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Effect of Flour Blending on Bread Characteristics

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Abstract

Raw, germinated and fermented cowpea flours were blended with wheat flour at 5, 10, 15 and 20% substitution level. Composite flours were analyzed for protein, fat, fiber, ash, gluten contents, mineral contents and for farinographic characteristics. Bread thus prepared from composite flour was analyzed for loaf volume and weight as well as for sensory characteristics. Increasing levels of cowpea flour in the blend resulted in the increased protein, fiber, fat, ash contents, water absorption, dough development time, and dough stability. Gluten contents, sedimentation and pelshenke value and peak height of the blend decreased as the level of the cowpea flour increased in the combination. The bread volume decreased with increasing the cowpea flour substitution while the loaf weight increased. Substitution of wheat flour with cowpea flour also affects the sensory characteristics of bread. At the higher level, the acceptability of the bread decreased as the structure of the bread become compact at higher level of substitution. Replacement of wheat flour with cowpea flour up to 10% of substitution level produced acceptable bread.

Key words: Composite flour, Cowpea flour blend, Bread, Sensory evaluation

Introduction

Yeast-raised bread is highly favored worldwide because of its desirable sensory attributes. The quality and quantity of the protein in the wheat grain has very close relationship with bread making potential. The increase in protein content can improve the baking quality as a function of qualitative nature of gluten composition.

Wheat protein is deficient in some essential amino acids, especially lysine which is the first limiting amino acid in wheat (Kent and Evers 1994). This deficiency results in lowering the protein nutritional quality of products made from wheat flour (Wrigley and Bietz 1988).

The deficiency of lysine leads to the poor utilization of protein and thus results in protein malnutrition (Pellet and Ghosh 2004).

Cowpea (Vigna unguiculata), commonly known as black-eyed pea, is an important grain legume of tropical and subtropical areas. It is rich in protein and essential amino acid especially lysine. It contains 20–34% protein, 1-2% fat, 1.5% lysine and 50-65% carbohydrates (Sehirali 1998). Cowpeas are low in fat and contain on cholesterol. The high lysine content makes cowpeas an excellent enhancer of protein quality and, when blended with cereals, produces mixtures with complementary amino acid profiles and improves nutritional quality of the product (Fu et al. 1996; Mensa-Wilmot et al. 2001).

There is great interest has been generated in supplementing wheat flour with high protein, high lysine material to increase the protein content and improve the essential amino acid balance of baked products, especially bread. The high protein and lysine content and well-balanced amino-acid composition makes cowpea an excellent source of protein with potential to enhance the protein quality (Prinyawiwatkul et al. 1996).

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Despite of high protein content, the use of cowpea as a food source has not been explored to its full potential due to inherent antinutritional factors such as trypsin and chemotrypsin inhibitors and haemagglutinins, which reduce the digestibility of protein (Liener 1979).

Germination (Sathe et al. 1983) and fermentation (Zamora and Fields 1979) of cowpeas can not only improve nutritional quality by increasing protein content and also reduce undesirable factors. Germination increased the protein content from 24-32%, crude fiber 1.5-6.5% and ash 1.3-7.0% (Uwaegbute et al. 2000). It induces an increase in free limiting amino acids with modified functional properties of seed components. Germination has also been shown to decreased antinutritional factors like trypsin and chymotrypsin inhibitors and haemagglutinins (Uwaegbute et al. 2000; Fernandez and Berry 1989).

Fermentation of cereals improves amino acid composition, vitamin and protein contents besides lowering the levels of antinutrients such as trypsin inhibitor (Chavan and Kadam, 1989).

Therefore the present investigation was undertaken a) to partially replace wheat flour with raw, germinated and fermented cowpea flour to improve its protein quality and quantity b) to study the effect of supplementation on the functional, baking and sensory characteristics of bread c) to investigate the effect of germination and fermentation on the chemical composition of cowpea flour.

Material and Methods

Procurement of raw material

Wheat cultivar Uqab-2002 was procured from the Ayub Agricultural Research Institute, Faisalabad. Whereas cowpea, yeast, sugar, salt, shortening, etc were purchased from the local market.

Production of flour

Different flours (straight grade flour, whole wheat flour, raw cowpea flour, germinated cowpea flour and fermented cowpea flour) were produced according to their respective methods as described below:

Straight grade flour

The straight grade flour was produced by grinding the wheat grains through Quadrumat Senior Mill by following the method outlined in AACC (2000) method No. 26-95.

Whole wheat flour

The whole wheat flour was produced by grinding wheat grains through disc mill.

Raw cowpea flour

Cowpeas were washed and then dried at 50oC for 24 hours. They were ground and passed through 1 mm mesh screen to get fine flour.

Germinated cowpea flour

Cowpeas were washed and soaked in water for 8 hours at room temperature. The hydrated seeds were spread on trays lined with previously sterilized moist muslin sheets and covered with aluminum foil. Germination went on for three days in an incubator at 25oC and later, cowpeas were dried at 50oC for further three days, after which formed roots and testa were rubbed off. Dried, germinated seeds were ground and passed through 1 mm mesh screen to get fine flour (Hallen et al. 2004).

Fermented cowpea flour

Fermented cowpea flour was produced by subjecting the cowpea to natural lactic fermentation as described by Hallen et al. (2004). Cowpeas were washed, dried and ground and passed through a 1 mm mesh screen. The flour was then mixed with water (1:4, wt/wt) to form slurry followed by addition of 5% sugar by weight of flour. The slurry was left to ferment in incubator at 25oC for four days until the pH of the slurry reached to 5.50. The fermented slurry was dried at 50oC and ground to get fermented cowpea flour.

Preparation of composite flour

Wheat flour was blended with cowpea flour in different combinations as mentioned in Table 1.

Table 1: - Different combinations of composite flour

T_0= Control (100% wheat flour)

Analysis of composite flour

Treatments	Wheat flour (%)	Raw Cow pea flour (%)	Germinated Cowpea flour (%)	Fermented Cowpea flour (%
T_0	100	-	-	-
T_1	95	5	-	-
T_2	90	10	-	-
T_3	85	15	-	-
T_4	80	20	-	-
T_5	95	-	5	-
T_6	90	-	10	-
T_7	85	-	15	-
T_8	80	-	20	-
T_9	95	-	-	5
T_{10}	90	-	-	10
T_{11}	85	-	-	15
T12	80	-	-	20

Proximate analysis

Proximate analysis for moisture, protein, fat, ash and fiber of composite flours was carried out according to their respective methods as given in AACC (2000)

Lysine content

Lysine content was determined by reacting the lysine with trinitrobenzenesulphonic acid and absorption was measured using the spectrophotometer at 415nm according to the procedure as described by Grun et al. (1991).

Gluten content

Wet and dry gluten content in the flour samples were determined using the hand washing method by following the procedure as given in AACC (2000).

Pelshenke value

The pelshenke value of samples was determined by taking 4 g sample; a dough ball was prepared with 3% yeast solution and put it in a 200 ml beaker containing 150 ml water. The difference between the time of dough ball immersion in the water and disintegration was recorded and expressed as pelshenke value in minutes (AACC 2000).

SDS-Sedimentation test

The measurement of relative gluten strength in flour samples was determined by SDS-Sedimentation test according to the procedure described by Williams et al. (1986).

Determination of minerals

For mineral determination, wet digestion of the all samples was carried out according to the method of Jones at al. (1990). Calcium, magnesium and iron were determined by atomic absorption spectrophotometer while sodium and potassium were measured through flame photometer and phosphorus content was determined using a spectrophotometer.

Rheological studies

Water absorption, dough development time, dough stability, and degree of softening was measured by running samples through a Brabender farinograph (AACC 2000) while mixing time and maximum peak height was determined by using a Mixograph, according to the method given in AACC (2000).

Preparation of bread

The baking quality of composite flours was evaluated by preparing bread from composite flours. The bread was prepared from straight grade flour containing raw, germinated and fermented cowpea flour at levels of 0, 5, 10, 15 and 20%, by straight dough method according to the procedure developed by AACC (2000).

Evaluation of the products

Bread from all composite flours was evaluated for various attributes as described below:

Loaf volume of bread

Loaf volume of bread was measured using rapeseed replacement method according to the procedure of AACC (2000). The loaf was put in a metallic container with known volume (VC). The container was topped up with rapeseed, the loaf was removed and the volume of the rapeseed was noted (VR). Loaf volume (VL) was then calculated according to the following formula:

$$VL\ (cm3) = VC - VR$$

Loaf weight of bread

Loaf weight (W) of bread from all composite flours was measured after cooling for one hour, on digital scale.

Specific volume of bread

Specific volume of bread was measured by using the following expression:

$$VS\ (cm3/g) = \frac{VL}{W}$$

Sensory evaluation of bread

The prepared bread loaves were evaluated by a panel of judges for external and internal characteristics by following the method of Land and Shepherd (1988).

Statistical analysis

The data obtained from each parameter was subjected to statistical analysis using analyses of variance technique to determine the level of significance in different parameters according to the method described by Steel et al. (1997).

Results and Discussion

Proximate analysis of composite flour

Table 2 shows that moisture content of composite flours did not differ significantly by different types of cowpea flours. Maximum moisture was found in control while the flour containing 20% germinated cowpea flour gives the lowest moisture contents.

White flour used in this study had protein contents of 10.65 % and the protein contents for composite flours ranged from 11.04% to 13.56%. Protein contents of flour containing fermented cowpea flour were higher that the flour mixes having raw germinated cowpea flour. Ash contents of the flour containing cowpea flour were found to be considerably higher than those of white flour. However, the ash content of different cowpea flours did not differ significantly. Fat and fiber content also shows an increasing trend as the level of cowpea flour increased.

Table:- 2 Proximate analysis (%) of composite flour

Treatments	Moisture	Protein	Ash	Fat	Fiber
T_0	12.30	10.65	0.56	0.90	0.46
T_1	12.15	11.04	0.70	0.95	0.50
T_2	12.10	12.41	0.82	0.99	0.55
T_3	11.90	12.80	0.95	1.07	0.59
T_4	11.50	13.25	1.08	1.13	0.64
T_5	12.00	11.39	0.71	0.97	0.54
T_6	11.80	12.31	0.84	1.05	0.62
T_7	11.30	13.23	0.98	1.10	0.69
T_8	11.20	14.02	1.14	1.15	0.78
T_9	12.20	11.51	0.70	0.99	0.53
T_{10}	12.10	12.42	0.83	1.06	0.60
T_{11}	11.90	13.56	1.00	1.12	0.68
T_{12}	11.80	14.59	1.16	1.18	0.75

Gluten content:

Wheat flour give mean wet and dry gluten contents of 30.9% and 9.7%, respectively and it did not changed significantly to a supplementation level of 10% of cowpea flour. However, a significant decrease in gluten content was recorded at a substitution level of 15% and 20%. White flour blended with cowpea flour at a substitution level of 20% had the lowest gluten content.

Table:- 3 Gluten, SDS-Sedimentation & Pelshenke value of composite flours

Treat ments	Wet Gluten (%)	Dry Gluten (%)	Sedimentation Value (ml)	Pelshenke Value (min)
T_0	30.91	9.70	28.95	171
T_1	29.59	9.45	27.40	165
T_2	28.31	9.14	26.25	160
T_3	27.93	8.83	25.15	155
T_4	26.88	8.24	24.20	149
T_5	29.31	9.13	27.05	164
T_6	28.06	8.77	25.90	158
T_7	27.01	8.41	24.65	154
T_8	26.16	8.07	23.55	147
T_9	28.07	9.01	26.80	162
T_{10}	26.91	8.69	25.45	156
T_{11}	25.73	8.27	24.15	151
T_{12}	24.51	7.96	23.00	144

SDS-Sedimentation test

The SDS-Sedimentation value of wheat flour was 28.95 ml which decreased by increasing the levels of cowpea flour in the blend. The highest value was obtained from wheat flour while the lowest value was obtained from the flour containing 20% fermented cowpea flour 23.0ml. In the blend there was a gradual decrease in the sedimentation value and maximum decrease was found in the blend containing fermented cowpea flour.

Pelshenke value

The wheat flour exhibited Pelshenke value 155 min, which did not differ significantly upon blending with cowpea flour at a substitution level of 10%. Thereafter, a significant decrease was observed in pelshenke vale with increasing substitution level. Wheat flour containing 20% cowpea flour had the lowest pelshenke value 144 min.

Mineral analysis

The mineral contents of various wheat and cowpea flour blends are shown in Table 4. Sodium content of wheat flour was 0.062% which increased gradually as the level of substitution of cowpea flour was increased. Maximum sodium content was recorded in the blend at a substation level of 20% (0.073%). Contrary to sodium, the potassium content of wheat flour blended with cowpea flour show a decreasing trend as the level of substitution increased. The highest value was obtained from the wheat flour while lowest potassium contents was recorded in the blend containing fermented cowpea flour at a 20% substitution level.

Table :- 4 Minerals contents of different composite flours

Treat ments	Na	K	Ca	Mg	P	Fe
T_0	0.062	1.929	0.121	0.203	0.251	2.941
T_1	0.064	1.902	0.127	0.191	0.259	3.125
T_2	0.067	1.871	0.132	0.180	0.266	3.322
T_3	0.069	1.832	0.137	0.172	0.271	3.545
T_4	0.071	1.798	0.144	0.162	0.275	3.715
T_5	0.063	1.902	0.129	0.195	0.260	3.149
T_6	0.066	1.871	0.133	0.186	0.268	3.331
T_7	0.069	1.832	0.139	0.174	0.275	3.549
T_8	0.072	1.798	0.146	0.165	0.277	3.729
T_9	0.065	1.909	0.130	0.196	0.259	3.157
T_{10}	0.067	1.889	0.137	0.186	0.268	3.359
T_{11}	0.071	1.850	0.145	0.175	0.274	3.561
T_{12}	0.073	1.824	0.151	0.169	0.280	3.742

Table 4 shows that calcium content of flour containing 20% fermented cowpea flour was ranked at the top (0.151%) while wheat flour showed the lowest value (0.121%) for calcium content. There was a decreasing trend in the magnesium content as the level of substitution was increased. Overall, the magnesium content ranged from 0.162% to 0.203% in different composite flours. The highest magnesium content was found in the wheat flour and the lowest magnesium content was recorded in the flour containing 5% raw cowpea flour.

The phosphorus content of different flour blends shows that maximum phosphorus contents (0.28%) was found in blend containing 20% fermented cowpea. Generally there was an increasing trend in the phosphorus content as the level of substitution was increased. In the current investigation, the increasing trend of phosphorus contents for various composite flours is in conformity with the findings of Sharma et al. (1999).

Means for iron content of different composite flours (Table 4) demonstrated that iron content composite flours ranged from 3.742 mg/100g to 2.941 mg/100g. highest iron was recorded in the flour supplemented with 20% fermented cowpea flour while the lowest iron content was recorded in the wheat flour with cowpea. The present results are identical to the findings reported by other scientists such as Sharma et al. (1999).

Lysine content

A significant increase in the lysine content o composite flour was recorded as the level of substitution with cowpea flour of any type increased. Maximum lysine contents (0.562%) were given by blend supplemented with 20% fermented cowpea flour while lysine contents whereas minimum in wheat flour (0.235%). It is evident from the results that composite flours containing fermented cowpea flour gave more lysine contents as compared to germinated and raw cow pea flours.

Table :- 5 Lysine content, Loaf volume, Loaf weight and Specific volume of bread

Treat ments	Lysine (%)	Loaf Volume (cm^3)	Loaf Weight (g)	Specific Volume (cm^3/g)
T_0	0.235	631	146.2	4.32
T_1	0.304	612	146.4	4.18
T_2	0.377	573	146.9	3.90
T_3	0.430	547	147.1	3.72
T_4	0.516	492	147.3	3.34
T_5	0.311	605	146.3	4.14
T_6	0.397	565	146.5	3.86
T_7	0.442	532	146.9	3.62
T_8	0.521	450	147.4	3.05
T_9	0.341	595	146.6	4.06
T_{10}	0.413	559	147.2	3.80
T_{11}	0.477	497	147.6	3.37
T_{12}	0.562	440	148.1	2.97

Physical analysis of bread

Loaf volume of bread

As the level of cowpea flour in the blend was increased, loaf volume of bread decreased subsequently. At 5% of substitution level, volume did not decreased significantly but thereafter, a significant reduction in loaf volume was recorded in blend at a substitution level of 10%, 15% and 20%. Highest loaf volume was give by bread prepared from wheat flour while the lowest loaf volume (440 ml) was given by bread prepared from flour containing 20% fermented cowpea flour. The decrease in loaf volume of bread may be attributed due to the reduction in wheat structure forming proteins and low ability of dough to entrap air due to the dilution effect on gluten with the addition of non-wheat flour to wheat flour. The present findings are in close agreement with the results reported by Hallen et al. (2004); McWatters et al. (2004) and Sharma et al. (1999) who reported that incorporation of cowpea flour in the dough had a certain negative effect on loaf volume of bread.

Loaf weight of bread

Loaf weight of bread did not differ significantly by the supplementation of wheat flour with cowpea flour of any type. However, a gradual increase in the loaf weight of the bread was recorded. The highest loaf weight (148.1g) was recorded at 20% of substitution while minimum loaf weight (146.2g) was found in bread prepared from wheat flour. Increase in loaf weight may be attributed due to the increase in water absorption of cowpea flour. Loaf weight of bread in the present study are within the ranges as reported by Hallen (2004) and McWatters et al. (2004) who observed that loaf weight of bread increased progressively with increasing the level of cowpea flour.

Specific volume of bread

Results of specific volume indicate a decrease in specific volume on increasing the level of substitution of cowpea flour of any type. Maximum specific volume (4.32 ml/g) was given by wheat flour while the minimum specific volume (2.97 ml/g) was obtained at 20% substitution level. The results of the specific volume of bread found in this study indicated that there was a substantial decrease in the specific volume of bread when it was supplemented with any type of cowpea flour irrespective of level of supplementation. The results of present study are in agreement with the results reported by Hallen et al. (2004) who also reported a decreasing trend in specific volume of bread.

Dough rheological properties

Water absorption

The farinographic studies showed that blending of wheat flour with cowpea flour increased the waste absorption capacity of flour significantly. The highest value was found in fermented blended flour at 20% substitution level. Water absorption ranged from 64.2% to 69.8% among different composite flours. The increased water absorption was attributed due to the increase in protein and fiber content of wheat flour by supplementation of cowpea flour. The results are in agreement with findings of Hallen at al. (2004); Koksel et al. (2000) and Mustafa et al. (1986) who reported an increase in water absorption capacity of dough supplemented with cowpea flour.

Table :- 6 Rheological characteristics of different composite flours

Treat ments	Water Absorption (%)	Dough Development Time (min)	Dough Stability (min)
T_0	64.20	2.9	8.25
T_1	64.70	3.0	8.35
T_2	65.30	3.5	9.50
T_3	65.90	4.0	9.50
T_4	66.70	4.0	9.90
T_5	65.00	4.8	5.40
T_6	65.80	6.0	8.60
T_7	66.70	6.5	9.50
T_8	67.90	7.0	10.4
T_9	65.40	4.4	9.25
T_{10}	66.90	5.0	10.7
T_{11}	68.50	5.0	11.5
T_{12}	69.80	6.0	12.5

Dough development time

The dough development time of different composite flours shows that wheat flour had the lowest development time, which increased upon blending with cowpea flour. The decrease in development time was statistically non-significant up to 10% of substitution level, but thereafter it increased significantly. Dough development time ranged from 3.0 to 7.0 min. The findings of present study are in conformity with the studies of Hallen et al. (2004) who also reported an increase in dough development time when cowpea flour was used to replace the wheat flour.

Dough stability

Wheat flour exhibited 8.25 minute dough stability, which increase upon blending with cowpea flour. Dough stability did not differ significantly by raw cowpea flour at all levels of substitution, while germinated and fermented cowpea results in significant increase in dough stability at a substitution level of 15% and 20%.

Sensory evaluation

Sensory evaluation is an important criterion for quality assessment in new product development and to meet the consumer requirements. Any new product must give satisfaction and pleasure to the consumers if it has to be a part of their eating habits. For this reason, bread prepared from blends of wheat flour with cowpea flours are evaluated for various sensory attributes.

Color

Color of the bread changed from creamy white to brown as the level of cowpea flour was increased. Significant decrease in color scores was observed with increase in the level of replacement of cowpea flours in all cases. The effect of blending, on the color of bread was more pronounced when higher proportions of cowpea flour were used. However, up to 10% of substitution no significant difference was observed in the bread color. It was observed that at substitution level of 15% and 20%, the color become dark. The darker color may be attributed due to the greater amount of maillard reaction between reducing sugars and proteins. The results of this study are in line with findings of Hallen et al. (2004) and Sharma et al. (1999).

Table :- 7 Sensory evaluation of bread

Treatments	Color	Grain	Aroma	Taste	Texture
T_0	7.0	12.5	7.5	17.0	12.5
T_1	6.5	12.0	7.0	15.5	12.0
T_2	6.0	11.5	7.0	15.0	11.5
T_3	5.5	11.0	7.0	14.0	10.5
T_4	5.0	10.0	6.5	13.5	10.0
T_5	6.5	11.5	7.5	13.5	11.0
T_6	5.5	10.5	7.5	11.0	10.5
T_7	4.0	10.0	8.0	10.0	9.50
T_8	3.5	9.00	8.0	9.50	8.00
T_9	6.5	12.5	7.5	15.5	11.5
T_{10}	5.5	12.0	8.0	14.5	11.0
T_{11}	5.0	11.0	8.5	13.0	10.0
T_{12}	4.5	10.5	8.5	11.5	9.50

Grain

Grain score for the wheat bread decreased significantly upon increasing the blending level to 15 and 20% with cowpea flour of any type. Table 6 revealed that bread prepared from control and 5% cowpea flour obtained the highest grain score while the lowest grain scores was obtained by bread prepared from flour containing 20% cowpea flour. Grain of bread prepared from composite flours was affected by the nature of the cowpea flour used for mixing. Particularly germinated cowpea flour has a typical grain which resulted in lowering of scores in bread. Better score for grain of bread prepared from raw cowpea flour blends was obtained.

Aroma

Aroma score for bread revealed that the aroma score decreased on increasing the level of raw and germinated cowpea flour. The highest scores for aroma (8.5) were gained by bread prepared from 15% and 20% fermented cowpea flour while the lowest aroma scores (6.5) was obtained by bread prepared from flour containing 20% raw cowpea flour. The effect of blending, on the aroma of bread was more pronounced when higher proportions of germinated and fermented cowpea flour were used. This was primarily due to the aroma difference of cowpea flour as compared to wheat flour.

Taste

Score for taste revealed that control and at 5% level of substitution had almost the same results. Score for taste of flour blends at a substitution level of 15 and 20% decreased significantly. However, wheat blend with cowpea show a satisfactory taste score up to 10% level of substitution. Highest taste score (17.0) was gained by control while the bread containing 20% germinated cowpea flour was assigned the lowest taste score (9.5). It is obvious from the results that the taste scores for bread decreased proportionally with increasing levels of cowpea flour in wheat flours.

Texture

Texture score also decreased with increase in the substitution of cowpea flour as compared to control bread. Among the blended bread the highest score was obtained by bread at 5% substitution level. Texture score was decreased significantly at a substitution level of 15 and 20%. It is revealed from the results that the highest texture score (12.5) was assigned to control while lowest texture score (8.0) was obtained by bread prepared from flour containing 20% germinated cowpea flour.

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