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Rheological and Baking Performance of Composite Flours

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ABSTRACT

Composite flour samples were prepared by blending commercial wheat flour "*resultant atta*" with various legumes i.e. lentil, chickpea and guar gum in different proportion to study their rheological and baking performance. Sixteen treatments were prepared by blending commercial wheat flour with lentil, chickpea and guar gum in different proportion for the preparation of chapati. Rheological behavior of the composite flours showed decrease in water absorption and increase in dough development time in a storage period of 60 days. Sensoric attributes of chapati such as color, flavor, taste, texture, chewing ability and folding ability decreased during the storage period. It is notable that guar gum gives whiter look and puffiness to the chapaties. Chapaties were acceptable from flour samples stored upto 60 days. We conclude that blending of various legumes particularly the guar gum with wheat flour improves rheological and sensoric attributes of chapaties.

Key Words: Composite flour; Rheological characteristics; Chapati; Sensoric attributes

INTRODUCTION

Information on the fortification of wheat flour with edible legumes for the preparation of chapati is rather scanty. In Pakistan, chickpea flour was blended with wheat flour to bake "*basini roti*" that is unleavened bread commonly consumed by diabetic patients (Raza, 2003). Physical properties of dough made from combinations of wheat flour by replacing 0, 5, 10, 15, and 20% chickpea flour were not affected to any extent by levels of chickpea flour. Mechanical and rheological properties of dough play an important role in governing the quality of baked products (Bloksma & Bushuk, 1988). The rheological characteristics reflect the dough properties during processing and the quality of the final product (Spies, 1990; Lindahal, 1990). Both quantity and quality of protein influence water absorption (Holas & Tipples, 1978; Finney, 1984; MacRitchie, 1984). Matz (1972) reported that the increase in protein content increased the water absorption. Water absorption, an important characteristic of the wheat flour (Sollars & Rubenthaler, 1975), in Indo-Pakistan wheat varieties ranged from 60-76 % (Nurul Islam & Johansen, 1987). Mixographic and Farinographic characteristics showed gradual increase in water absorption (49 to 52%) in commercial flour and laboratory milled flour as the level of guar gum was increased to 1.5% in the bread formulation. Dough characteristics of whole wheat flour and resultant commercial flour (locally called as *atta*) during storage showed that the water required for making the chapati dough of optimum consistency decreased by about 3.0 % at the end of storage period of four months in both the samples. The dough development time and dough stability were however not affected due to storage in case of *atta* while a considerable increase in the above characteristics was observed in the resultant *atta* (Leelavathi *et al.,* 1984).

In a similar study, farinograms of different resultant atta and *atta* showed higher dough development time and dough stability. The excessively high dough development time may be due to the presence of higher moisture content of the bran particles in the *atta* which may interfere in the quicker development of gluten (Haridas Rao *et al*., 1983). The physical, rheological and baking properties of decorticated cracked broad beans-wheat composite flours and the acceptability of the bread were evaluated by sensory tests. The farinographic studies showed that water absorption, arrival time and dough development time increased as the amount of DCBF increased, while dough stability time increased at 5% and 10% and decreased at 15% and 20% of DCBF substitution (Abdel-Kader, 2000).

Generally, chapati is prepared from whole wheat flour obtained by grinding wheat in a disk mill (locally known as chakki). Chapati quality can be assessed from its softeness and flexibility which may be affected by flour protein quantity and quality. The chapati quality is also influenced by the dough consistency, which in turn depends mainly on the quantity of water added (Austin & Ram, 1971). The quality of chapati is also affected by extraction rate of flour. The chapaties made from resultant *atta* were more leathery and chewy than that made from whole meal *atta* (WMA). This can be attributed to the presence of higher amounts of gluten forming proteins (Haridas Rao *et al.,* 1983). Chapati of good quality can be made by adding chickpea even upto 10% (Qayyum *et al.*, 2003). The chapaties made from composite flour showed higher extensibility even after 24 hours storage. Some of the additives like wet gluten also significantly improved the texture of chapati (Gujral & Pathak, 2002). In this study, the baking properties of blends containing 5, 10, and 20% of the legume flours with hard red spring wheat flour were investigated in order to assess their acceptability by the consumers.

MATERIALS AND METHODS

Commercial wheat flour, guar gum, chick pea and lentil were procured from the local market. The legumes were cleaned manually to remove extraneous materials. The particle size of treated dehulled chickpea, lentil and guar gum was reduced into fine flour through sample mill (Cyclotec-1093, Tecator, Sweden). Wheat flour was blended with lentil, chickpea and guar gum in different combinations (Table I). Composite flour samples were stored in polypropylene bags. The rheological behavior of composite flour samples was evaluated by using Brabender Farinograph to assess the physical dough behavior of each sample. Dough characteristics such as water absorption, dough development time and dough stability were interpreted from each farinogram at 0, 30 and 60 days according to the standard method (AACC, 2000). Chapaties were prepared at the pre-determined intervals from all the samples as described by Haridas Rao *et al.* (1986). The sensory evaluation of chapaties for various attributes such as color, flavor, taste, texture, folding-ability and chewing ability was carried out at 0, 30 and 60 day intervals using Hedonic Score System according to the method described by Land and Shepherd (1988). Analysis of variance for each parameter was performed to find significant difference among treatments (Steel *et al.,* 1997).

RESULTS AND DISCUSSION

Rheological characteristics. The rheological behavior of individual composite flour samples were evaluated by using Brabender Farinograph. Mean squares for water absorption, dough development time and dough stability of different flour samples (Table II) indicated a fair variation among different composite flour samples due to storage and treatments for different dough characteristics. The interaction for these attributes showed no significant difference in the rheological parameters of composite flour.

Means for water absorption of different flour samples (Table III) showed that water absorption ranged from 61.24 to 67.60% among different treatments. The studies of Nurul Islam and Johnsen (1987) regarding water absorption in commercial wheat flour reported 60 to 70% water absorption. There was an increase in water absorption in all the composite flour samples with an increase in the amount of legume flours. Flour samples containing chickpea and lentil absorbed more water due to increase in protein content of composite. Enhanced protein content results due to an increase in pentosans, especially ribose and deoxyribose, which has a higher water holding capability. Matz (1972) also found the similar pattern of water absorption with increase in protein content of flour. This behavior was due to increased viscosity with guar gum addition. Likewise Venkateswara *et al.* (1985) also observed that water absorption increased from 49.6, 50.4 and 52 % with the addition of guar gum at 0.5, 1.0 and 1.5 % level.

Table I. Different treatments used to prepare composite flours

Treatments	Wheat flour %	Lentil %	Chickpea %	Guar gum %
T_1	100	-	-	-
T_2	95	5	-	-
T_3	92.5	7.5	-	-
T_4	90	10	-	-
T_5	95	-	5	-
T_6	92.5	-	7.5	-
T_7	90	-	10	-
T_8	99	-	-	1
T_9	98	-	-	2
T_{10}	97	-	-	3
T_{11}	94	5	-	1
T_{12}	91.5	7.5	-	1
T_{13}	89	10	-	1
T_{14}	94	-	5	1
T_{15}	91.5	-	7.5	1
T_{16}	89	-	10	1

T_1 = Commercial wheat flour; T_2 = lentil 5%; T_3 = lentil 7.5%; T_4 = lentil 10%; T_5 = chickpea 5%; T_6 = chickpea 7.5%; T_7 = chickpea 10%; T_8 = guar gum 1%; T_9 = guar gum 2%; T_{10} = guar gum 3%; T_{11} = lentil 5%+ guar gum 1%; T_{12} = lentil 7.5%+ guar gum 1%; T_{13} = lentil 10%+ guar gum 1%; T_{14} = chickpea 5%+ guar gum 1%; T_{15} = chickpea 7.5% + guar gum 1%; T_{16} = chickpea 10%+ guar gum 1%

In present study composite flour samples containing chickpea showed more dough development time as against the remaining samples. Drop in dough development time was observed as a consequence of mixing wheat flour with legume flours except chickpea (Table III). Highest dough development time (6.31 minutes) was observed in T_7 (chickpea 10%) followed by 6.24 and 6.20 minutes in T_5 (chickpea 5%) and T_1 (commercial wheat flour) that were non significantly different from each other. Kailasapathy and MacNeil (1985) observed an increase in peak time with an increase in winged bean flour in wheat flour.

Highest dough stability (5.41 minutes) was recorded in T_6 (chickpea 7.5%) which was not much different from the other samples except T_3 (lentil 7.5%), T_{12} (lentil 7.5% + guar gum 1%) and T_{13} (lentil 10% + guar gum 1%). Minimum dough stability (4.26 minutes) was noted in T_{12}. The rheological characteristics of the flour were influenced by the addition of guar gum. Apparently this viscosity change had a significant bearing on the dough consistency and handling properties (Venkateswara *et al.*, 1985). Variation existing in the characteristics of legume flours results in increased or decreased stability of the composite flour dough. The decrease in stability was also due to the decrease in wheat gluten content. In the present case, addition of chickpea up to 10% level that cause an increase in dough stability conform to the findings of Abdel-Kader (2000), who noted that dough stability time increased at 5% and 10% of DCBF substitution and decreased at 15% and 20% substitution.

Table II. Mean squares for water absorption, dough development time and dough stability of different flour samples

S.O.V	df	Water Absorption	Dough development time	Dough stability
Storage	2	45.436**	44.76**	41.516**
Treatments	15	42.057**	1.085**	0.749**
S x T	30	0.299 ns	0.118ns	0.259ns
Error	96	2.612	0.277	0.213

** $P \leq 0.01$; * $P \leq 0.05$ and ns non significant

Table III. Effect of different treatments on water absorption, dough development time and dough stability of different flour samples

Treatments	Water Absorption	Dough development time	Dough stability
T_1	61.24 d	6.20 a	5.11 abcd
T_2	62.44 cd	5.75 abcd	5.34 ab
T_3	63.41 dc	5.75 abcd	4.85 bc
T_4	64.17 bc	5.40 de	4.89 abc
T_5	66.61 a	6.24a	5.21 abc
T_6	67.20 a	5.94 abcd	5.41a
T_7	67.60 a	6.31a	5.22 abc
T_8	62.51 bcd	5.59 bcde	5.17 abc
T_9	63.93 bc	5.58 bcde	4.91 abc
T_{10}	64.24 b	5.13e	5.09 abc
T_{11}	62.52 bcd	5.73 abcd	5.00 abc
T_{12}	62.78 bcd	5.42 cde	4.26 d
T_{13}	63.32 bc	5.39 de	4.76 c
T_{14}	66.35 a	5.99 abc	5.14 abc
T_{15}	67.30 a	5.94 abcd	5.34 ab
T_{16}	67.45 a	6.11 ab	5.31 ab

Mean carrying same letters in a column differ not significantly

Table IV. Effect of storage on water absorption, dough development time and dough stability of different flour samples

Days	Water Absorption	Dough development time	Dough stability
0	65.51 a	4.73 c	4.06 c
30	64.62 b	5.98 b	5.22 b
60	63.57 c	6.63 a	5.90 a

Mean carrying same letters in a column differ not significantly

Storage has significant affect on water absorption of different composite flours. Means for water absorption at 0 day were 65.51% followed by 64.62 and 63.57% after 30 and 60 days storage, respectively (Table IV). Water absorption decreased during 60 days storage from 65.51 to 63.57%. In the present rheological study, farinographic behavior showed a decline in water absorption during two month storage. Leelavathi *et al.* (1984) reported that the water required for making chapati dough of optimum consistency decreased by about 3.0% at the end of storage.

Storage time affected dough development time of composite flour samples. Dough development time increased during 60 days storage from 4.73-6.63 min. The dough development time increased from 6 to 10 minutes during four months of storage. In a similar study, farinograms of different resultant *atta* and *atta* showed higher dough development time and dough stability for *atta*. The excessively high dough development time may be due to the presence of higher moisture content of the bran particles in the *atta* which may interfere in the quicker development of gluten (Haridas Rao *et al.*, 1983).

Data showed increasing trend in dough stability of different flour samples (Table IV). At the beginning, the dough stability time was 4.06 min, which increased to 5.22 and 5.90 min at 30 and 60 days, respectively. Dough stability, measured with different farinographic characteristics, increased with storage of the flour samples. This might be attributed to the difference in the protein content and its protein quality (Holas & Tipples, 1978; Finney, 1984; Hosney, 1986).

Sensoric attributes. Mean squares for sensory attributes indicated that the quality characteristics of chapati such as color, flavor, taste, texture, chewing-ability as well as folding-ability differed significantly due to storage and various treatments of composite flours (Table V). The mean scores for color of chapaties indicated that their preparation from T_{10} (guar gum 3%) got the highest color score (7.60) followed by T_5 (chickpea 5%) and T_9 (guar gum 2%) which obtained 6.87 and 6.73 scores for color, respectively. Judges were unable to differentiate between T_8 (guar gum 1%), T_9 (guar gum 2%) and T_{11} (lentil 5% + guar gum 1%) with respect to all other treatments except T_5 (chickpea 5%) and T_1 (commercial wheat flour). The lowest color scores (5.27) was noted in T_{13} (lentil 10% + guar gum 1%) and T_4 (lentil 10%) with non significant difference score (5.33) for T_{16} (chickpea 10% + guar gum 1%). Decrease in color scores was observed with increase in the level of replacement in composite flours in all cases except guar gum.

The mean scores for flavor of chapaties (Table VI) reveled that chapati prepared from T_{10} (guar gum 3%) was the best in flavor attribute followed by T_9 (guar gum 2%) and T_1 (commercial wheat flour). However, judges were unable to differentiate between T_9 (guar gum 2%) and T_1 (commercial wheat flour). Better score for flavor of chapaties prepared from guar gum flour blends may be attributed due to the good look, refinement in color and texture by the addition of this legume.

Mean scores for taste of chapaties showed that highest taste was gained by T_{10} (guar gum 3%) followed by T_9 (guar gum 2%) and T_{14} (chickpea 5% + guar gum 1%), while T_{12} (lentil 7.5% + guar gum 1%) had least taste score (Table VI). Similarly decrease in taste scores were observed with increasing level of lentil and chickpea except for guar gum. The maximum scores for taste were observed in the chapaties containing 3% guar gum.

Table V. Mean squares for various sensory attributes of chapaties prepared from different flour samples

Source	df	Color	Flavor	Taste	Texture	Chewing Ability	Folding ability
Storage	2	30.829**	32.317**	29.954**	31.088**	32.067**	29.629**
Treatments	15	7.120**	9.724**	8.884**	10.102**	6.870**	8.782**
S x T	30	0.038^{NS}	0.054^{NS}	0.132^{NS}	0.083^{NS}	0.093^{NS}	0.207^{NS}
Error	192	0.642	0.633	0.704	0.783	0.883	0.821
Total	239						

Table VI. Effect of different treatments on various sensory attributes of chapaties prepared from different flour samples

Treatments	Color	Flavor	Taste	Texture	Chewing ability	Folding ability
T_1	6.60 bcd	6.87 bc	6.60 bc	6.73 bc	6.80 bc	6.67 bc
T_2	5.87 efg	6.07 efg	5.53 defg	5.47 e	5.53 defg	6.07 cdef
T_3	5.80 efg	5.60 fghi	5.07 fg	5.27 e	5.60 defg	5.87 def
T_4	5.27 g	5.00 i	5.53 defg	5.07 e	5.47 efg	5.53 f
T_5	6.87 b	6.40 cde	6.13 cde	5.60 e	6.20 cde	6.47 bcde
T_6	5.73 efg	5.87 efgh	5.73 def	5.73 de	5.47 efg	5.73 ef
T_7	5.47 fg	5.13 i	5.27 fg	5.13 e	5.07g	5.60 f
T_8	6.67 bc	6.13 def	6.20 cd	6.87 abc	6.20 cde	6.60 bcd
T_9	6.73 bc	7.27 ab	7.27 a	7.07 ab	7.13 ab	7.20 ab
T_{10}	7.60 a	7.60 a	7.47 a	7.53 a	7.60 a	7.47 a
T_{11}	6.67 bc	5.53 fghi	5.53 defg	6.13 cd	6.00 def	6.20 cdef
T_{12}	5.53 efg	5.40 hi	4.93 g	5.13 e	5.67 defg	5.73 ef
T_{13}	5.27 g	5.07 i	5.73 def	5.47 e	6.27 cd	6.53 bcd
T_{14}	6.13 cde	6.73 bcd	6.87 ab	6.07 cd	7.00 ab	6.80 abc
T_{15}	6.00 def	5.47 ghi	5.47 efg	5.67 e	5.40 fg	6.07 cdef
T_{16}	5.33 g	5.33 hi	5.33 fg	5.27 e	5.07 g	4.80 g

Table VII. Effect of storage on various sensory attributes of chapaties prepared from different flour samples

Days	Color	Flavor	Taste	Texture	Chewing ability	Folding ability
0	6.65 a	6.53 a	6.48 a	6.43 a	6.53 a	6.78 a
30	6.21 b	6.10 b	6.01 b	5.94 b	6.21 b	6.33 b
60	5.43 c	5.28 c	5.26 c	5.19 c	5.35 c	5.53 c

Mean values for treatments carrying same letters in a column are not significantly different

Best texture of chapaties was due to addition of 3% guar gum followed by T_9 (guar gum 2%) and T_8 (guar gum 1%). Chapaties prepared with T_4 (lentil 10%) had low quality texture. Mean scores for chewing-ability of chapaties revealed remarkable effect of legumes addition in different proportions (Table VI). Chapaties prepared from T_{10} (guar gum 3%) flour sample acquired the highest chewing-ability score (7.60) followed by T_9 (guar gum 2%) and T_{14} (chickpea 5% + guar gum 1%) that got 7.13 and 7.00 scores, respectively. Lowest score (5.07) was gained by T_{16} (chickpea 10% + guar gum 1%) and T_7 (chickpea 10%). T_9 and T_{14} showed non significant variation from each other.

Folding-ability of chapaties revealed that preparations from T_{10} (guar gum 3%) flour sample attained the highest folding-ability followed by T_9 (guar gum 2%) and T_{14} (chickpea 5% + guar gum 1%) (Table VI). This finding agreed with regard to hand feel, which was smooth and highly pliable particularly in case of chapaties containing guar gum. This may be partly due to higher moisture absorption capacity of the guar gum.

The chapati from commercial flour had a desired light brown spots as compared to lentil and chickpea having more brown spots. However addition of guar gum gives whiter look and puffiness to the chapati. The deterioration in color of chapaties with storage might be due the absorption of moisture, oxidation of fats and carotenoids, rancidity and progressive increase in the mold count of composite flour samples with the passage of time. At 0 day, means for flavor of chapaties during storage (Table VII) were 6.53 which were decreased to 6.10 and 5.28 after 30 and 60 days storage. During storage peroxide value and acidity rises significantly that further enhance the lipolytic activity and thus rancidity. Moreover increase in the flour moisture during storage also favors hydrolytic rancidity; all these are the contributory factors towards decline of flavor score. Storage has momentous effect on taste of chapaties (Table VII). At the beginning the taste of chapaties during storage was 6.48 which decreased to 6.01 and 5.26 after 30 and 60 days storage. Increase in moisture, peroxide value and acidity of flour samples have an inverse correlation with texture (Anjum *et al.* 2003). All these factors contribute towards deterioration in the quality of stored flour samples and ultimately influence the texture of chapati. Storage also has momentous effect on chewing-ability and folding-ability of chapaties prepared from different composite flours.

CONCLUSION

From present research, it is concluded that blending various legumes with wheat flour, improves rheological and sensoric characteristics of chapati. The results also indicated that apart from the commercial flour, chapaties prepared from composite flour containing guar gum at 3%, 2% and chickpea 5%+ guargum 1% level improved the sensoric parameters of chapaties. However addition of lentil and chickpea at 10% could not make any significant impact on the sensory attributes. It was further observed that decrease in scores were almost linear to the percent replacement of lentil and chickpea.

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