

Effects of Creaming Method and Flour Formulation on Acceptability and Proximate Characteristics of Cake from Corn, Wheat and Soya Bean Composite Flour

Vincent Kwaku Asimah[1] Courage Sedem Dzah[1,2 *] David Asante-Donyinah[1] Otilia Adzinyo[1]
1. Faculty of Applied Sciences and Technology, Department of Hospitality and Tourism Management, Ho Polytechnic, P.0. Box HP 217, Ho, Ghana
2. Centre for Research in Efficient Agricultural Technology, Ho Polytechnic, Ghana

Abstract
The study tested the possibility of incorporating corn and soya bean flours to partially substitute wheat flour in the production of cakes. A 3x2 factorial design was followed using three different composite flour formulations (A, B= 80 soya bean: 15 corn: 5 wheat; C, D= 15 soya bean: 80 corn: 5 wheat; E, F= 50 soya bean: 20 corn: 30 wheat) at two levels of creaming (manual and machine creaming). Samples A, C and E were manually creamed whereas B, D and F were subjected to machine creaming. Composite flours were used to bake cakes, with 100% wheat flour cake serving as control. A total of seven samples were produced, coded and tested for acceptability using a nine-point hedonic scale in affective sensory test. Correlation analysis was performed to ascertain the influence of individual flour components on the performance of cake samples. Proximate analysis was also conducted on best overall scored sample and control sample (G). Results showed that all cake samples compared well sensorially with average score of 7.23 for overall acceptability against G (7.33), inferring they were all liked moderately by the sensory panel. Correlation coefficients showed that sensory scores were lower for increasing amounts of soya bean (-0.4656) and corn (-0.3637) but higher for increasing amounts of wheat (0.8680). For proximate and energy contents, sample F had significantly higher values for moisture (24.71) and protein (18.50) than G (19.01 and 8.19 respectively) ($P<0.05$). The control sample (G) also recorded higher values for fibre (26.23) and lipids (42.77) than sample F (23.92, 30.41 respectively) ($P<0.05$). Energy values of samples revealed a higher value for G (520.61 kcal) than F (443.37 kcal). Creaming methods had no significant influence on the sensory performance of cakes. Substituting wheat flour with soya bean and corn flour was recommended but more work needs to be done to improve on associated heaviness and rough texture of cakes produced.
Keywords: Cakes, Sensory, Flour, Corn, Soya beans

1. Introduction

Incorporation of indigenous food ingredients in the manufacturing of food products is crucial to the sustainability of agri-food industry and to the alleviation of poverty especially among smallholder farmers who are primarily producers. This initiative will create a ready market for foods produced at the farm levels and as well become a means of employment to many others. Cereals and legumes such as corn, millet, cowpea, soya bean, and sorghum among others grown in Ghana have the functional and nutritional potential to be used in the development of novel or value added food products. Some of these cereals and legumes have been used in the production of cakes and other baked products (Agboka *et al*., 2015; Kpodo, 2014; Ndife *et al.,* 2011; Akubor, 2004).

The "ready-to-eat" nature of bakery products and pastries make them convenient foods and have become essential to the survival of the hospitality and tourism sectors in Ghana and the world at large. In Ghana majority of bakery products and pastries are produced from wheat flour which is not grown in Ghana. According to Index Mundi (2014) Ghana imported wheat to the tune of 595,000 metric tonnes in 2014 compared to amount imported five years ago in 2009 (306, 000 metric tonnes). However, in struggling as a developing country to achieve developmental goals, the incorporation of locally produced ingredients into the production of known foods such as cakes will not only alleviate the economic burden of wheat flour importations on Ghana, but also enhance the sustainability of its agri-food sector.

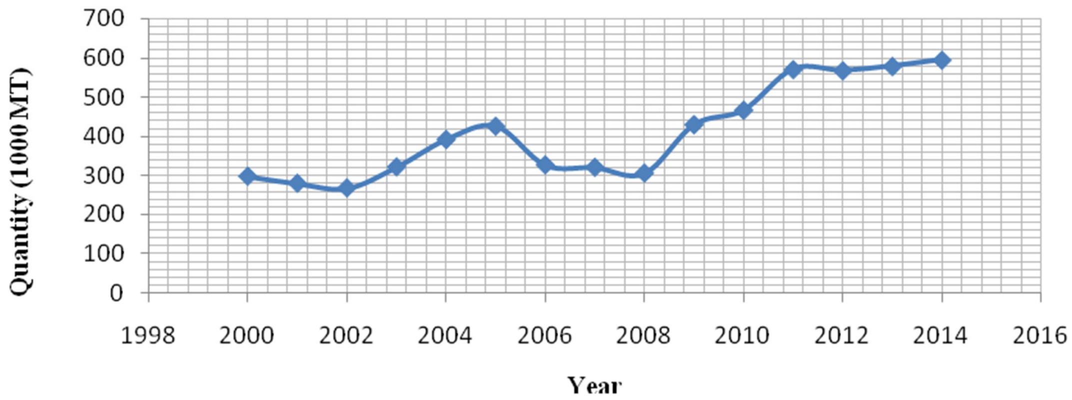

Figure 1: Ghana annual wheat imports between 2000 and 2014

Pastries are known globally to be mainly produced from wheat flour. although wheat flour is known to be a good source of calories and other nutrients, its protein content is of lower nutritional quality compared to soy bean, peanut and cowpea (Agboka *et al*., 2015; Ndife *et al.,* 2011; Olapade, 2012; Akubor, 2004). Creativity, innovation and product diversification among other factors like nutrition have necessitated the use of other ingredients such as corn flour, soya bean flour and plantain flour among others in the production of pastries and other bakery products (Abou-Zaid *et al.,* 2011; Anyango *et al.,* 2011). For example, soya bean flour has been used to complement wheat flour to improve on nutritional value of pastries whilst meeting consumer demands for products of high nutritional value without compromise on safety (Mune *et al.,* 2013).

Beside the argument that new locally grown ingredients be used in developing food products, there still remains an important question concerning the methods to adopt such that new products developed compete well or better than those already on the market. This has relevance to how well these novel products will fair in order to improve on socio-economic status of producers especially. This study partly looked at how creaming as a method influences the sensory performance of cakes developed from indigenously grown cereals and legumes.

Creaming is a major mixing process in the production of cakes enabling them to incorporate air and to make them light and fluffy (NFSMI, 2009). This is crucial as it impacts the sensory characteristics of cake products. During creaming, whether manually or by machine-aided, it is important to consider ingredient temperature and mixing speed necessary for good air cell formation. Temperatures below 60°F/16°C is not favourable to form good air cells as fat (butter) gets hardened, and fat that is warm above 75°F/24°C gets too soft to trap air. Mixing speed should also be moderate as high speed generates more heat from friction which warms the ingredients above optimum temperature as explained earlier. Not as many air cells are formed, and those that do form tend to be coarse and irregular. The focus on creaming has been on the timing, temperature and speed as well as gluten content of flour but not on the differences between a machine-aided approach and manual method (by hand).

The main goal of this study was to test the possibility of using locally available ingredients (corn and soya bean flours) to complement wheat flour in producing cakes. The specific objectives of the study were to produce cakes from different formulation of flours from corn, soya bean and wheat; conduct sensory evaluation on cake samples to ascertain acceptability; investigate the influence of creaming method on sensory performance; and to determine the proximate compositions of cake samples.

2.0 Materials and methods

2.1 Experimental design

The design for this study followed a 3x2 factorial design as described by Dzah (2015). It included three different formulations (A, B= 80 soya bean: 15 corn: 5 wheat; C, D= 15 soya bean: 80 corn: 5 wheat; E, F= 50 soya bean: 20 corn: 30 wheat) at two levels of creaming [manual creaming (A, C and E) and machine creaming (B, D and F)] following the conventional creaming method (National Food Service Management Institute, 2009). Formulation containing 100% wheat served as control. In total, seven (7) samples were used in this study. Wheat flour was purchased from the Ho central market. Soya bean and corn were also purchased from the same source, sorted and processed into flours (Figure 1). Cakes were produced from the different formulations using the same recipe [except for changing flour proportions (Table 1)], sensorially evaluated and proximate composition analysed.

Table 1: Recipe for cake development

Ingredient	**Quantity**
Composite flour (%soya bean: % corn: % wheat)	According to formulation (A,B,C,D,E,F,G)
Fat	100 g
Sugar	50 g
Egg	8 medium size
Vanilla essence	3 table spoon
Baking powder	3 table spoon

2.2 Cake production

Cake production followed the method described by Agboka *et al*. (2015) as depicted in Figure 3 with some modification. Cakes were baked using flour combinations (A, B; C, D; and E, F) and ingredients as in recipe (Table 1). Seven cake samples including control sample were produced following outlined method (Figure 3).

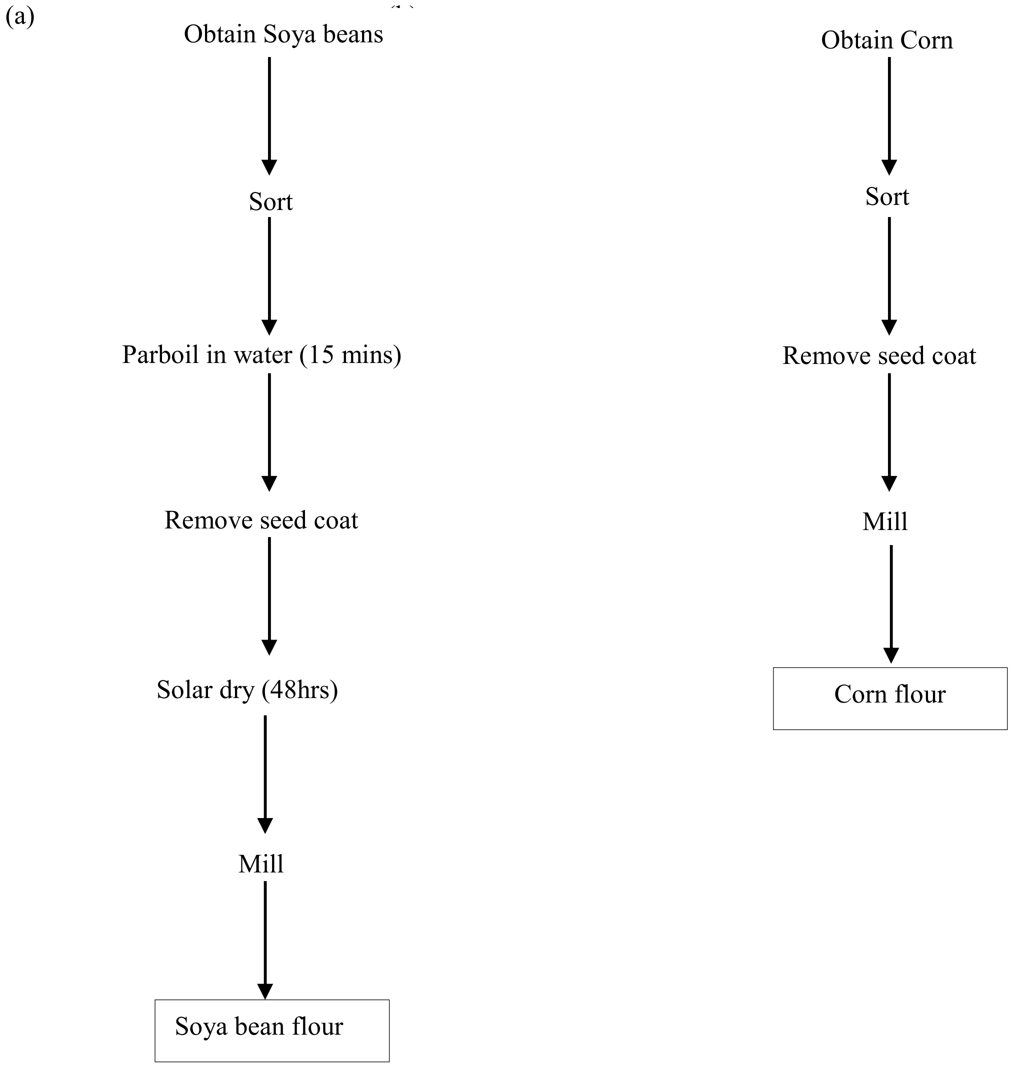

Figure 2: Process flow diagram for flour production: (a) soya bean flour, (b) corn flour

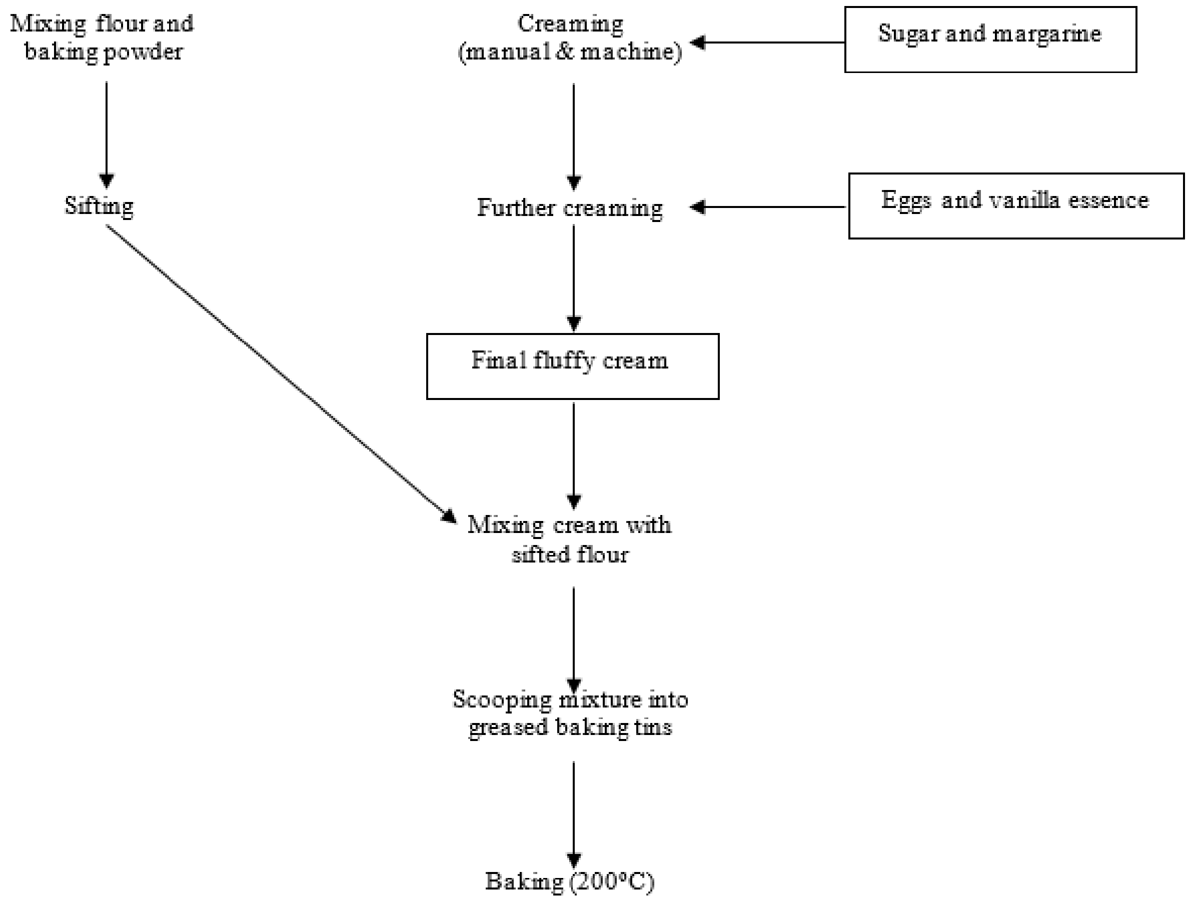

Figure 3: Cake baking process flow diagram

2.3 Sensory evaluation

Assessment of sensory attributes of cake samples was done using a nine-point hedonic scale in an affective test with 35 randomly selected untrained panellists (Dzah, 2015). Cake samples were randomly coded to minimize random errors. Sensory attributes assessed were colour, taste, flavour, mouthfeel and overall acceptability which were all ranked based on a scale (1 = dislike extremely, 5 = neither like nor dislike and 9 = like extremely).

2.4 Proximate analyses

Proximate analyses of the cake samples followed the method of Association of Official Analytical Chemists (AOAC, 2000) and as described by Dzah (2015). These analyses included moisture, lipids, crude fibre, protein, ash and energy contents. All analyses were done in triplicates and average values calculated with standard deviations.

2.4.1 Moisture content determination

Labelled Petri dishes were dried in a hot air oven at 105°C for about 30 minutes and cooled in a desiccator. The dishes were then weighed with a properly calibrated digital analytical balance and their various weights recorded. 2g of each sample was weighed into the labelled pre-weighed Petri dishes and weighed again and immediately transferred into a hot air oven pre-set at 105°C to dry. Crucibles containing cake samples had their weights severally taken to ensure constancy and weights were recorded as final values. The difference in initial and final weights indicated moisture contents of cake samples.

2.4.2 Lipids Content Determination

1.0g each of the samples was weighed into a pre-weighed thimble. 150ml pet ether was measured into a 250ml conical flask using the measuring cylinder. The samples were then soxhlet extraction using a soxhlet extractor fitted with thimble containing samples for eight (8) hours and the thimbles with contents removed, dried in an oven at 105°C for two (2) hours and weighed with an analytical balance.

2.4.3 Ash Content Determination

Labelled porcelain crucibles were dried in the hot air oven pre-set at 105°C for about 30 minutes and cooled in a desiccator. The initial weights of the cooled crucibles were recorded after which 2.0g of each cake sample was weighed into crucibles and placed in a muffle furnace (Gallenkamp model) to carbonize at 600°C for 2 hours till the samples had a cotton wool like texture. The crucibles containing ash were removed and kept in a desiccator to cool after which they were weighed again and the percentage ash was calculated using the difference between initial and final weights.

2.4.4 Protein Content Determination

One gram (1.0g) each of the cake samples was weighed into the kjeldahl flask. 1.0g of K_2SO_4 and 0.1g Ca_2SO_4 were added into the flask, mixed with 20ml of H_2SO_4 and the content digested on heating mantle in a slanting position in a fume chamber. The process was monitored for a black to bluish-green colour change which marked the end point. The reaction was then stopped and digests removed and allowed to cool. They were then made up with distilled water to 200ml mark on ice. 50ml of aliquot of each digest was then poured into a distillation flask and carefully layered with 50ml of NaOH. The solution was then distilled into a receiving flask containing 50ml of 0.1N H_2SO_4 with two drops of methyl red indicator. Distillation was stopped by removing the solution in the receiving flask immediately before putting of hot mantle to avoid drop in pressure. The distillate was titrated with 0.1M NaOH and percentage nitrogen calculated as protein content.

2.4.5 Crude Fibre Content Determination

The crude fibre content was determined by the formula, 100-(% Moisture+% Ash+% Lipid+% Protein) as described by Dzah (2015).

2.4.6 Energy content determination

Energy content was determined according to standardised AOAC (2000) method using the approximate conversion factors for fats (9 kcal/g), proteins (4 kcal/g) and carbohydrates (4 kcal/g) in the formula, Energy (kcal) = 9 (%Fat) + 4 (%Protein) + 4 (%Carbohydrate).

3.0 Results and Discussion

3.1 Sensory assessment of cake samples

3.1.1 Overall sensory performance summary

The six cake samples were sensorially compared to the control cake (G) (Table 2). On the overall, all cake samples compared favourably with average scores ranging from 6.50 to 7.22 (approximately 7.00) against 7.33 for the control sample (Table 2). That is, all samples fall within the value of 7 on the hedonic scale inferring that they were liked moderately by the sensory panel.

Table 2: Mean scores on sensory parameters for cake samples

Samples	**Sensory parameters**					
	Colour	Taste	Flavour	Mouthfeel	Overall accept	Average
A	6.00(±1.879)^{a}	6.71(±1.949)^{a}	6.71(±1.759)^{a}	6.80(±1.967)^{ab}	7.14(±1.717)^{ab}	6.67
B	6.49(±1.961)^{ab}	6.23(±1.671)^{a}	6.63(±1.592)^{a}	6.29(±1.637)^{a}	6.86(±1.665)^{a}	6.50
C	6.83(±1.801)^{ab}	7.23(±1.457)^{ab}	6.80(±1.562)^{a}	6.49(±2.188)^{a}	7.00(±1.680)^{ab}	6.87
D	6.74(±1.868)^{ab}	6.89(±1.530)^{a}	6.71(±1.775)^{a}	7.06(±1.697)^{ab}	7.31(±1.300)^{ab}	6.94
E	6.71(±1.919)^{ab}	7.26(±1.336)^{ab}	7.26(±1.651)^{ab}	7.06(±1.679)^{ab}	7.51(±1.853)^{ab}	7.16
F	6.49(±1.961)^{ab}	7.23(±1.800)^{ab}	7.46(±1.268)^{ab}	7.34(±1.814)^{ab}	7.57(±1.668)^{ab}	7.22
G	7.06(±1.890)^{b}	7.26(±1.615)^{ab}	7.60(±1.576)^{b}	7.03(±1.871)^{ab}	7.71(±1.708)^{b}	7.33

Legend: (A, B= 80 soya bean: 15 corn: 5 wheat; C, D= 15 soya bean: 80 corn: 5 wheat; E, F= 50 soya bean: 20 corn: 30 wheat)

3.1.2 Effects of sample composition on sensory performance of cake samples

Since all ingredients except flour proportions remained constant for all samples, it was likely that changes in sensory parameters (colour, taste, flavour, mouthfeel, overall acceptability) were resulting from differences in flour proportions.

Colour

Observing trends in scores for colour (Table 2), samples A and B contained the highest amounts of soya bean (80 soya bean: 15 corn: 5 wheat) and scored the lowest (6.00 and 6.49 respectively). Similarly, samples containing the lowest amounts of soya bean (C, D and G) generally had the highest scores for colour (6.83, 6.74 and 7.06 respectively). To confirm the accuracy of this observed trend, a correlation matrix was established between soya bean content in samples and scores for colour. A strong negative correlation (-0.864) was observed indicating that higher amounts of soya bean flour in cake samples resulted in low scores for colour (Table 3). A positive correlation was observed for corn (0.2261) and wheat flours (0.5438) with the later being strong such that higher amounts of wheat encouraged higher scores for colour. This may be due to the fact that the sensory panel was more familiar with wheat cakes (control) than cakes from new ingredients like soya bean and corn. Although the colour of cake with high soya bean flour content (80%) was bright gold, the panel was not familiar with it, resulting in the low score. A study conducted by Sanful *et al.* (2010) also showed that scores for colour of cakes generally reduced with increasing soya bean contents.

Table 3: Correlation between amounts of flour components and sensory parameters

Flour components	**Sensory parameters**				
	Colour	Taste	Flavour	Mouthfeel	Overall accept
Soya bean	-0.8644	-0.6666	-0.3989	-0.2968	-0.4656
Corn	0.2261	0.1257	-0.5049	-0.1535	-0.3637
Wheat	0.5438	0.5949	0.9479	0.5598	0.8680

Taste

All cake samples compared well with the control for taste as scores ranged from 6.23 to 7.26 (Table 2). Taste score for control sample (G) was 7.26, same as recorded for sample E (7.26). The flour components that affected the taste of cakes most were soya bean and wheat flours with respective correlation coefficients of -0.6666 and 0.5949 (Table 3). Samples were generally scored high for taste with increasing amount of wheat flour whereas the opposite was observed for soya bean flour. Corn flour did not have an appreciable influence on taste. Ndife *et al*. (2011) recorded a similar trend of low scores for taste of breads with soya bean flour compared to whole-wheat flour breads.

Flavour

Scores for flavour ranged from 6.63 to 7.60 (Table 2). The control sample (G) was the highest scored (7.60) followed by F (7.46). Like taste, flavour is another key determinant of cake acceptance by consumers and is impacted significantly by product composition. Considering the different flour components used in producing cake samples, flavour was impacted most by the amount of wheat flour added. A strong positive correlation (0.9479) was established between the amount of wheat flour added and the score for flavour (Table 3). Cake samples were scored better or higher with increasing amounts of wheat flour but scored lower with increasing amounts of corn and soya bean flours both of negative correlation coefficients (Table 3). The incorporation of soybean flour into whole-wheat bread resulted in poor flavour scores in a study conducted by Ndife *et al.* (2011). Another reason for the low flavour scores associated with addition of soya bean flour would be the beany flavour is commonly associated with food legumes (Serrem *et al.,* 2011; Okoye and Okaka, 2009; Awadelkareem *et al.,* 2008).

Mouthfeel

Except for wheat flour, none of the other flour components had a significant influence on mouthfeel. A positive correlation (0.5598) was observed between amount of wheat flour and mouthfeel unlike the weak, negative correlations for corn and soya bean flours (Table 3). Cakes containing high amount of soya bean and corn had rough texture compared to the control cake containing 100% wheat flour (Figure 4). This could be explained by the reduced gluten content and concomitant inefficient air cell formation during creaming (NFSMI, 2009). This was the most probable reason for the low scores for mouthfeel in samples containing high amount of soya bean and corn.

a. b.

Figure 4: Crust texture of cake samples: a. Cake containing 100% wheat flour (control-G). b. Cake containing 80% soya bean, 15% corn and 5% wheat flour.

Overall acceptability

On the overall assessment of cake samples, wheat flour composition was most influential as indicated by a strong positive correlation value of 0.8680 against average to weak negative correlations (-0.4656, -0.3637) observed for soya bean and corn flours respectively (Table 3). It was realized that although samples were coded, the familiarity of the sensory panel with the standard control (100% wheat flour cake) was significantly influential. As the panel scored favourably for high wheat flour content in cakes, it did same for low contents of corn and soya bean flours. The rough texture and heavy nature of cake samples with higher soya bean and corn flour contents also explained the low scores observed supported further by the beany flavour associated with the soya bean flour (Serrem *et al.,* 2011; Okoye and Okaka, 2009; Awadelkareem *et al.,* 2008).

3.1.3 Effects of creaming methods on sensory performance of cake samples

Although creaming methods have been associated with air cell formation and sensory characteristics (especially mouthfeel) of cakes, they did not significantly influence results obtained in this study (Table 4). That is, both machine-aided and manual creaming methods produced cakes that were similarly scored by the sensory panel.

Table 4: Mean scores on the influence of creaming methods on sensory parameters

Creaming method	**Sensory parameters**				
	Colour	Taste	Flavour	Mouthfeel	Overall accept
Manual creaming	6.51 (±1.887)a	7.07(±1.607)a	6.93(±1.660)a	6.78(±1.951)a	7.22(±1.749)a
Machine creaming	6.57 (±1.916)a	6.76 (±1.713)a	6.93(±1.589)a	6.90(±1.759)a	7.25(±1.568)a

3.2 Proximate analyses and energy content of cake samples

Cake samples F and G were subjected to proximate and energy contents analyses. Sample F had significantly ($P<0.05$) higher values for moisture (24.71) and protein (18.50) contents than for control sample G (19.01 and 8.19 respectively) (Table 5). The added soya bean flour enhanced the protein content of sample F as supported by other studies (Sanful *et al*., 2010; Olaoye *et al*., 2006). The control sample (G) also recorded higher values for fibre, and lipids ($P<0.05$) than sample F. Energy values of samples revealed a higher value for the control (520.61 kcal) than F (443.37 kcal) ($P<0.05$) (Table 5). This difference in energy contents were better explained by the significantly higher amount of lipids in the control than sample F.

Table 5: Proximate composition and energy content of most liked cake sample against control

Samples	**Proximate composition**					
	Moisture (%)	Lipids (%)	Ash (%)	Protein (%)	Crude fibre (%)	Energy (kcals)
F	24.71(±1.120)^a	30.41(±1.788)^a	2.46(±1.639)^a	18.50(±1.992)^a	23.92(±1.002)^a	443.37(±1.606)^a
G	19.01(±0.781)^b	42.77(±2.001)^b	3.80(±0.910)^a	8.19(±2.210)^b	26.23(±1.573)^b	520.61(±1.791)^b

Legend: (E, F= 50 soya bean: 20 corn: 30 wheat; G=100 wheat)

Conclusion

Substituting wheat flour with corn and soya bean flours in cake production showed promising results as almost all six (6) cake samples compared well with the control sample in sensory testing. Proximate composition also revealed that adding soya bean flour especially to wheat flour and others improved the protein content of cakes. A recurring issue of concern was the heaviness of cakes and the beany flavour with higher amounts of soya bean flour as well as the rough texture associated with the addition corn flour in cake products. Although wheat flour substitution with soya bean and corn flour improves on nutritional value and introduces variety, more work need to be done on improving their functional performance in products. Added, reducing the amounts of wheat flour in cakes is beneficial as issues with gluten intolerance is of nutritional concern.

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