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Development and Assessment of Conformance of Cowpea Flour for Cake Production

Agboka Judith Akosua, Kpodo Fidelis Mawunyo Kwasi, Dzah Courage Sedem, Mensah Christopher

Department of Hospitality and Tourism Management, Faculty of Applied Science and Technology, Ho Polytechnic, Ho, Ghana

Email address:
judithagboka@yahoo.com (A. J. Akosua), fideliskpodo@yahoo.com (K. F. M. Kwasi)

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Abstract: Cowpea is a nutritious component in human diet as well as livestock feed. It is of major importance to the livelihoods of millions of people in developing countries because it is an important source of proteins, minerals and vitamins. The leaves, pods and seeds of cowpea are consumed. This study explored the feasibility of preparing a Supreme Quality Cowpea Flour (SQCF) as a substitute for wheat flour for the preparation of cakes. Development of the composite cowpea-wheat flour followed a 3 x 2 factorial design with cowpea-wheat proportions (100%:0%, 75%:25% and 50%:50%) and heat treatments (150 and 200 ^{o}C) as factors. The composite flour produced was then used to produce cake and evaluated sensorially based on ranking for preference. Hundred percent (100%) wheat flour cake was used as control. The composite flour with proportion 50%:50% cowpea: wheat baked at 200 ^{o}C produced the most preferred cake which was significantly higher ($P < 0.05$) in terms of taste (7.22±2.01) and overall acceptability (7.03±1.82) when compared with the taste (6.67±1.84) and overall acceptability (6.80 ±1.81) of the control. The application of this by industry will encourage the use of cowpea, a readily available legume for the production of cake.

Keywords: Cakes, Composite Flour, Cowpea, Supreme Quality Cowpea Flour (SQCF)

1. Introduction

Cakes are unleavened pastries made mainly from wheat flour, shortening, sugar, egg, milk and little or no baking powder [1]. Wheat flour is well suited for making pastry products because of its unique protein called gluten. The gluten protein forms an elastic network which is essential for dough development [2]. Although wheat is a good source of calories and other nutrients, its protein content is of lower nutritional quality when compared to soy bean, peanut and cowpea [3]. Coupled to its deficiency in some essential amino acid, virtually all of Ghana's wheat consumption is through imports from primarily the US, Canada, Argentina, and the EU. Currently 90 percent of all wheat is imported from the U.S. with the remaining 10 percent being imported from the other sources previously mentioned [4]. In 1998, Ghana imported 278,334 metric tons of wheat for an overall value of 35.6 million dollars, up 39 percent when compared to 1997. This made Ghana the fourth largest wheat importer in the Sub-Saharan Region. Ghana is also the second largest importer of U.S. wheat in the Sub-Saharan region [4,5].

In order to reduce the nation's expense on wheat importation other flour products from indigenous crops such as cowpea should be developed and their utilization for baking pastries encouraged. Cowpea is the second most important legume in Ghana after groundnut. Ghana has been self-sufficient in cowpea production over the last decade with production outstripping consumption [6]. Cowpea contributes a significant amount of protein and water-soluble vitamins to the African diet. The cowpea seed is a nutritious component in the human diet as well as livestock feed. Cowpea is of major importance to the livelihoods of millions of people in developing countries of the tropics particularly in Asia and Africa. It is consumed in many forms: young leaves, green pods and green seeds are used as vegetable and the dry seeds are used in various food preparations. Cowpea is a major source of protein, minerals and vitamins in daily diets and thus it positively impacts on the health of consumers.

Besides the nutritional benefits that can be derived from cowpeas, it is one of the drought-resistant food crops grown

by farmers in Ghana, especially in the rural settings. These rural communities are largely deprived of essential social amenities with many poor households benefiting immensely in economic terms if cowpeas are demanded in higher quantities. This will aid in the alleviation of poverty in Ghana and other developing countries. There is an increasing world demand for less expensive proteins with good nutritional and functional properties, particularly in developing and under-developed countries where the supply of food of animal origin is limited due to non-availability and high cost [7]. Enrichment of cereal-based foods with legume protein has received considerable attention because cereal proteins are generally low in lysine and total protein content although high in sulphur amino acids [8]. Combination of these cereal products with cheaper and more available plant proteins sources like cowpea can improve the nutritional quality of cereal based foods. Cowpea is used in diverse ways around the globe for the preparation of Salads, Casseroles, Fritters, Bean cakes (*koose, agawu*), Curry dishes and Southern dishes with ham and rice. The main objective of this study is to develop and assess composite cowpea-wheat flour for cake preparation. In addition, to evaluate the cakes produced from cowpea-wheat flour sensorially based on ranking for preference.

2. Material and Methods

2.1. Materials

Wheat flour (*Triticum aestivum*) and cowpea beans (*Vigna unguiculata*) were used to develop the composite wheat-cowpea flour. The raw materials were purchased from a source supplier at a local market in Ho. The cowpea beans were then sorted to remove foreign materials and stored in a cool, dry place prior to its use for production of the flours. Other ingredients purchased included margarine, eggs, nutmeg, vanilla essence and sugar.

2.2. Preparation of Supreme Quality Bean Flour (SQBF)

The cowpea beans were sorted to remove unwholesome ones and foreign materials. The sorted beans were parboiled (5 minutes) for easy removal of skin and the black eyes. The parboiled beans were dehulled to remove the outer covering including the black eye. The dehulled beans were dried in convection oven at a temperature of 150^{o}C for 3 hours. The oven dried beans were milled into refined bean flour referred to as supreme quality bean flour and stored in an air tight container (Figure 1).

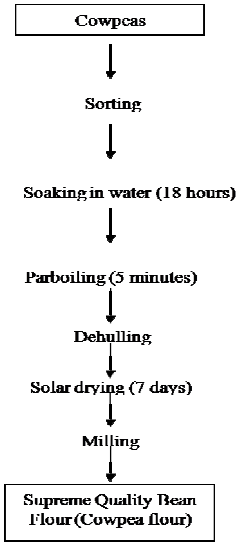

Figure 1. *Flowchart of the procedure for Supreme Quality Bean Flour (SQBF) production.*

2.3. Experimental Design

A 3x2 full factorial design was employed, and the factors were; a) percentage of cowpea flour (SQBF)-wheat flour (50:50, 75:25 and 100 cowpea flour) and b) the baking temperatures (150 and 200 ^{o}C). Cake of 100% wheat flour baked at 200 ^{o}C was used as control.

2.4. Preparation of Cowpea-Wheat Cake

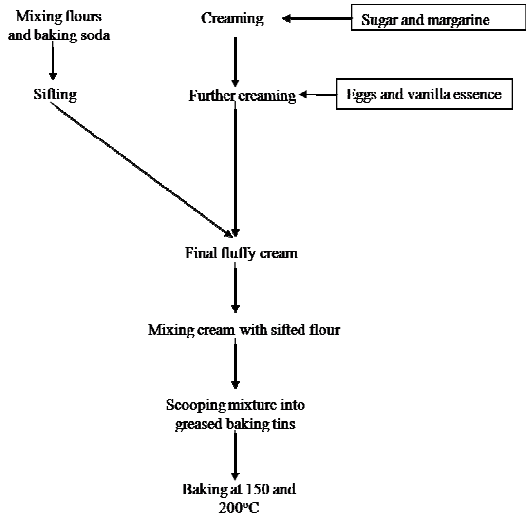

Figure 2. *Flowchart of cake baking process.*

Sugar and margarine (Table 1) were creamed until fluffy (Figure 2). The eggs and vanilla essence (Table 1) were then added and creamed further for 6-10 minutes. The refined cowpea flour (100%) / cowpea: wheat flour composite/ wheat flour (100%)were combined with baking powder, sifted and poured into the sugar and margarine mixture. The flour was folded into the mixture and scooped into greased baking tins and baked in oven at temperatures of 150 and 200 ^{o}C (Figure 2). This procedure was followed to produce cakes containing cowpea: wheat composite flour in the following percentages, 50:50, 75:25 and 100% cowpea flour. Another cake was baked with 100% wheat flour which served as control for sensory evaluation.

Table 1. *Recipe for QSBF Cake (100%).*

Ingredient	Quantity
Margarine	250 g
Eggs	5 medium pieces
Sugar	250g
Vanilla essence	28 ml
Powdered nutmeg	2 teaspoons
Baking powder	2 teaspoons
Lemon juice	2 tablespoons
Browning	3 tablespoons

2.5. Sensory Evaluation

Table 2. *Cake sample description.*

Sample	Formulation (%)	Baking Temperature (^{o}C)
A	50 cowpea:50 wheat	150
B	75 cowpea:25 wheat	150
C	100 cowpea	150
D	50 cowpea:50 wheat	200
E	75 cowpea:25 wheat	200
F	100 cowpea	200
G (control)	100 wheat	200

The sensory evaluation was done on 7 different cake samples (A,B,C,D,E,F,G) as shown in Table 2. A total of thirty fife (35) untrained panellists were randomly recruited from among students in Ho Polytechnic, Ho. The criteria for recruitment were that they were familiar with the quality parameters of cake, had no health conditions associated with eating cake and willing to participate in the test. Panellists were asked to evaluate the 7 randomly coded samples on a 9 – point hedonic scale (1 extremely, 5 – neither like nor dislike and 9 extremely) in an experiment for sensory evaluation on parameters (colour, taste, mouth feel, flavour and overall acceptability). The samples were rated using a nine points hedonic scale with 1 = dislike like extremely, 5 = neither like nor dislike and 9 = like extremely. The test was carried out in a well illuminated room free of environmental factors that could interfere with the normal perception of panellists.

2.6. Data Analysis

Data was analysed using analyses of variance (ANOVA). Individual consumer preference scores from panellists were averaged and data analyzed using SPSS 17.0.1. Statistical significance was set at a level of 95% confidence interval. The difference between mean values was determined by least significant difference (LSD) test. Significance was accepted at $P < 0.05$.

3. Results and Discussion

3.1. Sensory Characteristics of Composite Cowpea-Wheat Cake

Sensory evaluation is a critical stage in product development and product optimization studies, because products targeted at consumers must first appeal sensorially to them [9]. Sensory attributes evaluated included colour, taste, flavour, mouth feel and overall acceptability. A summary of the mean scores for the sensory attributes is shown in Table 3. For each attribute the scores were made on a scale of 1 to 9 on a hedonic scale where 1 was the least liked and 9 the most liked. The means for the attributes taste and overall acceptability were significantly different ($P < 0.05$) for all formulations. Formulations however did not show significant differences ($P > 0.05$) in the mean scores for colour, mouth feel and flavour (Table 3). On the whole all cake formulations including the control (100% wheat baked at 200^{o}C) ranged from 5.03 (neither like nor dislike) to 7.22 (like moderately). The composite cake sample with equal amounts of wheat and cowpea baked at 200^{o}C (D) rated better for taste, flavour and overall acceptability relative to other formulations including the control (whole wheat baked at 200^{o}C) (Table 3). However consumer preference in terms of colour and mouth feel was higher in the control (G).

Table 3. *Sensory evaluation of cake samples.*

Treatment	Colour	Taste	Mouth feel	Flavour	Overall acceptability
A	5.45(±2.10)^{a}	6.08(±2.18)^{ab}	5.91(±2.10)^{a}	6.11(±1.87)^{a}	5.88(±1.96)^{a}
B	6.40(±1.92)^{a}	6.37(±1.81)^{abc}	5.74(±1.91)^{a}	6.03(±2.02)^{a}	6.83(±1.52)^{bc}
C	5.66(±2.24)^{a}	5.65(±2.41)^{a}	5.74(±2.26)^{a}	5.83(±2.09)^{a}	6.00(±2.10)^{ab}
D	6.08(±1.91)^{a}	7.22(±2.01)^{c}	5.94(±2.32)^{a}	6.66(±2.14)^{a}	7.03(±1.82)^{c}
E	5.77(±2.23)^{a}	5.83(±2.35)^{ab}	5.34(±2.53)^{a}	5.97(±2.26)^{a}	6.03(±2.20)^{ab}
F	6.54(±2.22)^{a}	5.94(±2.48)^{ab}	5.08(±2.13)^{a}	5.66(±1.96)^{a}	6.08(±2.02)^{ab}
G	6.68(±1.95)^{a}	6.67(±1.84)^{bc}	6.74(±1.78)^{a}	6.22(±1.91)^{a}	6.80(±1.81)^{bc}

Means sharing the same letters in a column are non-significant (P>0.05)

3.2. Effect of Formulation Components on Taste

The mean scores for taste of formulations ranged from 5.94~ 6.00 (like slightly) to 7.22 (like moderately). The differences in the taste of formulations were statistically significant ($P < 0.05$). Since sugar was held constant in all samples, differences that may have occurred among formulations were due to individual component difference of the formulations. The cake formulation that tasted best was D (50% wheat and 50% cowpea) which contained equal amounts of cowpea and wheat baked at 200^{o}C. This result confirms that of Atef *et al.* (2011) having the best cake with 50%:50% cowpea-wheat composite flour. It had a mean score of 7.22 statistically higher than the control value of 6.67 ($P < 0.05$). Taste was however least preferred (5.65) in the whole cowpea cake baked at 150^{o}C which is substantiated by Atef *et al.* (2011) who reported that increasing amounts of cowpea negatively influenced the taste of cakes. Considering this effect on taste, McWatters (1995) also used cowpea flour to substitute wheat flour in preparing muffins, noodles and tortillas but kept the percentages of cowpea low (8% to 43%). Whole cowpea cake formulation baked at 200^{o}C had a mean test score of 5.94, a value significantly higher than the same product baked at 150^{o}C. Taste mean scores for formulations A, E and F were not significantly different ($P<0.05$).

3.3. Effect of Formulation Components on Colour

The appearance of food products either colour alone or in conjunction with other quality attributes influences consumer decision at the point of sale. Colour is the most important appearance attribute of food products. The colour of the cake formulations had mean scores ranging from 5.45 (neither like nor dislike) to 6.68 (like moderately). Although the mean score attribute for colour was higher for the control sample, it was not significantly different from the other formulations ($P < 0.05$). Ellin *et al.* (2004) indicated that in cowpea-wheat formulations, products get progressively darker when the proportion of cowpea in the composite flour increases. The darkening of these products have been attributed to Maillard reactions during baking of cowpea products. Maillard reactions are chemical reactions that occur between reducing sugars and the amino group of proteins or amino acids such as lysine [13]. The high lysine content of cowpea might have contributed to the low sensory scores for colour in the cowpea rich products when compared with the control.

3.4. Effect of Formulation Components on Flavour

Flavour is the most important sensory attribute that affects acceptability of foods [14]. Mean scores for flavour were not statistically significant ($P > 0.05$). Cake developed with whole cowpea flour baked at either 150 or 200^{o}C recorded the least scores for flavor whereas cake prepared with composite wheat and cowpea flour of equal proportions baked at 150 and 200^{o}C recorded the highest scores. Also flavour generally improved as proportion of cowpea decreased in samples. This is in line with other findings by Tortoe et al. (2014) and Olapade et al. (2012) that high amounts of cowpea negatively affect consumer acceptability in products due to its beany flavour.

3.5. Effect of Formulation Components on Mouth Feel

All cake samples scored between 5.08 and 5.94 (neither like nor dislike) for mouth feel with the exception of the control which was liked moderately. Thus mouth feel generally had the least score relative to the other sensory attributes (Table 3). Other studies showed that high cowpea inclusion levels increase product coarseness which negatively influence mouth feel especially in products which are generally perceived by consumers to have fine mouth feel like cakes [15,16].

3.6. Effect of Formulation Components on Overall Acceptability

Figure 3. *Supreme Quality Bean Flour-SQBF Cake (D: 50% cowpea: 50% wheat at 200^{o}C).*

Overall acceptability scores for samples ranged from 5.88 ~ 6.00 (like slightly) to 7.03 (like moderately) (Table 3). Significant difference ($P < 0.05$) was observed for cake formulation D (Figure 3) which consisted of equal amounts of wheat and cowpea baked at 200°C with mean preference score (7.03) and the control G-100% wheat baked at 200°C (6.8) and formulation B (6.83). Acceptability score for formulation B (6.83) which consisted of 75% cowpea and 25% wheat baked at 150°C was not significantly different ($P > 0.05$) from control G-100% wheat baked at 200°C (6.8) (Figure 4).

Beany flavor associated with cowpea has been known to negatively affect consumer acceptability in products containing high amounts of cowpea [15, 16]. However, cake sample D outperformed the control which contained no cowpea. Hot water treatment and dehulling have been found to reduce beany flavor in legumes such as cowpea used in foods [17, 18]. The equal amounts of cowpea and wheat components (50:50%), coupled with dehulling, parboiling and the use of vanilla essence explains the masking of beany flavor in sample D, hence its better performance compared to control (G).

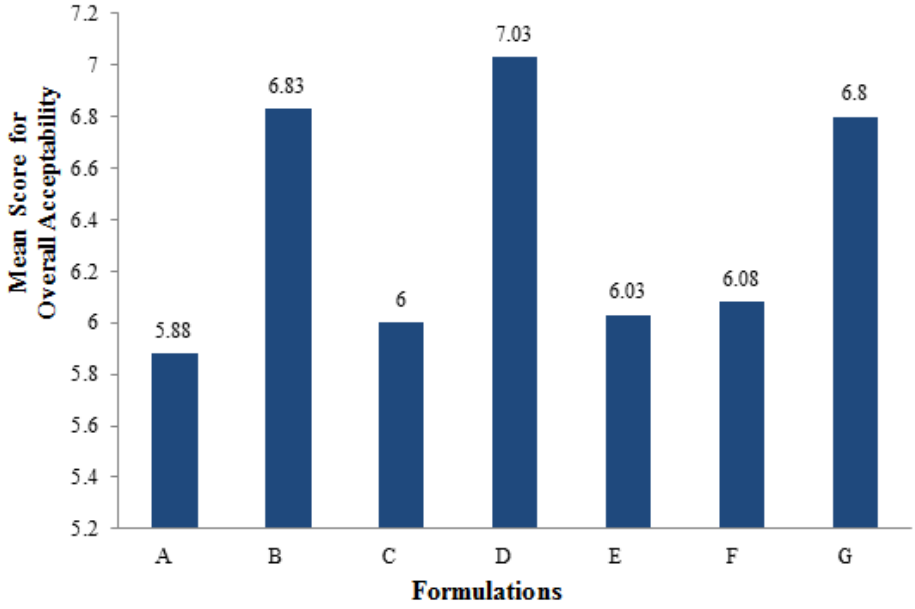

Figure 4. *Mean scores for overall acceptability for all samples. A (50cowpea:50wheat/150°C; B (75cowpea:25wheat/150°C); C (100cowpea/150°C); D (50cowpea:50wheat/200°C); E (75cowpea:25wheat/200°C); F (100cowpea/200°C); G (100wheat/200°C).*

4. Conclusion

The composite flour consisting of 50% cowpea and 50% wheat flour baked at 200°C yielded the best cake product which was significantly higher in terms of taste and overall acceptability when compared with the control (100% wheat cake). Hence composite flour consisting of 50% wheat and 50% cowpea flours can be used as a suitable replacement for the 100% wheat flour traditionally used for cake production. Since the overall acceptability rating for the composite flour (75% cowpea: 25% wheat) baked at 150°C was not significantly different from control (100% wheat baked at 200°C), this composite flour can also be used instead of the control to encourage the utilization of indigenous crops such as cowpea in food products and subsequently help reduce the cost of cake products.

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