for 25 minutes. The dough was molded by passing it through a molding machine and foldedinto a cylinder and proofed in a greased pan for 62 minutes. The dough was baked in an ovenat 240^{o}C for 24 minutes. The loaves of bread were cooled to room temperature and weighed.

Physical properties of wheat-cassava composite bread

The volume of the bread was measured using rapeseed displacement method. The specific volume was calculated using the weight and the volume of the bread (volume /weight).The loaves were sliced into10mm thickness and the width and height of the central slice measured to determine the form ratio.The baked loaves were packaged in resealable polythene bags and stored at room temperatures for 12 hours.

Sensory evaluation of the bread

The loaves of bread were then cut into 2×3×5cm slices using a bread knife and labeled using different codes.The samples were then presented to 25 semi-trained panelists for sensory analysis. A five point hedonic scale 1 representing dislike extremely and 5 representing like extremely was used to rate the different bread attributes: The external bread characteristics (shape, crust color,aroma and texture) using a whole loaf, the internal loaf characteristics (Crumb color, crumb softness and taste) and overall acceptability of the loaves. 1 representing dislike extremely and 5 representing like extremely.

Statistical Analysis of Data

Data obtained from proximate analysis, alveograph analysis, physical properties and sensory evaluation on wheat cassava bread was analyzed by SAS Version 9.1 for Analysis of Variance (ANOVA) using General Linear Model (GLM) procedure. Means separation was done using Least Significant Difference (LSD) method (Gacula Jr, 2013) at P≤0.05. Principal Component Analysis (PCA) was performed on sensory attributes using PROC FACTOR procedureanalysis data in order to reduce the set of attributes to a smaller set of variables called factors based on patterns of correlation among the original variables (Lawless and Heyman,2010).

RESULTS AND DISCUSSION

Wheat-cassava flour

Proximate composition of wheat-cassava flour

The effect of different substitution levels of cassava flour with wheat flour on the protein content, gluten content, moisture content and water activity is shown in Figure 1. It was found out that the protein content, gluten content, moisture content and water activity of wheat-cassava composite flour decreased significantly (P<0.05) with increase in substitution of baker’s flour with cassava flour. The control which is baker’s flour had the highest values for protein and gluten of 13.2% and 31.43% respectively while there was no significant (P>0.05) differencefor the protein content and gluten content among thethree cassava varieties at each substitution level. It was also found out that the highest moisture content was in the baker’s flour (control) with 13.43% and the lowest was 12.67% in the MH95/0193 cassava variety at 30% substitution level. Similarly, the highest water activity was in the baker’s flour (control) with 63.20 and the lowest was 55.17 in the MH95/0193 cassava variety at same substitution level as it’s for moisture content.

Cassava has no gluten and therefore its progressive increase at each substitution level was the reason for the decrease in the gluten content of the wheat-cassava composite flour. Similarly, cassava has very low protein content of 3- 4% (Apea-Bah *et al*, 2011) when compared to wheat flour which has protein content of between 9-13% (KEBS, 2009) and therefore the increase of cassava in the composite flour results in decrease of the overall protein. However, from the results, substitution with cassava flour to 20% would give good quality bread that meets the Kenyan standards that requires protein content of above 11% in flour used for baking bread (KEBS, 2009). The quantity of moisture and water activity plays a significant role in the spoilage of the bread because most of the spoilage microorganisms will grow rapidly at higher moisture content and higher water activity especially fungi (Wambua, 2016).

Alveograph Properties

The effect of different substitution levels of cassava flour

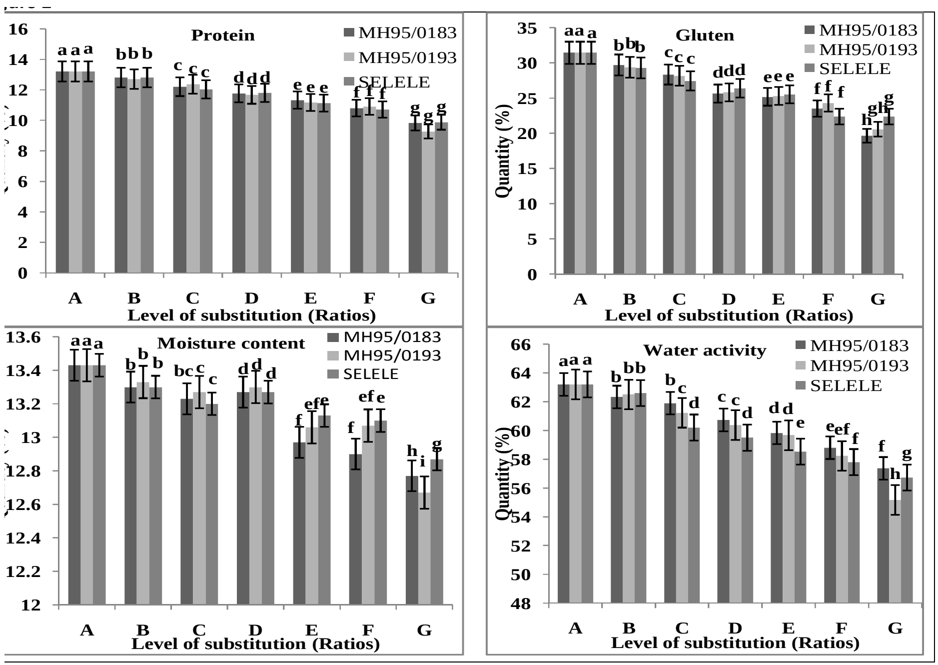

figure 1.Proximate composition of wheat-cassava flour
: A=100% baker's flour (control); B=95% baker's flour, 5% cassava flour, C=90% baker's flour, 10% cassava flour, D=85% baker's flour, 15% cassava flour; E=80% baker's flour, 20% cassava flour; F= 75% baker's flour, 25% cassava flour; G= 70% baker's flour, 30% cassava flour

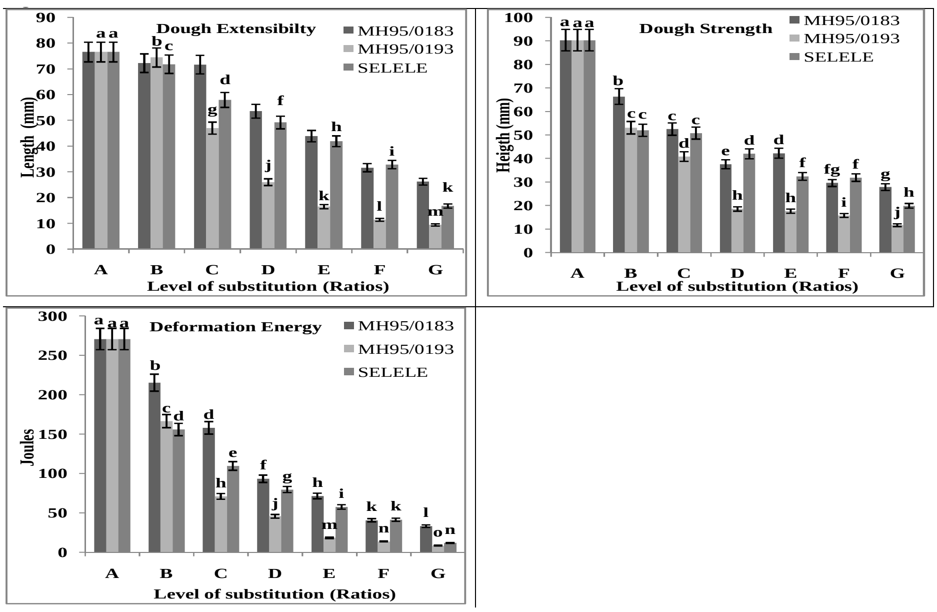

figure 2: Alveograph Analysis of composite wheat-cassava flour
A= 100% baker's flour (control); B= 95% baker's flour, 5% cassava flour, C= 90% baker's flour, 10% cassava flour, D= 85% baker's flour, 15% cassava flour; E= 80% baker's flour, 20% cassava flour; F= 75% baker's flour, 25% cassava flour; G= 70% baker's flour, 30% cassava flour

with wheat flour on the rheological properties of the dough is shown in Figure 2. It was found out that the dough extensibility, the dough strength and dough deformation energy reduced significantly (P<0.05) with increase in cassava flour substitution levels. The type of the cassava variety also had a significant (P<0.05) effect

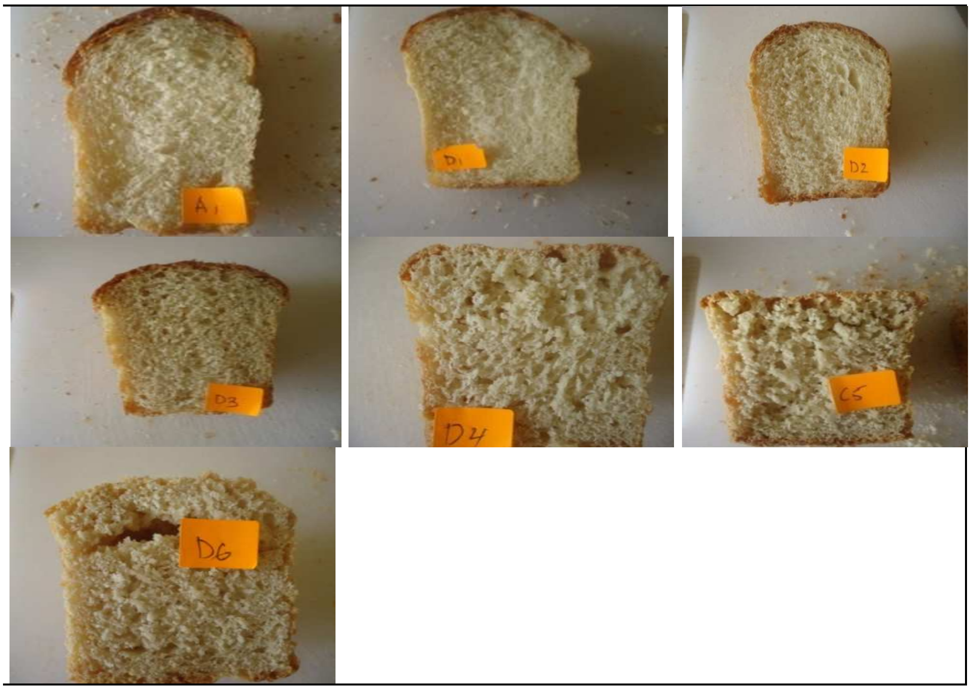

Figure 3. Cross-sections of wheat-cassava composite bread Cross-sections of wheat-cassava bread, A_1; Bread made with 100% wheat, D_1; Bread made with 95% wheat: 5% cassava, D_2; Bread made with 90% wheat: 10% cassava, D_3; Bread made with 85% wheat: 15% cassava, D_4; Bread made with 80% wheat: 20% cassava, C_5; Bread made with 75% wheat: 25% cassava, D_6; Bread made with 70% wheat: 30% cassava

on dough rheological properties with the dough made from MH95/0193 cassava variety having weaker rheological properties at each level of substitution while MH95/0183 variety having the strongest.

The decrease in the rheological properties of the dough with increase in substitution levels of wheat with cassava flour indicate that baking quality of the dough was decreasing which resulted into weaker dough because the gluten levels were diluted (Ribotta et al., 2005). Wheat flour contains more gluten which contributes to elasticity of the dough by trapping carbon dioxide produced by yeast during fermentation (Mepba et al., 2007) and this reason is why the bakers' flour had the highest values for dough extensibility, dough strength and deformation energy when compared to the composite dough.

Wheat-cassava bread

Physical properties of wheat-cassava bread

The physical characteristics of wheat-cassava composite bread are presented in Table 1. The specific volume and form ratio of the composite bread decreased significantly (P<0.05) with increased substitution levels with cassava flour. The control (A) with 100% Baker' flour had the highest values of 4.77 cm3/g and 1.77 for specific volume and form ratio ,respectively while sample B6 which was made up of MH95/0183 cassava flour at 30% substitution level had the lowest values of 2.15cm3/g and 0.86 for specific volume and form ratio, respectively. Different cassava varieties had significantly different (P<0.05) effect on the specific volume and form ratio of the bread where *Selele* variety had the highest and MH95/0183 variety had the lowest specific volume and form ratio. The specific volume and form ratio for *Selele* variety was 3.07cm3/g and 1.34,respectively while MH95/0183 variety had 2.78cm3/g and 1.18,respectively.

This reduction of specific volume and form ratio with increase cassava can be attributed to dilution of gluten protein which is present only in wheat flour and is responsible for rising the dough during proofing and thus disruption of its rheological and mechanical properties (Schoenlechner et al., 2013). The specific volume and form ratio are important quality parameters that influence consumer acceptability of the bread (Onyango et al., 2015). Therefore the variety of cassava used had significant effects on the physical properties of the bread.

Effects of substitution level on the wheat cassava bread

The cross-sections of bread made from the different wheat- cassava ratios are shown in Figure 3. Substitution of baker's flour with cassava flour had effects on the

Table 1. Physical properties of wheat-cassava bread

Sample	Sample code	Ratio	Specific volume(cm^3/g)	Form ratio
Baker's flour(A)	A	100:0	**4.77 ± 0.06[a]**	**1.77 ± 0.03[a]**
MH95/0183	B_1	95:5	3.56 ± 0.05[d]	1.54 ± 0.01[b]
	B_2	90:10	3.04 ± 0.05[g]	1.38 ± 0.02[e]
	B_3	85:15	2.81 ± 0.01[j]	1.22 ± 0.02[h]
	B_4	80:20	2.74 ± 0.02[l]	1.09 ± 0.02[e]
	B_5	75:25	2.35 ± 0.04[q]	0.93 ± 0.02[o]
	B_6	70:80	2.15 ± 0.04[s]	0.86 ± 0.01[p]
Mean			**2.78 ± 0.47[c]**	**1.18 ± 0.25[c]**
MH95/0193	C_1	95:5	3.63 ± 0.06[c]	1.37 ± 0.01[h]
	C_2	90:10	3.10 ± 0.06[f]	1.33 ± 0.00[g]
	C_3	85:15	2.95 ± 0.03[i]	1.20 ± 0.02[i]
	C_4	80:20	2.76 ± 0.05[k]	1.16 ± 0.00[j]
	C_5	75:25	2.69 ± 0.05[n]	1.13 ± 0.00[k]
	C_6	70:80	2.37 ± 0.04[p]	1.01 ± 0.01[m]
Mean			**2.95 ± 0.40[b]**	**1.20 ± 0.13[c]**
SELELE	D_1	95:5	4.19 ± 0.04[b]	1.75 ± 0.02[b]
	D_2	90:10	3.45 ± 0.02[d]	1.54 ± 0.01[b]
	D_3	85:15	3.19 ± 0.04[e]	1.42 ± 0.01[c]
	D_4	80:20	2.99 ± 0.02[h]	1.35 ± 0.02[f]
	D_5	75:25	2.39 ± 0.01[o]	1.02 ± 0.02[l]
	D_6	70:80	2.19 ± 0.01[r]	0.94 ± 0.03[n]
Mean			**3.07± 0.69[b]**	**1.34±0.29[b]**

Values are means ± SD triplicate determinations
Means in the same column followed by the same letter are not significantly different ($p<0.05$) from each other.

shape of the bread and crumb appearance. The shape of the bread changed from oval to flat at the top with increased substitution of baker's flour with cassava flour. Substitutions of cassava up to 15% produced bread with a better shape. The crumb firmness of the bread increased with increase in substitution of baker's flour with cassava flour which caused formation of more spaces between the crumb particles.

The change in shape can be attributed to the decrease in gluten content in the flour which is responsible for increase in volume of the dough during fermentation due to accumulation of carbon dioxide gas. Substitution of wheat with non-wheat flour reduces and disrupts the formation of Visco-elastic network that hinders entrapment of carbon dioxide within the particles thus leading to increased crumb firmness (Onyango et al., 2015) which breaks easily. Substitutions of cassava up to 15% also produced bread with a better crumb firmness. Crumb firmness is also an important factor to consider when slicing the bread. When the firmness is increased it becomes difficult to slice the bread because it breaks easily.

External sensory loaf characteristics of wheat-cassava composite bread

There were significant differences ($P<0.05$) in the external loaf characteristics of bread from baker's flour(control) and bread from wheat-cassava composite flour with different cassava varieties at the various substitution level.

Generally there was a decrease in the panelists liking of the loaf shape, crust color, texture and aroma with increase in the substitution levels of cassava for all the varieties as shown in Table 2. The cassava variety also had significant ($P<0.05$) effect on external characteristics of the bread where substitution level of 5% for all varieties and substitution of up to 15% for *Selele* variety had higher likeability of external characteristics than the control.*Selele* variety had the best external loaf characteristics compared to MH95/0193andMH95/0183 varieties. Increasing cassava flour causes significant decrease in the volume of the bread which is an important feature that the customer looks at on buying the product.

Table2. External loaf characteristics of wheat-cassava composite bread

		External loaf characteristics			
Sample Code	**Ratio**	**Loaf shape**	**Texture**	**Crust color**	**Aroma**
Control	100:0	3.91±0.13^{ab}	3.95±0.11^{ab}	3.66±0.13^{bc}	3.95±0.13^{a}
MH95/0183	95:5	4.25±0.12^{a}	3.89±0.19^{ab}	3.61±0.21^{c}	3.54±0.20^{b}
	90:10	3.82±0.15^{bc}	3.71±0.13^{bc}	3.54±0.15^{c}	3.25±0.20^{bc}
	85:15	3.75±0.18^{c}	3.68±0.17^{bc}	3.82±0.15^{b}	3.61±0.19^{a}
	80:20	3.61±0.15^{c}	3.50±0.20^{c}	3.71±0.17^{b}	3.43±0.20^{bc}
	75:25	3.39±0.20^{d}	3.25±0.22^{d}	3.36±0.19^{d}	3.00±0.17^{bc}
	70:30	3.36±0.20^{d}	3.14±0.22 ^{e}	3.11±0.22^{e}	2.93±0.16^{c}
Mean		**3.70 ± 0.95^{c}**	**3.53 ± 1.03^{c}**	**3.53 ± 0.98^{c}**	**3.30 ± 0.96**
MH95/0193	95:5	4.25±0.20^{a}	4.07±0.19^{ab}	4.32±0.19^{a}	3.90±0.17^{a}
	90:10	3.71±0.19^{c}	3.86±0.20^{ab}	3.71±0.20^{b}	3.75±0.18^{a}
	85:15	3.61±0.17^{c}	3.36±0.19^{d}	3.54±0.16^{c}	3.36±0.19^{bc}
	80:20	3.57±0.16^{c}	3.17±0.17^{e}	3.47±0.15^{cd}	3.27±0.16^{c}
	75:25	3.60±0.16^{c}	3.07±0.17^{e}	3.37±0.19^{d}	3.03±0.17^{c}
	70:30	3.23±0.20^{d}	3.27±0.20^{d}	3.20±0.19^{de}	3.20±0.18^{c}
Mean		**3.66 ± 1.00^{c}**	**3.47± 1.06^{c}**	**3.60 ± 0.89^{c}**	**3.42 ± 0.98^{bc}**
Selele	95:5	4.13±0.18^{ab}	4.03±0.13^{ab}	3.93±0.16^{a}	3.70±0.15^{a}
	90:10	4.27±0.16^{a}	4.20±0.15^{a}	3.87±0.16^{b}	3.67±0.16^{a}
	85:15	4.00±0.17^{ab}	3.87±0.15^{ab}	4.00±0.14^{a}	3.73±0.14 ^{a}
	80:20	3.87±0.13^{b}	3.53±0.14^{c}	3.67±0.14^{bc}	3.43±0.16 ^{b}
	75:25	3.50±0.18^{c}	3.10±0.12^{e}	3.30±0.19 ^{d}	3.57±0.18^{b}
	70:30	3.13±0.20^{d}	3.03±0.20^{e}	3.07±0.17^{e}	2.90±0.19 ^{c}
Mean		**3.81 ± 1.01^{ab}**	**3.63 ± 0.93^{bc}**	**3.64 ±0.94^{c}**	**3.50 ± 0.93^{b}**

Values are means ± SD triplicate determinations
Means in the same column followed by the same letter are not significantly different ($p<0.05$) from each other.

Table 3. Internal loaf sensory characteristics of wheat-cassava composite bread

		Internal loaf characteristics			
Sample Code	**Ratio**	**Crumb color**	**Crumb softness**	**Taste**	**Overall acceptability**
Control	100:0	3.93±0.12^{a}	4.16 ± 0.91^{a}	3.97 ± 0.13^{a}	4.16 ± 0.11^{a}
MH95/0183	95:5	3.68±0.15^{b}	4.04 ± 0.84^{a}	3.64 ± 0.16^{a}	3.89± 0.16^{bc}
	90:10	4.00±0.17^{a}	3.39 ± 0.83^{b}	2.89 ± 0.18^{c}	3.61±0.^{16bc}
	85:15	3.96±0.15^{a}	3.11 ± 0.81^{bc}	3.36 ± 0.19^{bc}	3.86±0.16^{bc}
	80:20	3.57±0.21^{b}	3.07 ± 1.09^{bc}	3.54 ± 0.20^{bc}	3.57±0.20^{bc}
	75:25	3.50±0.20^{b}	2.96 ± 0.96^{c}	2.89 ± 0.19^{c}	3.29±0.16^{d}
	70:30	3.29±0.20^{c}	2.96 ± 0.92^{c}	3.03 ± 0.22^{bc}	3.21±0.18^{d}
Mean		**3.67 ± 0.99^{b}**	**3.26 ± 0.99^{bc}**	**3.23 ± 1.04^{bc}**	**3.57 ± 0.92^{bc}**
MH95/0193	95:5	4.14±0.18^{a}	4.18 ±0.90^{a}	3.86 ± 0.18^{ab}	4.29±0.17^{a}
	90:10	3.86±0.18^{a}	3.82 ± 0.96^{a}	3.71 ± 0.18^{a}	3.89±0.15^{b}
	85:15	3.68±0.16^{b}	3.43 ± 0.96^{b}	3.61 ± 0.18^{a}	3.68±0.^{14bc}
	80:20	3.53±0.14^{b}	3.07 ± 0.94^{bc}	3.43 ± 0.18^{bc}	3.60±0.^{13bc}
	75:25	3.40±0.14^{bc}	3.17 ±0.91^{bc}	3.17 ± 0.16^{bc}	3.60±0.^{16bc}
	70:30	3.37±0.16^{c}	2.83 ± 1.05^{c}	2.77 ± 0.16^{c}	3.13±0.15^{d}
Mean		**3.66 ± 0.89^{b}**	**3.41 ± 1.04^{b}**	**3.43 ± 0.98^{b}**	**3.70 ± 0.86^{bc}**
Selele	95:5	4.00±0.15^{a}	4.00 ± 0.95^{a}	4.00 ± 0.16^{a}	4.10±0.15^{a}
	90:10	3.90±0.15^{a}	3.80 ± 0.85^{a}	3.77 ± 0.16^{a}	4.20±0.15^{a}
	85:15	3.93±0.14^{a}	3.80 ± 0.85^{a}	3.67 ± 0.15^{a}	3.93±0.14^{ab}
	80:20	3.67±0.15^{b}	3.30 ± 0.99^{bc}	3.37 ± 0.15^{bc}	3.47±0.17^{d}
	75:25	3.37±0.15^{c}	2.97 ± 0.35^{c}	3.10 ± 0.15^{bc}	3.20±0.15^{d}
	70:30	3.27±0.17^{c}	2.57 ± 1.17^{c}	2.70 ± 0.22^{c}	3.07±0.17^{d}
Mean		**3.69 ± 0.87^{b}**	**3.41 ± 1.07^{b}**	**3.44 ± 1.00^{b}**	**3.67 ± 0.96^{bc}**

Values are means ± SD triplicate determinations
Means in the same column followed by the same letter are not significantly different ($p<0.05$) from each other.

Table 4. Principle component factor loadings for wheat-cassava bread attributes

Sensory attribute	Principle component scores	
	Factor 1	**Factor 2**
Shape	0.72582	-0.27769
Texture	0.76142	-0.27372
Crust color	0.82319	-0.22191
Crumb color	0.60180	0.43848
Crumb softness	-0.38595	0.70152
Aroma	-0.24988	0.81716
Taste	-0.24683	0.80378
Proportion of the total variance	54.5%	11.08%

Internal sensory loaf characteristics of wheat-cassava composite bread.

There were significant differences (P<0.05) in the internal loaf characteristics of bread made from the baker's flour (control) and the wheat-cassava composite bread at different substitution levels as shown in Table 3. However, the composite bread with MH95/0193 and *Selele* varieties with 5% level of substitution and MH95/0183 variety with 10% level of substitution had a higher rating on internal loaf characteristics than the control.The panelists liking of the crumb softness decreased with increase in cassava substitution. There was no significant difference (P>0.05) in the taste of bread made from unblended wheat flour (control) and bread made up to 15% cassava flour. There was also no significant difference in the overall acceptability of bread made from baker's flour (control) and that made of cassava flour up to 15% substitution. *Selele* variety still had the best liking for crumb color, crumb softness, taste and overall acceptability compared to MH95/0183 and MH95/0193 varieties.

Principle component analysis

The results from Principle Component Analysis (PCA) show the existence of two principle components (factors) for the seven sensory attributes of the bread. The first factor accounted for 54.5% while the second factor accounted for 11.08% of total variation (Table 4)**.** The first factor consists of attributes such as loaf shape, texture and crust color. These are the most influential sensory characteristics which the customer will use to judge the bread. The results shows that external loaf characteristics are major factors that determine consumer acceptability of the bread and that substitution of cassava up to 15% will produce good quality wheat-cassava bread that is acceptable to the consumers. The second principle component include attributes like crumb softness, aroma and taste which are the internal loaf characteristics. Therefore this study shows that the external loaf characteristics are the most important attributes the bakers should put in mind while baking bread so that the consumers can accept the product.

CONCLUSION

Substitution of baker's wheat flour with cassava flour decreased the protein and gluten content of the flour with increase in substitution levels which caused weakening of dough rheological properties (alveograph properties). The changes were reflected in the physical properties of wheat- cassava bread which declined with increased substitution levels of wheat flour with cassava flour. Cassava varieties also affected the rheological properties and physical properties of the bread but not protein and gluten.

The MH95/0183variety had the best rheological properties in the composite flour while *Selele* had the best physical and sensory properties in the composite bread. However, despite the significant differences in the proximate composition and alveograph properties of the different flour blends and physical properties of bread made from the different flour blends, there were no significant differences in the sensory attributes of bread made from baker's wheat flour (control) and bread made with substitution of up to 15% cassava flour. External loaf characteristics played a major role in the acceptability of wheat-cassava bread compared to the internal loaf characteristics.

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