Sensory and Proximate Characteristics of Annatto-colored Soy-wheat Cake Formulations

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Abstract Annatto extract was used as colorant in cakes from soy-wheat flour formulations. The effects of flour component and colorant were investigated on sensory attributes and proximate composition. A 3x2 factorial design of three factors (3 flour formulations) at 2 levels (annatto, sugar-flair colorant) was followed. Six cake samples (A, B, C, D, E, F) were produced and compared with a control (G) for affective sensory test and proximate analysis. Annatto-colored cakes closely matched the control (sugar-flair) in sensory performance although the later was scored higher for mouthfeel and flavour (P<0.05). All formulations had higher protein and crude fat contents than control. Samples C and E recorded significantly higher values for proteins (15.31 and 11.9% respectively against 8.27% for control) and moisture (24.87 and 25.59% respectively) than control (19.01%) (P<0.05). The control sample had higher ash (3.8%) and crude fibre (26.32%) against 1.87 and 15.89% for sample C and 1.56 and 10.52% respectively for sample E (P<0.05).

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1. Introduction

Food fortification through the addition of new ingredients or by way of ingredient supplementation and substitution is crucial to meet the health and gastronomic demands of consumers. Wheat flour has been known to be the major flour used worldwide in the production of cakes. However, for health concerns, variety and gastronomic reasons, the use of other cereals as substitutes in composite flours is gaining higher public interest [1,2].

Cakes produced from wheat flour alone were found to lack adequate protein needed for growth, repair of tissues and building of cells beside the fact that wheat flour is relatively expensive [3]. Previous study conducted by others also showed that the protein content of wheat flour is of lower nutritional quality when compared to soy bean, peanut and cowpea [1,4]. Indigenous legumes with high protein contents are being used as substitutes to wheat or in composite for use in the production of baked foods like cakes and other pastries. This has an added economic advantage of decreasing the demand for imported wheat [5-7].

The use of soya bean or soy in the form of flour is not new to the food industry as several studies have shown how food products performed when major ingredients such as wheat flour are replaced or substituted. Wheat flour was substituted with cowpea flour in the manufacture of cake and the formulation with flour proportion (50% wheat and 50% cowpea) baked at 200°C was the most preferred and significantly scored higher

(P < 0.05) for taste (7.22±2.01) and overall acceptability (7.03±1.82) compared with the control (6.67±1.84; 6.80 ±1.81 respectively) of 100% wheat flour [8]. Other works also confirm the use of other flours in substituting wheat flour in cake production [1,6,9]. These substituent flours used impact the sensory attributes such as colour, flavour, tastes and texture of food products.

Not only are new flour ingredients introduced in the production of foods but also other additives like colorants, acidifiers, sweeteners, emulsifiers can be used [10-12]. The colour of foods as well as other sensory parameters plays crucial roles in their appearance and acceptability by consumers [13,14]. Ingredients added to food to enhance or to impact colour are generally called colorants and may be from synthetic or natural sources [11,13]. One of such is the annatto (*Bixa orellana L.*) seed which can be used in its powder or liquid (extracted) form. In the liquid form, annatto colour is extracted in water, alcohol or oil as concentrate and used in small quantities to impact colour of foods. Annatto is confirmed to contain carotenoids which serve as rich antioxidant sources in annatto-coloured diets [15]. It is also considered safe to be used in foods [16].

In this study, wheat flour was substituted with soya bean flour (75 wheat: 25 soya bean; 50 wheat: 50 soya bean; 25 wheat: 75 soya bean) and annatto colour extract was used to colour cakes produced and compared with sugar-flair (control). The influence of annatto colorant and soya bean flour on the sensory attributes and proximate composition of cake samples were also investigated following standardized methods [17].

2. Materials and Methods

2.1. Experimental Design

The study followed a 3x2 factorial design. It included three different formulations (A, B= 75 wheat flour: 25 soya bean flour; C, D= 50 wheat flour: 50 soya bean flour; E, F= 25 wheat flour: 75 soya bean flour) at two levels of colouring [annatto colouring (A, C and E) and sugar flair colouring (B, D and F)]. 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 the proximate composition determined.

Table 1. Flour blends and colorants for cake preparation

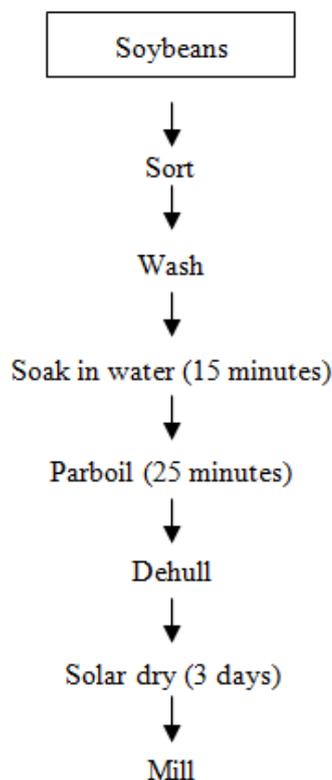| Flour blend sample (%)	Wheat flour (%)	(Soya bean flour (%)	Coloring
A	75	25	Annatto
B	75	25	Sugar-flair
C	50	50	Annatto
D	50	50	Sugar-flair
E	25	75	Annatto
F	25	75	Sugar-flair
G	100	-	Sugar-flair

Figure 1. Flow chat of the Preparation of soybeans flour

2.2. Statistical Analysis

Data obtained were statistically analysed using the Statistical Package for the Social Science (SPSS). Data were coded and differences between samples analysed using analysis of variance (ANOVA) with a confidence interval of 95%. Fisher's least significant difference (LSD) was used to discriminate among means when ANOVA indicated significant F values.

2.3. Soya Bean Flour Preparation

Soya bean was purchased from the Ho central market, 1kg was weighed, sorted, washed under running pipe-borne water and soaked in warm water for 15 minutes. 2L water was measured into a pan and heated on hot a plate. Soaked soya bean was poured into simmering water and allowed to boil for 25 minutes. The parboiled soybeans were then drained and put immediately in cold water to loosen seed coat more. Seed coats were then removed by rubbing beans between the palms. After, the beans were thoroughly washed with clean water and solar-dried for 3 days on a table layered with clean white cheese cloth and covered with clean netting to avoid contamination. The dry beans were milled into smooth flour and sieved for later use (Figure 1).

2.4. Oil Extraction of Colour from Annatto Seed

75ml of oil was placed on a hot plate in a deep frying pan for 2 minutes for preheating. 100g annatto seed was poured into hot oil and stirred continuously for 5 minutes. It was then taken off the heat source and stirring continued for 3 more minutes. Intermittent heating and stirring continued this way for a total of 20 minutes to ensure optimal colour extraction from seeds without burning. A thick consistent red colour was obtained, strained to remove seeds, allowed to cool and packaged in glass bottle for further use.

2.5. Cake Production

Cake samples were produced following the method described by Agboka *et al.* (2015).

2.6. Sensory Evaluation

Sensory analysis of cake samples was done using a nine-point hedonic scale in an affective test with 35 randomly selected untrained panellists [8,17]. Cake samples were randomly coded and presented in a randomized fashion. Sensory attributes assessed were colour, taste, flavour, mouthfeel and overall acceptability which were all ranked based on a 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike and 9 = like extremely).

2.7. Proximate Evaluation

The proximate composition of the cake samples were analyzed according to the method of Association of Official Analytical Chemists [18]. 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.

2.7.1. Moisture Content Determination

This followed the method described in AOAC [15]. Petri dishes were labelled and dried in a hot air oven at 105°C for about 30 minutes and held in a desiccator to

cool. They were weighed and their various weights were recorded as W1. 2g of each sample was weighed into the labelled pre-weighed Petri dishes, weighed and dried in a hot air oven pre-set at 105°C until no change in weight was recorded. They were taken out of the oven, cooled in a desiccator and re-weighed (W2). The difference in initial and final weights (W2 – W1) indicated moisture contents of cake samples.

2.7.2. 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 extracted in triplicates using a soxhlet extractor fitted with pre-weighed thimble containing samples for eight (8) hours. The thimbles with contents were removed, dried in an oven at 105°C for two (2) hours and weighed with an analytical balance. Calculation of % fat followed the formula below:

$$
\begin{aligned}
&\left(\% \; Fat + Moisture\right) \\
&= \frac{\left[\left(initial \; weight \; of \; sample + Thimble + Glass \; wool\right) - \left(Final \; wt \; of \; sample + Thimble + Glass \; wool\right)\right] x \; 100}{\left[\left(Wt \; of \; wet \; sample \; + \; Thimble\right) - \left(Wt \; of \; Thimble\right)\right]}
\end{aligned}
$$

$$\% \; Fat \left(wt / wt\right) = \left(\% \; Fat + \% \; Moisture\right) - \left(\% \; Moisture\right).$$

2.7.3. Ash Content Determination

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

2.7.4. Protein Content Determination

1.0g each of cake samples was weighed into the kjeldahl flask. 1.0g K_2SO_4 and 0.1g Ca_2SO_4 were added, mixed with 20ml of H_2SO_4 and 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 of digestion.

The reaction was then stopped and digests removed and allowed to cool. The flasks with content were made up with distilled water to 200ml mark on ice. 50ml aliquot of each digest was then poured into a distillation flask and carefully layered with 50ml of NaOH. The solution was then distilled and received in a 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 using the formula: % Protein = % N × Protein Factor.

2.7.5. Crude Fibre Content Determination

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

2.7.6. 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. Results and Discussion

3.1. Overall Sensory Performance

The overall average performance of cake samples as scored by panellists showed that two (2) of them (B and D) were liked more than the control (G) (Table 3). Sample A also had an average of 7.30 compared to that of G (7.35). For all samples, likeability ranged from 5.95 to 7.47 implying a scale from dislike slightly to like moderately on the 9-point hedonic scale.

Table 2. Recipe for cake development

Ingredient	Quantity (per 100 g)
Composite flour (% soya bean: % wheat)	According to formulation (A,B,C,D,E,F,G)
Fat	1g
Sugar	0.5 g
Egg	4.22 g
Vanilla essence	0.28 ml
Baking powder	0.12 g

Figure 2. a. annatto seeds b. extracted colour from annatto seeds c. soya bean flour

The highest ranked cake sample for colour was A (7.29), not significantly different from samples B, D and control (G) but significantly different from samples C, E and F.

The control sample (G) had the highest score for taste (7.80) explained by the familiarity of panellists with the usual cake taste on the market [19]. However, other

samples (B, D) were not scored differently for taste from the control except for sample A (7.00) (P<0.05). For flavour, sample B was the highest ranked with a score of 7.57 followed by D (7.51), A (7.20) and was significantly different from the control sample (7.05) (P<0.05). For mouthfeel and overall acceptability respectively, samples D and A were the highest ranked (Table 3), not unexpected as they contained the highest wheat flour contents (75 and 50% respectively).

Table 3. Mean scores on sensory parameters for cake samples

Samples	Sensory parameters					
	Colour	Taste	Flavour	Mouthfeel	Overall accept	Average
A	7.29(±1.879)[a]	7.00(±1.949)[a]	7.20 (±1.759)[a]	7.05 (±1.967)[a]	7.97 (±1.717)[a]	7.30
B	7.00(±1.961)[a]	7.54(±1.671)[ac]	7.57 (±1.592)[ab]	7.45 (±1.637)[a]	7.80 (±1.665)[a]	7.47
C	6.40(±1.801)[b]	6.71(±1.457)[a]	6.54 (±1.562)[b]	6.68 (±2.188)[ab]	7.14 (±1.680)[b]	6.69
D	7.20(±1.868)[a]	7.51(±1.530)[ac]	7.51 (±1.775)[ab]	7.48(±1.697)[a]	7.63(±1.300)[a]	7.47
E	5.91(±1.919)[b]	5.82(±1.336)[b]	6.11 (±1.651)[b]	5.57 (±1.679)[b]	6.34(±1.853)[ab]	5.95
F	6.03(±1.961)[b]	6.02(±1.800)[b]	6.74 (±1.268)[b]	6.66 (±1.814)[ab]	6.66(±1.668)[ab]	6.42
G	7.11(±1.890)[a]	7.80(±1.615)[ac]	7.05 (±1.576)[a]	7.17 (±1.871)[a]	7.63 (±1.708)[a]	7.35

(A, B= 75 wheat: 25 soya bean; C, D= 50 wheat: 50 soya bean; E, F= 25 wheat: 75 soya bean). Colouring-[annatto (A, C and E) and sugar flair (B, D and F)].

3.2. Effects of Individual Flour Compositions on Sensory Performance

Colour was scored significantly higher for increasing amounts of wheat flour than for soya bean flour with a strong positive correlation of 0.8156 (P<0.05). In other words, the higher the amounts of soya bean flour in cake samples, the lower the scores for colour. This trend was observed for all other sensory parameters evaluated for the seven coded cake samples with correlation figures for wheat flour being 0.8674, 0.5931, 0.6549 and 0.8299 for taste, flavour, mouthfeel and overall acceptability respectively.

3.3. Effects of Colorant on Sensory Performance

The consistency with which the control colorant (sugar flair) out-performed annatto may confirms that the sensory panel was more familiar with the traditional whole wheat cake colour (Table 4) [19]. It was however commendable that the newly introduced colorant (annatto) closely matched the control in performance although there were significant differences observed in favour of the control cake for flavour and mouthfeel (P<0.05).

Table 4. Mean scores on the influence of cake colorant on sensory parameters

Treatments	Sensory parameters				
	Colour	Taste	Flavour	Mouthfeel	Overall accept
Annatto colour	6.53 (±2.04)[a]	6.51(±2.15)[a]	6.62(±1.76)[a]	6.44(±1.96)[a]	7.20(±1.74)[a]
Sugar Flair colour	6.74 (±2.00)[a]	7.02 (±1.99)[a]	7.28(±1.69)[b]	7.20(±1.82)[b]	7.36(±1.88)[a]

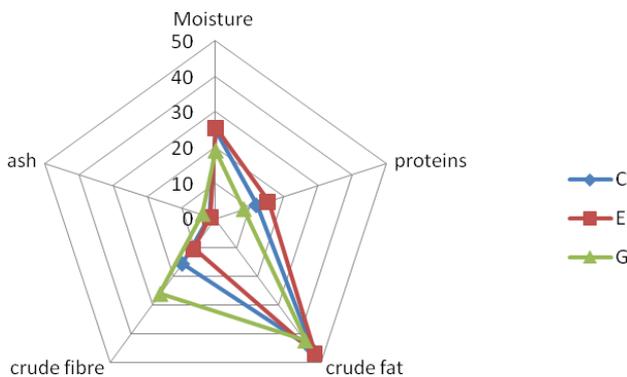## 3.4. Proximate Evaluation of Cake Samples

Figure 3. Proximate composition of cake samples (C = 50 wheat: 50 soya bean, annatto; E = 25 wheat: 75 soya bean, annatto and G = 100 wheat, sugar flair)

Cake samples compared well against the control (100% wheat flour) cake sample (Figure 3). Samples C and E recorded significantly higher values (24.87 and 25.59% respectively) for moisture than control (19.01). A similar observation was made for proteins (15.31 and 11.9% respectively against 8.27% for control) consistent with other studies on the superiority of soy protein [1,4]. This increased protein content was due to the added soya bean flour. For crude fat content, sample E had higher values (47.02%) compared to the control sample (45.47%). This was expected because of the added soya bean flour (75%) which has high lipids content [4]. The control sample contained significantly higher amounts of ash (3.80%) and crude fibre (26.32%) compared to 1.87 and 15.89% for sample C and 1.56 and 10.52% respectively for sample E (P<0.05) (Figure 3).

4. Conclusion

The composite wheat-soya bean flour produced cakes that were generally accepted by the sensory panel. Although cakes with higher amounts of wheat flour were generally preferred, cakes with high soya bean contents also were more preferred for some parameters such as mouthfeel (cake sample D) and overall acceptability (cake sample A). Thus, the best cake sample in terms of overall acceptability was cake with 75% soya bean flour: 25% wheat flour. The addition of soya bean flour also reflected in increased proteins content as supported by other literature. For colouring of cake samples, the annatto colour matched the control closely in influencing sensory characteristics and showed great potential for use in cakes.

Further work must be done to improve on the acceptability of soya bean by reducing beany flavour and product heaviness.

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