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# Utilization of Faba Bean and Cowpea Flours In Gluten Free Cake Production

[1]Atef, A.M. Abou-Zaid, [1]Mostafa, T. Ramadan and [2]Samia A. AL-Asklany

[1]Food Science and Technol. Dept., National Research Center, Dokki, Giza, Egypt.
[2]Special Food and Nutrition Dept., Food Technol. Institute., ARC, Giza, Egypt.

**Abstract:** The current research aims to produce gluten free bakery product such as cake to use it in autism disease cases nutrition. Raw and germinated of either beans (GB) or cowpea (GC) flours, as a substitute for wheat (W) flour in cake production, were evaluated. The rheological properties of flour dough and product quality properties (physical, chemical, protein content, color and sensory characteristics) resulted from wheat flour, raw and germinated of either beans or cowpea flours were examined in cake manufacturing. Wheat flour was replaced by raw and germinated beans and cowpea flours in ratios of 25, 50, 75 and 100%. The results should that the water absorption, dough development time (DDT) and dough weakening increments, mixing tolerance index (MTI) and dough stability decrements in the case of raw and germinated legumes flours, were observed. On the other hand, the mixing tolerance index values (MTI) was increased in the case of germinated legumes flour. Baking properties, color and sensory evaluation tests showed that the 100% wheat flour amounts could be replaced by the same amounts of germinated bean and still providing good quality. But substitution of wheat flour by 50% cowpea flour gave good cake but in the other ratios the taste became unable as a resulted increasing the germinated and ungerminated cowpea flour. The staling rate was reduced in cake made from 100% germinated bean flour compared to control cake. It could be concluded that the resulted products possessed a long shelf life period with good qualities and could be easier in transportation.

**Key words:** Legumes,chemical composition, Cowpea, Faba bean, cake.

## INTRODUCTION

The prevalence of autism and celiac disease (CD), an intolerance of gluten, has been reported to be as high as one in 200 of the world population (Fasano and Catassi 2001). The majority of those diagnosed with this disease are silent and latent cases and have the potential but may or may not develop the disease (Feighery 1999). Challenge for food scientists to overcome such problem is of importance, because it can only be treated by strict adherence to a gluten-free diet. Developing gluten-free foods, regulated to have gluten level not exceeding 200 ppm, is difficult because gluten is very common in food sources. Attempts to remove the gluten ingredient in foods, also, may resulted in the loss of nutritional balance of the products (Mariani *et al.*, 1998; Grehn *et al.*, 2001).

In Egypt, the total yield of bread grains does not satisfy the needs of the country requirments. The total production of wheat grains cover only about 55% of the total needs. The way to overcome this problem is to search for the native cereal sources or others which could be substituted the wheat flour. Cakes are convenient food products and the most popular bakery items consumed nearly by all levels of society in Egypt. Some of the reasons for such wide popularity are low cost among other processed foods (affordable cost), good nutritional quality and availability in different varieties, varied taste and easy availability (Eissa *et al.,* 2007 and Sudha *et al.,* 2007). Legumes are good sources of food proteins for humans. Together with proteins, legume seeds provide a high proportion of carbohydrates, starch and fibers. Among them bean and lubia have a great potential, due to their high and good quality-protein (24–35%), whereas legumes have better nutritional qualities (higher lysine and soluble dietary fiber and lower methionine than wheat) (Varughese *et al.*, 1996; Petrovska *et al.*, 2002). Therefore, fortification with high protein legume flours could provide a good opportunity to improve the nutritional quality of protein consumed by many people. Fortification of wheat flour with non-wheat proteins , also, increases protein quality by improving its amino acid profiles. Protein quality is affected by essential amino acid composition, amino acid imbalance, digestibility and biological availability of the amino acids and by the anti-nutritional activity of some components of the seeds (Deshpande and Damodaran, 1990). In general, legumes are rich in lysine, but deficient in sulphur containing amino acids (methionine and cystine). However, with a small increase in one of these two amino acids, tryptophan would become the next limiting amino acid in legume seeds. Except for the case of peanuts, the preparation of legume seeds for human consumption invariably involves some rehydration and heating. Hydration process results in softening and swelling, heating process results in denaturation of proteins. The reason for processing of dry legume seeds is first, developing aroma and softening the seeds, but a more important reason is in inactivation of anti-nutritional

**Corresponding Author:** Atef, Food Science and Technol. Dept., National Research Center, Dokki, Giza, Egypt.

factors such as trypsin inhibitor and lectins which are present in the raw seeds. Studying the effect of germination on the chemical composition in relation to their nutritional value is interested (Pirman *et al.*, 2001).

Autio *et al.,* (1998) reported that the germination–induced micro-structural changes of cell walls in dough's were very extensive. The larger values of the area of visible cell walls of the germinated than for the native grains suggest that germination induces swelling of cell walls, but the smaller values suggest that germination causes fading of cell walls. However, the microstructure examination of dough section showed that germination caused two types of structural changes in the cell walls: (1) swelling and (2) fading of the blue fluorescence of cell walls. Moreover, doughs made from flours of germinated grains were always softer than dough's made from flours of native grains. Hence, development and consumption of such therapeutic bakery products would help to raise the nutritional status of the population and low staling rate in bakery products produced from this flour. Information on incorporation of raw and germinated legumes (bean and cowpea) flour in cake products are available.

Average values of bean and cowpea amino acid composition could be found in nutrition tables. However, most published data on composition is related to the raw, rather than to the germinated seeds and the information about the amino acids composition of bean or cowpea are rare. Since cowpea and faba bean are very popular food in, known to contain a high amounts of crude proteins and are gluten free, thus the aim of our work was designed to evaluate the suitability of replacement of wheat flour by ungerminated and germinated bean and cowpea flours in cake making. It was,also, aimed to evaluate the effects of raw and germinated bean and cowpea flours addition at various ratios (25, 50, 75 and 100%) on the rheological properties of dough and on the quality (physical, chemical, protein content, color and sensory characteristics) properties of the resulted cake. Thus the aim of the current work is to produce specified cake to be suitable to autism and celiac disease (CD) patients.

## MATERIAL AND METHODS

### *Materials:*

Wheat flours (72% extraction) were obtained from the North Cairo Flour Mills Company, Egypt. Beans (*ficea faba*) and cowpea were purchased from The Ministry of Agriculture in season 2010–2011 and kept at 3–4°C until used in technological studies.

### *Preparation of Raw and Germinated Legumes Flour and Wheat Flour Blends:*

The raw materials of bean and cowpea were germinated in sterile petri-dishes lined with wet filter papers for 48 h at 37°C, with frequent watering. The sprouts were rinsed in distilled water and dried at 45–50°C. The dried samples of raw and germinated bean and cowpea were ground to fine powder in an electric grinder using a Laboratorial disc mill (Quadrumat Junior flour mill or Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979, Germany) to pass through a 20 mesh/inch sieve and then stored in pouches bags for further use. Preparation of raw and germinated legumes flour and wheat flour blends. Wheat flour (72% extraction rate) was well blended with the raw and germinated legumes flour to produce individual mixtures containing 25, 50, 75 and 100% replacement levels. All samples were stored in airtight containers and kept at 3–4°C until required.

### *Chemical Composition:*

Standard Association of Official Analytical Chemistry methods, AOAC (2000) were adopted for estimating moisture, ash, crude fiber, protein and fat contents. Total carbohydrates were calculated as 100 - (protein + fat + moisture + ash).

### *Determination of Amino Acids:*

Amino acid compositions were determined according to the method described in AOAC (2000).

### *Farinograph Properties:*

Actually, 0, 25%, 50%, 75% and 100% amounts of the raw or germinated legume flours were replaced the same amounts of wheat flour. The effect of the different flour replacement levels on dough rheology was determined by farinograph apparatus (Model Type No: 81010 using 31, 50 and 63 rpm, ©Brabender® OHG, Duisburg, 1979, Germany) according to the standard methods of AACC (2000). The measured parameters were water absorption, dough development time, dough stability and mixing tolerance index (MTI).

### *Cake Making:*

Cake making was carried out at automatic commercial baking line according to AACC (2000). The cake ingredients were100g flour, 104 g sugar, 40 g shortening, 56 g egg albumen, 11.5 g skimmilk, 5.8 g baking powder, 0.5 g vanillia, 1g emulsifier agent (Glecrid Mono Stearat) and 64ml water. The cake was manufactured as follows:

The sugar and shortening were mixed together and the egg albumen was added and the mixture was whipping. The other components were added and the whipping process was completed and after that, the paste was put in bowel and baking at 170-175$^{o}$C for 35-40min. After two hours the organoleptic evaluation test was carried out. The cakes were allowed to cool at room temperature for 2 h before being packaged in polyethylene bags and stored at room temperature for further analysis.

***Physical Characteristics of Cakes:***

Weight, volume and specific volume of cakes were measured according to the methods described by Bennion and Banford (1983). A graduated scale (in centimeters) was used to measure the height of cakes. For measuring cakes volume, a glass box designed to hold the article was used. The box was placed on the tray and filled with rap seeds delivered from its container in a steady stream to a fixed height until the box was filled and the seeds over flowed into the tray. The surface of the seeds was then leveled by removing the surplus by straight edged scraper. The seeds in the box which representing the volume of the box were transferred to an empty container and the cake was placed in the measuring box. The seeds were filled into the box containing the cake until the box over flowed. Leveling of surface of the seeds and the excess seeds in the container were measured. The volume of the cake was the volume of rape seed rest. The specific volume of the cake was calculated by using the following equation:

**Specific volume = volume ($cm^3$) / weight (gm)**

***Color Determinations:***

Objective evaluation of surface crust and crumb color of cake samples was measured. Hunter a*, b* and L* parameters were measured with a color difference meter using a spectro-colorimeter (Tristimulus Color Machine) with the CIE lab color scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Color Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16) (Sapers and Douglas, 1987).

***Sensory Characteristics:***

The cakes were allowed to cool on racks for about 1h before evaluation. Cakes were organoleptically estimated for the testedattributes by 10 well trained panelists according to Bennion and Banford (1983).

***Statistical Analysis:***

The obtained results were statistically analyzed using SPSS statistical package (Version 9.05) according to Rattanathanalerk *et al.,* (2005), analysis of variance (ANOVA). Duncan's multiple range test and least significant difference (LSD) was chosen to determine any significant difference among various treatments at $p<0.05$.

## RESULTS AND DISCUSSION

***The Chemical Composition:***

The chemical composition of wheat flour (72% extraction rate) and legumes flour are presented in Table (1). The data are in agreement with that founded by Abou-zaid (2011). The chemical composition of legumes (either germinated or ungerminated bean and cowpea) flour contained high quantities of crude protein, crude fat, crude fibers and ash higher than wheat flour (72% extraction). Similar results were also reported by Palander *et al.,* (2006). However, raw and germinated legumes, as a source of proteins, could primarily be used in cereal products to improve nutritional properties.

***Amino Acid Compositions:***

The data presented in Table (2) show that the amino acid profile in proteins of legume flours. Legumes protein had a higher percent of lysine than wheat flour. While sulfur amino acids in legumes were lower than those found in wheat flour. These results are in agreement with the findings of Jezimy *et al.,* (2011) and Uwaegbute *et al*., (2000).

**Table 1:** Chemical compositions (as % on dry basis) of wheat flour (72% extraction), bean and cowpea flours.

| Components | Wheat flour (72% extraction) | Raw bean flour | Germinated bean flour | Raw cowpea flour | Germinated cowpea flour |
|---|---|---|---|---|---|
| Protein | 12.80 | 34.90 | 36.50 | 29.8 | 31.62 |
| Carbohydrates | 85.47 | 50.80 | 49.05 | 59.5 | 54.28 |
| Crude Fat | 0.80 | 2.10 | 1.90 | 4.7 | 6.30 |
| Crude fibers | 0.41 | 8.80 | 8.85 | 3.50 | 4.00 |
| Ash | 0.52 | 3.40 | 3.70 | 2.5 | 3.80 |

**Table 2:** Amino acids composition of wheat flour, raw and germinated legumes flour (g/100g crude protein).

| Amino acids | Wheat flour (72% extraction) | Raw bean flour | Germinated bean flour | Raw cowpea flour | Germinated cowpea flour |
|---|---|---|---|---|---|
| Arginine | 4.20 | 10.8 | 10.7 | 9.80 | 9.70 |
| Histidine | 2.40 | 3.20 | 3.80 | 2.90 | 3.20 |
| Isoleucine | 3.40 | 3.20 | 3.10 | 4.00 | 4.00 |
| Leucine | 6.00 | 7.10 | 7.40 | 6.30 | 6.50 |
| Lysine | 2.10 | 7.40 | 7.10 | 4.70 | 4.50 |
| Methionine | 1.35 | 1.20 | 1.20 | 0.70 | 0.80 |
| Phenylalanine | 4.55 | 4.30 | 4.20 | 4.00 | 3.90 |
| Threonine | 2.30 | 4.00 | 4.00 | 3.40 | 3.50 |
| Valine | 4.45 | 3.60 | 3.50 | 4.20 | 4.20 |
| Alanine | 3.20 | 5.10 | 5.60 | 3.30 | 3.60 |
| Asparatic acid | 4.38 | 12.8 | 13.6 | 9.00 | 9.80 |
| Cystine | 2.78 | 1.30 | 1.20 | 1.50 | 1.50 |
| Glycine | 4.55 | 4.80 | 4.60 | 4.20 | 4.00 |
| Glutamic acid | 33.2 | 15.8 | 15.6 | 19.4 | 19.2 |
| Proline | 10.6 | 4.90 | 5.10 | 4.10 | 4.30 |
| Serine | 4.30 | 5.70 | 5.50 | 5.00 | 4.80 |
| Tyrosine | 3.30 | 3.50 | 3.30 | 3.10 | 3.00 |
| Tryptophan | 1.12 | 1.10 | 1.20 | 0.90 | 1.00 |

***Farinograph Properties:***

Influence of incorporation of raw and germinated legumes flours (at 0, 25, 50 75 and 100%) levels with wheat flour on dough mixing properties (Farinograph) of cake was found in Table (3). It show that the addition of raw and germinated legumes flours mainly increased the water absorption. By increasing the replacement level, a linear relation with ahigher increment in water absorption was found. The addition of legumes flour samples led to a significant change from 62.5% in control to 72.5% and 72% in 100% raw bean flour and raw cowpea flour, respectively. But it was 73 & 73.3% in case of germinated bean flour and germinated cowpea flour replacement, respectively. The increase in the water absorption in the case of raw and germinated legumes flour was marginal. Similar effects on water absorption were observed by Sudha *et al.,* (2007) when wheat bran or rice bran was added.

Rosell *et al.,* (2001) and Eissa *et al.,* (2007) reported that the differences in water absorption might be due to that raw and germinated legumes flour containing more fiber, sugars and higher protein content. Such components retained more water and mainly caused the greater number of hydroxyl groups, which were existed in the fiber structure, allowed to compose more water interactions through hydrogen bonding. The extent of increasing in dough development time (DDT) was high in the case of raw and germinated legumes flours. Dough stability, which indicates the dough strength, decreased in a varied pattern by increasing raw and germinated legumes flour percentages. Greater effects were observed on the mixing tolerance index values (MTI). It increased in the case of germinated legumes flour, whereas the extent of decrease was relatively marginal in the case of raw legumes flour with increasing the supplementation level. Similar results were reported by Eissa *et al*. (2007) for the addition of wheat flour with chickpea and kidney peas blends. The results showed the weakening of dough was detected with the increasing level of raw and germinated legumes flours,

**Table 3:** Effect of replacement levels of wheat flour (72%) by the same levels of raw and germinated legumes flours on farinograph measurements.

| Samples | Water absorption% | Arrival time (min) | Devecowpeag ime (min) | Stability time (min) | Mixing tolerance index (BU) | Weakening (BU) |
|---|---|---|---|---|---|---|
| 100% wheat flour | 62.5 | 1.2 | 4.5 | 5.5 | 21 | 90 |
| [75% (W) +25% (B)] flours | 65.0 | 1.3 | 6.5 | 12.8 | 16 | 100 |
| [50% (W) +50% (B)] flours | 67.5 | 1.5 | 6.5 | 10.0 | 20 | 120 |
| [25% (W) +75% (B)] flours | 70.1 | 1.4 | 6.5 | 10.0 | 25 | 130 |
| 100% bean flours | 72.5 | 1.4 | 8.0 | 9.5 | 28 | 135 |
| [75%(W) +25% (GB)]flours | 65.1 | 1.2 | 3.5 | 12.5 | 20 | 120 |
| [50%(W) +50% (GB)]flours | 67.7 | 1.3 | 5.5 | 8.0 | 25 | 140 |
| [25%(W) +75% (GB)]flours | 70.2 | 1.5 | 6.0 | 7.5 | 30 | 150 |
| 100% (GB) flours | 73.0 | 1.8 | 6.2 | 8.0 | 35 | 160 |
| [75%(W) +25% (C)] flours | 65.5 | 1.3 | 8.0 | 12.0 | 25 | 90 |
| [50%(W) +50% (C)] flours | 67.5 | 1.5 | 7.5 | 10.0 | 20 | 90 |
| [25%(W) +75% (C)] flours | 70.0 | 1.8 | 7.5 | 9.0 | 18 | 80 |
| 100% cowpea flours | 73.3 | 2 | 8.0 | 9.0 | 15 | 95 |
| [75%(W) +25% (GC)] flours | 64.5 | 1.3 | 5.0 | 11.0 | 35 | 100 |
| [50%(W) +50% (GC)] flours | 67.2 | 1.2 | 4.0 | 10.0 | 40 | 100 |
| [25%(W) +75% (GC)] flours | 69.5 | 1.2 | 4.5 | 10.0 | 50 | 120 |
| 100% (GC) flours | 72.0 | 1.0 | 5.0 | 9.0 | 60 | 145 |

(w): wheat flour, (B): bean flour, (GB): germinated bean flour, (C): cowpea flour and (GC): germinated cowpea flour.

***Backing Quality:***

Physical characteristics of cakes, such as density, volume and weight, were affected by the increase in the level of raw and germinated of legumes flour replacements (Table 4). The slightly changes in volume and weight are reflected in density which consistently decreased from 0.458 to 0.445 in raw legumes, 0.444 and 0.445 in germinated bean and cowpea, respectively at 100% levels. These results indicated that the addition of raw and germinated legumes flour slightly affected the volume and weight and thus, density of the supplemented cakes. The increasing in volume due to increasing the replacement of wheat flour with raw and germinated legumes flour caused weakened the gluten network which is responsible for retaining the leavening gases. However, the density of cakes was decreased by increasing raw and germinated legumes flour replacement levels. These results are confirmed with those found by Abou_Zaid (2011).

The hydrolyzed particles were formed during germination, as free amino acids, dextrins, mono sugars, fibers and minerals and rapid partitioning of free water of these hydrophilic sites occurs during dough mixing resulted in increases in the dough viscosity, thereby limiting increase in cake volume. Influence of raw and germinated legumes flours on protein content (mg/100 g) of cakes shows that protein content increased with increasing raw and germinated legumes in the blends (Hooda and Jood, 2005).

**Table 4:** Baking quality of cakes as affected by replacement with different concentrations of raw and germinated legumes flours.

| Samples | Density | Volume | Weight |
|---|---|---|---|
| 100% wheat flour | 0.458 | 396.85 | 183.5 |
| [75% (W) +25% (B)] flours | 0.446 | 405.10 | 183.8 |
| [50% (W) +50% (B)] flours | 0.445 | 410.80 | 184.5 |
| [25% (W) +75% (B)] flours | 0.446 | 412.90 | 185.2 |
| 100% bean flours | 0.445 | 415.10 | 185.5 |
| [75%(W) +25%(GB)] flours | 0.458 | 398.20 | 184.0 |
| [50%(W) +50% (GB)]flours | 0.446 | 410.50 | 184.1 |
| [25%(W) +75% (GB)]flours | 0.445 | 415.10 | 185.0 |
| 100% (GB) flours | 0.444 | 418.20 | 185.0 |
| [75%(W) +25% (C)] flours | 0.457 | 402.30 | 184.0 |
| [50%(W) +50% (C)] flours | 0.448 | 411.10 | 184.0 |
| [25%(W) +75% (C)] flours | 0.446 | 415.20 | 185.0 |
| 100% cowpea flours | 0.445 | 417.20 | 185.5 |
| [75%(W) +25% (GC)] flours | 0.452 | 406.20 | 183.8 |
| [50%(W) +50% (GC)] flours | 0.449 | 410.50 | 184.5 |
| [25%(W) +75% (GC)] flours | 0.447 | 414.40 | 185.1 |
| 100% (GC) flours | 0.445 | 416.80 | 185.3 |

(w): wheat flour, (B): bean flour, (GB): germinated bean flour, (C): cowpea flour and (GC): germinated cowpea flour.

***Color Characteristic:***

Color characteristic is a major criterion that affects the quality of the final product. The fortified flours blends showed a difference in color in relation to the control sample (100% wheat flour). The slight improvement in color was interpreted as an intense color and it was dependant on the fortification level. Mean color values of cakes of different treatments are recorded in Table (5). It was unconsidered to be a real disadvantage since event the commercial control cakes vary in color intensity according to the fortified cakes from which it is produced by addition of raw and germinated legumes flour (Barron & Espinoza, 1993). Table (5) shows Hunter values of whiteness (L), redness (a) and Yellow (b) measured for crumb and crust colors. Crust and crumb color of all incorporating cakes of wheat flour with raw and germinated legumes, especially germinated legumes flour, had lower crust L values than the control, indicating that a darker color could be detected. These results are in coincidence and confirmed with those obtained by Kenny *et al.,* (2000). On contrary, as the replacement percentage of raw and germinated legumes flours was increasing, the values of whiteness (L), redness (a) and Yellowness (b) were slightly decreased in all samples. Subjective evaluations confirmed that the raw legumes flour cakes samples became more darker and more redness (a-values) than the germinated legumes flour and control samples. The results showed that the a-values (redness) and browning index increased in the fortified cakes samples with the increasing level of raw and germinated legumes flour (Table 5). There results are consistent with these obtained by Ahmed (1999) and Kenny *et al.,* (2000).

***Sensory Characteristics of Cakes:***

The effects of legumes supplementation on the sensory characteristics of cakes are presented in Table (6). With the increase in the level of legumes (raw and germinated) in the formulation, the sensory scores for highest, crust color, texture and odor of cakes slightly decreased. But it was sharply increased in the levels more than 75% of raw and germinated cowpea. Replacement of flour with 25, 50 and 75% legumes flour (raw and germinated) impaired the taste of cakes (control samples had 29.5 score), which slightly decreased from 28.5 to 27.8 in raw bean, while exhibited a significantly decreased in case of 50% replacement level in germinated cowpea to be 26.6 and at 25% raw cowpea was 25.9. While it was14.8 at 100% germinated cowpea and 14.5 at 100% ungerminated cowpea which might be due to the bitter taste of raw and germinated legumes flour. The control samples had a maximum overall acceptance, whereas cakes containing levels from 25% to 100% raw and germinated bean flour possessed significant lower values. It was due to cakes contained 50% to 100% raw and germinated cowpea have bitter taste reflecting unacceptable score to panels compared to control. But cakes

contained lower than 50% raw and germinated cowpea flour were slightly decreased in overall acceptance compared to that in control sample (at $p<0.05$). At all levels of substitution by raw or germinated bean flour the crust colors were insignificant differences among samples and control (at $p<0.05$). But above more than 50% substitution levels of raw and germinated cowpea the color of cake had lower scores andsignificantly differed than the control sample. Similar observations were also reported with supplementation of rice bran-fenugreek blends flour (Sharma and Chauhan, 2002) and fenugreek flour (Hooda and Jood, 2005) with wheat flour.

**Table 5:** Color characteristics of cakes contained various amount of raw and germinated legumes flours.

| Samples | Crust color | | | Crumb color | | |
|---|---|---|---|---|---|---|
| | *L** | *a** | *b** | *L** | *a** | *b** |
| 100% wheat flour | 50.23 | 11.78 | 12.52 | 66.80 | 1.42 | 15.83 |
| [75% (W) +25% (B)] flours | 48.41 | 11.62 | 13.33 | 66.10 | 1.39 | 18.61 |
| [50% (W) +50% (B)] flours | 46.78 | 11.55 | 14.89 | 65.80 | 1.36 | 21.62 |
| [25% (W) +75% (B)] flours | 42.86 | 11.51 | 15.41 | 64.30 | 1.33 | 24.81 |
| 100% bean flours | 39.82 | 11.45 | 15.52 | 63.95 | 1.29 | 27.26 |
| [75%(W) +25% (GB)]flours | 48.39 | 11.66 | 13.39 | 66.21 | 1.40 | 18.64 |
| [50%(W) +50% (GB)]flours | 46.82 | 11.60 | 14.99 | 65.90 | 1.37 | 21.68 |
| [25%(W) +75% (GB)]flours | 43.02 | 11.50 | 15.42 | 64.40 | 1.35 | 24.92 |
| 100% (GB) flours | 40.00 | 11.50 | 15.58 | 64.10 | 1.31 | 27.32 |
| [75%(W) +25% (C)] flours | 47.91 | 11.54 | 13.24 | 66.00 | 1.38 | 18.32 |
| [50%(W) +50% (C)] flours | 45.82 | 11.42 | 14.81 | 65.60 | 1.34 | 21.22 |
| [25%(W) +75% (C)] flours | 41.46 | 11.38 | 15.68 | 64.11 | 1.30 | 24.52 |
| 100% cowpea flours | 39.00 | 11.33 | 15.36 | 63.75 | 1.27 | 27.00 |
| [75%(W) +25% (GC)] flours | 47.86 | 11.51 | 13.18 | 66.00 | 1.37 | 18.22 |
| [50%(W) +50% (GC)] flours | 45.62 | 11.48 | 14.70 | 65.50 | 1.33 | 21.02 |
| [25%(W) +75% (GC)] flours | 41.33 | 11.40 | 15.59 | 64.00 | 1.30 | 24.31 |
| 100% (GC) flours | 38.81 | 11.32 | 14.75 | 63.51 | 1.26 | 26.73 |

(w): wheat flour, (B): bean flour, (GB): germinated bean flour, (C): cowpea flour and (GC): germinated cowpea flour.

**Table 6:** Statistical analysis of sensory evaluation of cakes as affected by different levels of raw and germinated legumes flours (mean values).

| Samples of cake | Highest | Taste | Crust color | Odor | Crumb grain | Texture | General appearance |
|---|---|---|---|---|---|---|---|
| | 15 | 30 | 10 | 10 | 10 | 15 | 10 |
| 100% wheat flour | 14.6±0.22 | 29.5±0.29 | 9.8±0.11 | 9.5±0.44 | 9.9±0.02 | 14.8±0.08 | 9.9±0.01 |
| [75% (W) +25% (B)] flours | 14.5±0.14 | 28.5±0.28 | 9.4±0.24 | 9.1±0.25 | 9.3±0.54 | 14.5±0.18 | 9.2±0.57 |
| [50% (W) +50% (B)] flours | 14.5±0.32 | 28.4±0.59 | 9.7±0.18 | 9.2±0.33 | 9.1±0.32 | 14.2±0.37 | 9.3±0.54 |
| [25% (W) +75% (B)] flours | 14.2±0.44 | 27.8±0.45 | 9.6±0.25 | 9.3±0.45 | 9.3±0.49 | 14.1±0.65 | 9.4±0.50 |
| 100% bean flours | 14.6±0.24 | 28.4±0.50 | 9.8±0.08 | 9.4±0.22 | 9.4±0.42 | 14.5±0.42 | 9.5±0.48 |
| L.S.D. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| 100% wheat flour | 14.6±0.22 | 29.5±0.29 | 9.8±0.11 | 9.5±0.44 | 9.9±0.02 | 14.8±0.08 | 9.9±0.01 |
| [75%(W) +25%(GB)] flours | 14.6±0.10 | 27.9±0.81 | 9.5±0.22 | 9.1±0.25 | 9.3±0.24 | 14.3±0.18 | 9.2±0.27 |
| [50%(W) +50% (GB)]flours | 14.5±0.12 | 28.3±0.28 | 9.5±0.18 | 9.2±0.23 | 9.3±0.32 | 14.2±0.25 | 9.3±0.34 |
| [25%(W) +75% (GB)]flours | 14.3±0.35 | 28.5±0.35 | 9.6±0.21 | 9.3±0.35 | 9.2±0.19 | 14.4±0.35 | 9.4±0.41 |
| 100% (GB) flours | 14.7±0.01 | 28.8±0.08 | 9.7±0.08 | 9.2±0.24 | 9.4±0.31 | 14.5±0.32 | 9.4±0.26 |
| L.S.D. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. | n.s. |
| 100% wheat flour | 14.6±0.22 | $29.5^{a}$±0.29 | $9.8^{a}$±0.11 | $9.5^{a}$±0.44 | 9.9±0.02 | 14.8±0.08 | $9.9^{a}$±0.01 |
| [75%(W) +25% (C)] flours | 14.1±0.22 | $26.6^{b}$±0.04 | $9.0^{a}$±0.02 | $8.8^{b}$±0.65 | 9.1±0.19 | 14.1±0.22 | $9.2^{b}$±0.59 |
| [50%(W) +50% (C)] flours | 14.3±0.12 | $20.3^{c}$±0.98 | $8.9^{ab}$±0.32 | $8.5^{bc}$±0.42 | 8.9±0.51 | 14.0±0.25 | $9.2^{b}$±0.33 |
| [25%(W) +75% (C)] flours100% cowpea flours | 14.3±0.18 | $16.5^{d}$±0.88 | $8.7^{b}$±0.62 | $7.8^{c}$±0.21 | 9.0±0.22 | 14.0±0.15 | $8.4^{c}$±0.55 |
| | 14.0±0.13 | $14.8^{e}$±0.69 | $8.1^{bc}$±0.28 | $6.8^{d}$±0.64 | 8.8±0.11 | 14.1±0.22 | $8.0^{cd}$±0.66 |
| L.S.D. | n.s. | 1.843 | 1.188 | 0.962 | n.s. | n.s. | 0.712 |
| 100% wheat flour | 14.6±0.22 | $29.5^{a}$±0.29 | $9.8^{a}$±0.11 | $9.5^{a}$±0.44 | 9.9±0.02 | 14.8±0.08 | $9.9^{a}$±0.01 |
| [75%(W) +25% (GC)] flours | 14.1±0.44 | $25.9^{b}$±0.20 | $8.9^{b}$±0.31 | $8.8^{b}$±0.22 | 9.0±0.10 | 14.0±0.32 | $9.2^{b}$±0.28 |
| [50%(W) +50% (GC)] flours | 14.3±0.12 | $19.8^{c}$±0.48 | $8.7^{b}$±0.32 | $8.6^{b}$±0.32 | 8.9±0.25 | 13.9±0.78 | $9.1^{b}$±0.55 |
| [25%(W) +75% (GC)] flours | 14.4±0.56 | $17.0^{d}$±0.68 | $7.6^{c}$±0.15 | $7.9^{c}$±0.65 | 9.1±0.30 | 14.0±0.28 | $8.1^{c}$±0.75 |
| 100% (GC) flours | 13.9±0.28 | $14.5^{e}$±0.12 | $7.1^{c}$±0.42 | $7.9^{c}$±0.25 | 9.0±0.50 | 14.0±0.09 | $7.9^{c}$±0.10 |
| L.S.D. | n.s. | 1.642 | 0.902 | 0.821 | n.s. | n.s. | 0.682 |

(w): wheat flour, (B): bean flour, (GB): germinated bean flour, (C): cowpea flour and (GC): germinated cowpea flour.

With respect to the sensory evaluation, the organoleptic characteristics of cakes samples made from wheat flour and different levels of raw and germinated legumes flour are acceptable to customers, while the organoleptic characteristics of cakes samples made from wheat flour and raw or germinated cowpea flour more than 25% possessed lower significant values in all sensory properties of cake compared to the control sample. Cakes prepared with raw and germinated legumes flour at any level addition received non significantly difference for color, taste, shape, odor and texture with the highest acceptability except cakes made from blends contained raw and germinated cowpea flour more than 25% level. Therefore, it could be concluded that raw and germinated bean flour could be incorporated up to 100% level in the formulation of cake without affecting their sensory qualities.

***Conclusions:***

The obtained results indicated that raw and germinated legumes (bean and cowpea) flour may be blended with wheat flour (at specified levels) supported the blends with a high source of protein and increase the amino acid levels (except sulfuric amino acids). However, the addition of raw and germinated legumes to wheat flour affected the rheological, color and sensory characteristics of cakes in various ways. Cakes containing raw or germinated cowpea at more 25% levels were lower acceptabile. The protein composition of these samples showed that protein, which plays a very important role in improving rheological, technological and sensory properties of baking products, could be used for enriching the protein content of cake. These studies have shown the potential for devecowpeag protein-rich cake.

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