African Journal of Food Science Vol. 5 (2) pp. 50 - 56 February 2011
Available online http://www.academicjournals.org/ajfs
ISSN 1996-0794 ©2011 Academic Journals

Full Length Research Paper

Physicochemical and sensory properties of wheat-cassava composite biscuit enriched with soy flour

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Accepted 28 September, 2010

Cassava (*Manihot palmata*) and soybean were processed into flours and used to substitute wheat flour as composite flour. The wheat flour (WF) was substituted by cassava flour (CF) at levels of 0, 10, 20, 30, 40, 50, 60, and 70%; while the resulting composite flours at levels above 40% were replaced with 10% soy flour (SBF) to increase their protein levels for biscuit production. This study evaluated the physicochemical and sensory qualities of biscuits baked from the various formulations of the flours. The proximate composition, hydrocyanic acid (HCN), spread ratio, biscuit weight and sensory properties of the biscuits were measured. Trained panelist evaluated the differences in organoleptic properties using a consumer sensory panel. Colour, crispiness, taste and flavour of biscuit reduced with increase in cassava flour but the diameter, spread ratio and shape of the biscuit improved. Increase in the levels of cassava flour resulted in decrease in the protein content progressively from 13.04% in 100%WF to 8.4% in biscuit with 40% cassava flour. However, addition of 10% soybean flour to composite flour above 40% CF resulted in progressive rise in the protein content of the biscuit from 8.41% in the 40% cassava flour biscuits to 11.39% in biscuits with 50%CF with subsequent reduction as the cassava flour increased to 70% level. The hydrogen cyanide content of the biscuits was increased with the increase in level of cassava flour in the formulations with maximum level of 0.20 mg/kg and in biscuit with 70% cassava flour. There was no significant difference in the overall acceptability between the biscuit from the control (100% wheat flour) and the composite flours up to 7040% cassava substitution level. Further addition of soy flour above 40%CF levels also improved the overall acceptability and there was no significant difference in the overall acceptability sensory qualities and other biscuit without soy flour enrichment up to 60% cassava flour. This indicates the feasibility of producing nutritious biscuits with desirable organoleptic qualities from cassava/wheat/soy composite flour up to 7060% cassava substitution level.

Key words: Cassava, soybean, composite flours, biscuits, physicochemical and organoleptic qualities.

INTRODUCTION

Biscuits are one of the popular cereals foods; apart from bread, consumed in Nigeria. They are ready to eat, convenient and inexpensive food products, containing digestive and dietary principles of vital importance (Kulkarni, 1997). They are nutritive snacks produced from unpalatable dough that is transformed into appetizing product through the application of heat in the oven (Olaoye et al., 2007). In Nigeria, ready-to-eat baked products (snacks) consumption is continually growing and there has been increasing reliance on imported wheat (Akpapunam et al., 1999). Nigeria, moreover, grow staple crops other than wheat such as cassava, yam or sweet potatoes and cereals that can be used for bakery foods. It would therefore be economically advantageous if imported wheat could be reduced or even eliminated and the demand for baked foods such as biscuits could be met by the use of domestically grown products other than wheat.

Therefore, efforts are being made to partially replace wheat flour with non-wheat flours as a possibility for increasing the utilization of indigenous crops cultivated in Nigeria as well as contribute to lowering cost of bakery products, (Ayo and Gaffa, 2002). Many workers have studied the physical and baking properties of composite biscuits from starchy staples like cassava, cocoyam and plantain. Mepba et al. (2007) produced composite

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Fresh Cassava Roots

↓

Washing

↓

Grating Finely

↓

Dewatering

↓

Disintegration of lumps

↓

Drying

↓

Milling

↓

Sieving

↓

Cassava flour.

Figure 1. Flow chart for the production of cassava flour.

biscuits from mixed flours of wheat and plantain with a corresponding decrease in quality as the substitution levels increased. Sakyi-Dawson et al. (2006) produced biscuits from a mixture of cassava and cowpea flours with cowpea levels ranging from 30-55% while Okaka and Isieh (1990) substituted wheat flour with cowpea flours at various levels. Kure et al. (1998) studied the proximate composition and the effect of particle size on biscuit from plantain and soybean flours; while Kulkarni (1997) produced composite biscuit using roasted soybean. Onweluzo and Iwezu (1998) produced biscuits from different blends of wheat-soybean and cassava-soybean flours.

The composition, physical characteristics and sensory qualities of the biscuits were compared with wheat flour biscuits. Wheat-soybean flour (1:1) biscuits had twice the protein value of the wheat flour biscuits and higher calorific value. Sing et al. (1996) studied the effect of incorporating defatted soy flour on the quality of biscuits. Akubor and Ukwuru (2005) also substituted cassava flour with soy flour (SBF) and studied the effect on the functional properties and biscuit making potentials of soybean and cassava flour blends. They showed that soybean flour had a greater capacity to absorb water and oil. Sensory evaluation indicated that there were no significant differences in colour, texture, flavour, taste and overall acceptability of the flour blend biscuits. They found that at 50% level of soy flour incorporation, biscuits had higher scores for all the sensory attributes evaluated. Above this level, biscuits received lower sensory scores.

Oluwole and Karim (2006) produced biscuit from various blends of Bambara, cassava and wheat flours respectively. They observed that the blend (30:35:35) produced the most acceptable biscuit. Idowu et al. (1996) studied the use of cocoyam flour as composite with wheat flour in biscuit production. They found that up to 80% substitution with cocoyam flour produced acceptable biscuit. In most of the studies where the starchy staples were used it was found that the nutritional qualities decreased as the level of the starchy staples increased.

The objectives of this study are therefore to produce biscuit from varied ratios of cassava and wheat flour and enrich the composite wheat/cassava biscuit at high cassava ratio with soy flour in order to improve on the nutritional quality; and determine the effect of cassava and soybean flour inclusion in the composite formulations on the physicochemical and sensory qualities of biscuit from the composite blends.

MATERIALS AND METHODS

Materials

The cassava flour from the sweet variety of cassava (*Manihot palmata*) was obtained from Oke-Ayo Farms Limited in Ore, Ondo State, Nigeria; while, wheat, sugar, salt, fat, sodium bicarbonate (baking powder) and milk were purchased from main market in Akure, Ondo State, Nigeria.

Methods

Processing of cassava roots into flour

The fresh cassava variety (*Manihot palmata*) was processed into flour (Figure 1). The cassava roots were peeled manually with a sharp knife, washed and grated in a locally fabricated mechanical grater (Adeyemi and Balogh, 1985). The grater was made of a flat galvanized sheet punctured with holes with a big nail with opening of 0.75 cm diameter and fixed round a drum-like plank. This was connected through a belt to a 7 hp driving motor. The washed cassava roots was held by hand and grated over the rotating drum with extreme care that fingers and palm are not bruised (Agunbiade, 2001). They were then packed into Hessian sack and dewatered by pressing in a mechanical press (Addis Engineering Nig. Ltd, Nigeria) to dewater the mash. The dewatered lumps were pulverized with hands and sifted on a local raffia made sieve of mesh (0.3 cm x 0.3 cm) mounted on a rectangular wooden frame 40 cm^2 to remove the fibres. The sifted cassava meal obtained was allowed to dry in a cabinet dryer. The dried meal was milled and sieved with a fine mesh (200 µm) and later packaged in HDPE film and kept under refrigerated storage until ready for further analysis.

Processing of soya bean flour

This was developed according to the methods of Oluwamukomi et al. (2005). 1 kg of soybean (*Glycine max* L merriel) were sorted, washed and boiled in water at 100°C for 30min. It was dehulled manually, oven-dried at 55°C for 16 h, milled in a disc attrition mill (Agrico Model 2A, New Delhi, India) to obtain the flour followed by sieving using a sieve with 300 -µm aperture and then kept in an airtight HDPE film until ready for further use.

Table 1. Recipe for biscuit production.

Samples	Wheat flour (%)	Cassava flour (%)	Soybean flour (%)	Salt (NaCl) (g)	Sugar (g)	Fat (g)	Sodium-bi carbonate (baking powder) [g]
AA	100	-	-	1.0	30.0	20.0	2.0
AB	90	10	-	1.0	30.0	20.0	2.0
AC	80	20	-	1.0	30.0	20.0	2.0
AD	70	30	-	1.0	30.0	20.0	2.0
AE	60	40	-	1.0	30.0	20.0	2.0
AF	40	50	10	1.0	30.0	20.0	2.0
AG	30	60	10	1.0	30.0	20.0	2.0
AH	20	70	10	1.0	30.0	20.0	2.0

Range of sterile water used for mixing = 76 - 80ml

Ingredients
|
Mixing
|
Cutting
|
Baking (185°C for 15-20 minutes)
|
Cooling
↓
Packaging

Figure 2. Flow chart for biscuit production, (Ihekoronye, 1999).

Blend formulation and biscuit production

Eight blends were prepared by mixing wheat flour with cassava flour and soybeans in the percentages, as shown in Table 1, using a Kenwood mixer (model, HM400). Biscuit were produced from the eight formulations using the method of Ihekoronye (1999) Figure 2. Ingredients used were 20% sugar, 27% fat, 2.0% sodium bicarbonate, 0.1% salt, 7.5% milk and 76 – 80 ml of water (because as the ratio of cassava flour increased it required more water during mixing (Table 1). Sugar and fat (margarine) were mixed together, and then wheat flour, cassava flour, soybean flour, common salt, sodium-bicarbonate and water were added to prepare dough. The dough was mixed for 15 min until a uniform smooth paste was obtained using hand. The paste was rolled on a flat rolling board sprinkled with the some flour to a uniform thickness using a wooden hand roller. Circular biscuits were cut (using a circular biscuit-cuter of diameter 4 cm), placed on a greased baking tray and kept at a normal room temperature for 2 h to allow proper dough leaving. Then these trays of the eight blends were baked at once in an oven at a temperature of 184°C for between 15-20 min when a very light brown colour was formed, biscuits were removed, allowed to cool, packed in HDPE film and stored.

Analysis

Chemical analysis

The proximate compositions were determined according to the standard methods of AOAC (1990), No 935.39 for baked goods. The crude protein was determined by multiplying the total nitrogen by 6.25. The carbohydrate was obtained by difference. The total cyanide (mg/kg) was determined by the alkali titration method of AOAC (1990), No 915.03.

Physical analysis

The weight of the biscuits was measured by weighing on a weighing balance (Model Mettler PE1600, Mettler Instruments Corporation, Greifensee, Zurich, Switzerland) with an accuracy of 0.1 mg). The diameter was measured with a calibrated ruler as described by Ayo et al. (2007). The spread ratio was determined using Ayo et al. (2007) method. Three rows of the five well-formed biscuits were made and the height measured as well as arranging the same biscuits horizontally edge and the sum of the diameter measured.
Spread ratio= Diameter / Height

Sensory evaluation of the biscuits

The organoleptic evaluation of the biscuits samples was carried out for consumer acceptance and preference using 10-trained panellist (students and staff of the department of the Food Science and Technology, Federal University of Technology, Akure, Nigeria). They were to evaluate the sensory properties based on colour, aroma, taste, texture and overall acceptability using a nine point Hedonic scale where 1 represents "extremely dislike" and 9 "extremely like" respectively. Means and standard errors of the mean (SEM) of replicate scores were determined and subjected to analysis of variance (ANOVA) using the statistical package for social statistics (SPSS version 12). Means were separated using the Duncan's new multiple range test (Steel et al., 1997).

RESULTS AND DISCUSSION

Chemical Composition

The results of the proximate analysis on the biscuits are shown in Tables 2. Increase in the levels of cassava flour resulted in decrease in the protein content progressively from 13.04% in 100%WF to 8.4% in biscuit with 40% cassava flour. This must have been due to the low

Table 2. Chemical Compositions of Biscuit (%db)

Biscuits Samples	Ash content (%)	Protein content (%)	Crude fibre (%)	Fat content (%)	Carbohydrate content (%)	Hydrocyanic acid (mg/kg)
A=100% WF	2.78[a]	13.04[a]	0.27[c]	15.22[a]	68.69[c]	0.06[d]
B=90%WF: 10%CF	1.84[b]	12.35[a]	0.24[c]	14.45[b]	71.12[b]	0.14[c]
C=80%WF: 20%CF	1.68[b]	10.73[b]	0.25[c]	14.51[b]	71.63[b]	0.14[c]
D=70%WF: 30%CF	1.34[c]	10.68[b]	0.27[c]	14.46[b]	73.25[b]	0.14[c]
E=60%WF: 40%CF	1.06[c]	8.41[c]	0.33[c]	14.39[b]	76.81[a]	0.17[b]
F=40%WF: 50%CF:10%SBF	2.42[a]	11.39[a]	0.44[b]	16.57[a]	69.18[c]	0.17[b]
G=30%WF:60%CF:10%SBF	1.99[b]	9.07[b]	0.53[a]	16.10[a]	72.31[b]	0.17[b]
H=20%WF:70%CF:10%SBF	1.65[b]	7.43[c]	0.64[a]	15.83[a]	74.45[a]	0.20[a]

WF=Wheat flour, CF= Cassava flour, SBF= Soybean
*values are means of triplicate readings.

protein content of the cassava flour (1-2%) which must have diluted the protein content of the wheat flour thus reducing it with increase in the levels of cassava flour. Addition of 10% soybean flour to the 40%CF biscuit resulted in an increase the protein content of the biscuit from 8.41 to 11.39% in biscuits with 50%CF. However, increasing the cassava flour again resulted in the reduction of the protein content. The protein content again reduced progressively with further increase in the ratio of cassava flour to 7.43% in the biscuit with 70%CF. This is similar to the earlier findings where the protein content of biscuit reduced with supplementation with starch based products (Olaoye et al., 2007 for breadfruit flour; Mepba et al., 2007 for plantain). The sudden increase in the protein content with supplementation with 10% soy flour shows that cassava flour can be incorporated into biscuit at high supplementation level and still retain its nutrient content similar to 100% wheat flour biscuit.

The fat content of the biscuits initially decreased from 15.22% in the 100%WF to 14.39% in the sample with 40%CF substitution level. Enrichment with 10% soy flour resulted in sharp increase in the fat content from 14.39% in the sample with 40%CF to 16.57% in the sample enriched with 10% SBF. Further increase in the cassava flour resulted in decrease in the fat content to 15.83% in the sample with 70%CF. This decrease might have been due to the increase in cassava flour and reduction in the wheat flour which contributed the fat component, while the sudden increase to 16.57% in the sample with 10% soy flour was as result of the fat content in the soy flour. The carbohydrate content initially increased as the cassava flour ratio increased from 68.69% in the control sample to 76.81% in biscuit with 40% CF. It reduced again with substitution with 10% soy flour which later increased again to 74.45% in biscuit when the cassava flour was increased to 70%CF. The crude fibre content of the composite biscuits increased with substitution with cassava flour from 0.27% in the control sample to 0.64% in the sample with 70% cassava flour. The increase might have been due to the fibre content in the cassava flour which increased with increase in its level in the composite flour. However they were below the 1.5% maximum allowable fibre content of bread flour as stated by Omole, (1977) and the 2.0% recommended by Nigerian raw materials research and development council (RMRDC, 2004). The hydrocyanic acid content of the biscuit in mg/kg increased as the level of cassava flour increased in the formulation, with sample H with 70%CF having the highest value of 0.2 mg/kg, which is below the maximum required level of 10% mg/kg recommended by RMRDC, (2004).

Physical properties

As the ratio of cassava flour increased, the mean weight of the biscuits increased from the 4.48 g in the control to 5.98 g in the biscuit with 40%CF (Table 3). With the addition of 10% Soy flour, the mean weight reduced to 4.49 g but later increased to 6.0 g when the cassava flour was increased to 70%. The spread ratio values as well as the diameter of the biscuits from cassava/wheat composite flour increased with increase in the level of cassava flour. Enrichment of the biscuit with soy flour at substitution level above 40%CF also resulted in increase in the diameter and the spread ratio but with an initial decrease in weight. This can also be observed in Figure 3. Decrease in spread ratio with increase in wheat flour showed that starch polymer molecules are more tightly bound with granules and swelling is limited in the biscuit with wheat flour when heated.

Table 3. Physical properties of WF/CF/SBF composite biscuits.

Biscuit samples	Diameter (cm)	Spread ratio	Weight (g)
A=100%WF	3.53c	1.43b	4.48d
B=90%WF: 10%CF	3.12d	1.23d	4.90c
C=80%WF: 20%CF	3.73b	1.38c	5.41b
D=70%WF: 30%CF	3.77b	1.43b	5.79a
E=60%WF: 40%CF	4.13a	1.96a	5.98a
F=40%WF:50%CF:10%SBF	4.17b	2.04c	4.49c
G=30%WF:60%CF:10%SBF	4.42a	2.39b	4.86b
H=20%WF:70%CF:10%SBF	4.47a	2.71a	6.00a

*Mean values with similar superscript in a column are not significantly different (P > 0.05)
WF =Wheat flour, CF=cassava flour, SBF=soybean flour.

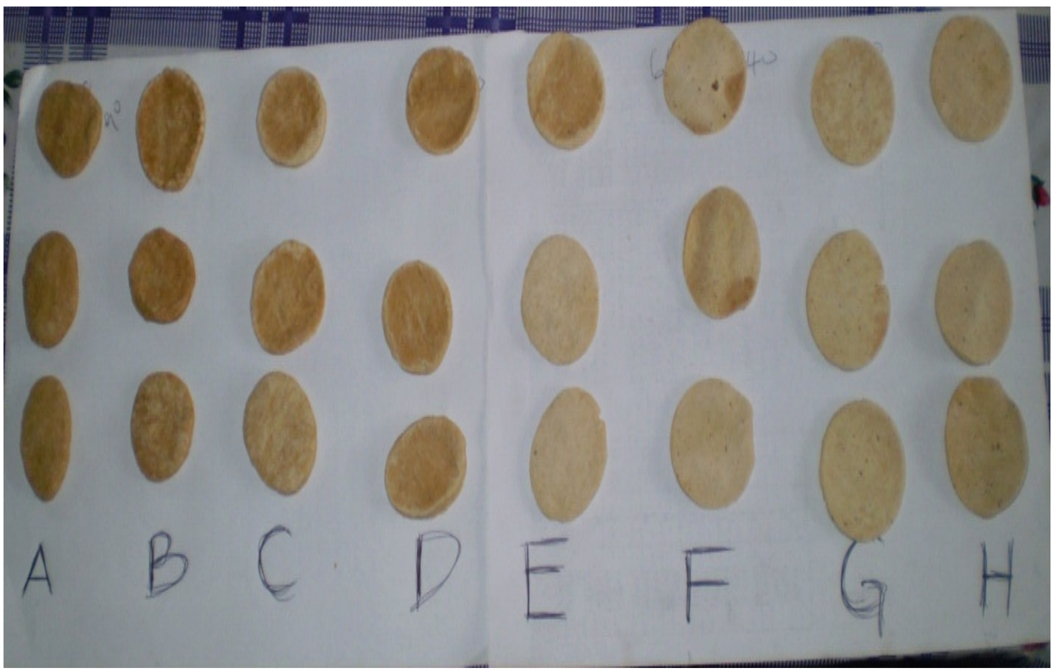

Figure 3. Biscuits prepared from different blends of composite flours.
A=100% wheat,
B=90% wheat/ 10% cassava,
C=80% wheat/ 20% cassava,
D=70% wheat/ 30% cassava,
E= 60% wheat/ 40% cassava,
F=40% wheat/ 50% cassava/ 10% soybean,
G=30% wheat/ 60% cassava/ 10% soybean
H=20% wheat/ 70% cassava/ 10% soybean.

On cooling the starch formed a rigid gel with capacity characteristics of large molecular aggregates (Agu et al., 2007).This is similar to the findings of Mridula, et al., (2007) that spread ratio decreased significantly with increase in proportion of sorghum flour in wheat/sorghum composite biscuit. This they attributed to the decrease in dough strength with increase in proportion of sorghum flour.

Sensory qualities

Samples of the biscuits prepared from the cassava-wheat-soybean composite flour are shown in Figure 3. The mean sensory scores are presented in Table 4. Increase in the substitution level of cassava flour resulted in decrease in crispness and colour scores (P < 0.05). The panel scores for crispiness decreased with increase

Table 5. Sensory scores of biscuits.

Samples	Crispness	Taste	Aroma	Overall acceptability	Shape (flatness)	Colour
A=100%WF	8.0^{a}	8.0^{a}	7.5^{a}	8.5^{a}	6.0^{b}	7.0^{a}
B=90%WF:10%CF	8.0^{a}	7.0^{a}	7.0^{a}	8.5^{a}	6.0^{b}	7.0^{a}
C=80%WF:20%CF	7.5^{ab}	6.5^{ab}	7.0^{a}	7.5^{a}	6.0^{b}	7.0^{a}
D=70%WF:30%CF	7.5^{ab}	6.5^{ab}	7.0^{a}	7.5^{a}	6.0^{b}	7.0a
E=60%WF:40%CF	5.5^{ab}	$6.5^{\mathbf{ab}}$	7.0^{a}	6.5^{ab}	7.5^{a}	4.5^{b}
F=4O%WF:50%CF:10SBF	6.0^{ab}	6.0^{ab}	7.5^{a}	7.0^{a}	7.5^{a}	4.5^{b}
G=30%WF:60%CF:10%SBF	5.0^{b}	6.0^{ab}	6.5^{ab}	6.0^{b}	7.5^{a}	4.5^{b}
H=20%WF:70%CF:10%SBF	5.5^{b}	5.5^{b}	4.5^{b}	6.0^{b}	7.5^{a}	5.0^{b}

*Mean values with similar superscript in a column are not significantly different (P > 0.05)
Values are means of 10 panellists' scores.

in the ration of the cassava flour from 8.0 to 5.5 for biscuit with 40%CF. This shows that the more the cassava flour the less the crispiness.

Composite biscuits C, D and E were not significantly different from A (100%WF) and B (90%WF: 10%CF) in terms of crispness. Substitution with 10% Soy flour resulted in a slight decrease in the crispness of the biscuit. This might have been due to the effect of the oil in the soy flour. There was a general decrease in the scores of colour, aroma and
overall acceptability with increase in the supplementation level with cassava flour (P < 0.05). In term of the colour score, it was evidence from Table 4 and Figure 3 that composite biscuit F, G and H (composite with 10%soybean flour) differed from the rest composite flour. They were lighter in colour and were scored lower than the rest (4.5-5.0). However, sample B, C and D were rated not significantly difference from the control sample A (P > 0.05). This result however differs from the work of Sakyi-Dawson, et al, (2006) who observed that the colour of biscuits from a composite of cowpea and cassava darkened as the non-wheat flour level increases from 30-55% whereas it lightens here. This might have been due to the different effects of cowpea and soy flours. Shape (flatness) is one the features that characterizes a good biscuit, they should be well formed, and crispness should be good. The pictorial view of the composite biscuits blends is shown in Figure 3. The shape of biscuits from composite flour blends E, F, G and H were score higher than those from the mixture of cassava flour (B, C and D) without soy flour, this is corroborated by the increase in the spread ratio and diameter values in the physical analysis (Table 3). On the basis of aroma and overall acceptability, there were no significant statistical differences between the control and biscuits from composite flours up to 40% level (P > 0.05). This means that biscuit from cassava substitution will be acceptable in terms of colour, aroma and overall acceptability up to supplementation level of 40% cassava flour. This is similar to the findings of Mepba et al., (2007) that biscuit from composite of plantain/wheat flour supplementation was acceptable up to 40% supplementation level. When wheat-cassava blends were substituted with 10% soy flour above 40% cassava level, sensory evaluation indicated that there were no significant differences in taste, aroma and overall acceptability of the soy-enriched biscuits with the unenriched biscuit up to 60% cassava flour. This is similar to the findings of Akubor and Ukwuru (2005) who studied the effect of soy flour on the functional properties and biscuit making potentials of soybean and cassava flour blends. They observed that there were no significant differences in colour, texture, flavour, taste and overall acceptability of both soy enriched and un-enriched flour blend biscuits. However, the colour of the soy enriched biscuits was significantly different from the un-enriched biscuits.

CONCLUSION

Substituting wheat flour with cassava flour produced biscuits with no significant differences in physicochemical and sensory qualities from biscuit from 100% wheat flour up to 40% substitution level (P>0.05). However, as the levels of cassava flour increased the protein content decreased and carbohydrate content increased significantly (P<0.05). This significant decrease was counteracted by supplementing with 10% soy flour which resulted in a significant increase in the protein content. Therefore biscuit with comparable nutrient content to 100% wheat flour could be produced with wheat/cassava composite flour up to substitution level of 60% cassava flour and a minimum of 10% soy flour. This means that biscuit from wheat, cassava and soy flour composite will be acceptable in terms of colour, aroma and overall acceptability up to supplementation level of 60% cassava flour.

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