Effect of incorporation of flours on the functional properties of composite flours

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Abstract

The present investigation was carried out to study the effect of incorporation of different flour on the functional properties of composite flours. Wheat flour was incorporated with mushroom flour, black gram flour, soya flour and jowar (sorghum) flour blends in ratios of 100:0:0:0:0, 90:2.5:2.5:2.5:2.5, 80:5.0:5.0:5.0:5.0 and 70:7.5:7.5:7.5:7.5, respectively. Wheat flour of the ratio of 100:0:0:0:0 was considered as control. The physical and functional properties of individual and composite flours were analyzed. Swelling water capacity, water absorption capacity and foam stability was increased while foam capacity, oil absorption capacity, emulsion activity, emulsion stability and bulk density decreased with increasing the level of incorporation other flours. Same trend was found in the ash content which was increased with increasing the level of incorporation and moisture content as vice-versa.

Keywords: Functional properties, swelling water capacity, water absorption capacity, foam stability, foam capacity, oil absorption capacity, emulsion activity, emulsion stability.

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Introduction

Cereals are an excellent source of vitamins and minerals including fat-soluble vitamin E, which is an essential antioxidant. The cereal grains easily supply quantity of protein as required for RDA but unfortunately they lack the essential amino acid lysine and therefore they must not to be used as the sole source of dietary protein (Khatkar, 2005). Cereal grains like wheat, corn, rice, barley, sorghum, etc. provide 68% of the total world food supplies. Wheat is mainly used as a dietary staple, averaging two-thirds of total consumption (Anjum *et al.*, 2005).

No legume or cereal alone can provide adequate amounts of all nutrients to meet the nutritional requirements of human being. However, even before knowledge on protein content, protein quality, digestibility and the nutrient requirements of humans became available, it was recognized that mixing legumes with cereals in the diet could improve

overall nutrition. The present and newly derived knowledge in these areas makes it possible to blend, mix or fortify one food material with others so that the resulting fortified mix has not only better nutritional quality but also the necessary attributes for consumer acceptance. Protein malnutrition is a serious problem in undeveloped countries due to cereal based dietary pattern therefore various preparation based on cereal pulse combination are of paramount importance to improve the protein quality of human diet. (Ruales and Nair, 1992).

Composite flour technology refers to the process of mixing various flours to make use of local raw material to produce high quality food products in an economical way. Formulation of composite flour is vital for development of value-added products with optimal functionality (Rehman *et al.*, 2007). Owing to shortage of wheat, several

developing countries have devised programs to assess the feasibility of alternate sources for substituting or blending with wheat flour. (Khader, 2001). Iyer and Singh (1997) explained the composite flours containing wheat and legumes are being utilized in many parts of the world.

Several studies about the influence of the addition of legume flours on the functional properties of bread dough and final bread quality have been reported in the last 30 years. The use composite flour based on wheat and other cereals including minor millets in bakery products is becoming popular because of the economic and nutritional advantages (Dasappa *et al.*, 2004). Therefore, efforts are being made to partially replace wheat flour with non-wheat flours as a possibility for increasing the utilization of indigenous crops cultivated in many countries as well as contribute to lowering cost of bakery products (Ayo and Gaffa, 2002). The combination of grain with legume proteins would provide better overall essential amino acid balance, helping to overcome the world protein calorie malnutrition problem (Livingstone *et al.*, 1993). Bakery products are varied by addition of value added ingredients. Among the added ingredients, dietary fiber has gained tremendous attention (Shuda *et al.*, 2007). Attempts have been made to substitute wheat with other flours such as cow pea (Okaka and Isieh, 1990; Akubor *et al.*, 2003a; Akubor, *et al.*, 2003b), amaranth grain (Adeyemi *et al.*, 1992; Ayo, 2001) and African bread fruit (Akubor and Badifu, 2004). Similarly, mixtures of non-wheat flours such as millet/pigeon pea (Eneche, 1999), Cowpea/maize (Akubor *et al.*, 2001), cowpea/plantain (Akubor *et al.*, 2003a), wheat/cassava / maize/cowpea blends (Oladunmaye *et al.*, 2010), Aestivum wheat bran/durum wheat bran (Ghobel *et al.*, 2010) and wheat/rice/mung/potato flour (Chandra *et al.*, 2015) have been evaluated the functional properties. Since the available literature on functional properties of composite flours made from wheat, mushroom, black gram, soybean

and sorghum flour is rather scanty. The present study was undertaken to develop the composite flour and analysis their functional properties for industrial information and utilization.

Materials and Methods

Raw materials viz., Wheat flour (maida), Mushroom flour, Blackgram flour, Soya flour and jowar flour and Chemicals and other desired materials etc. were procured from local market of Meerut (UP) India for the present study. The entire studies were conducted in the Department of Agricultural Engineering and Food Technology, S.V.P. University of Agric. & Tech., Meerut (U. P.). Instruments / equipment used were knife, trays, grinder, whiley mill, sieve, electronic balance, hot air oven, centrifuge, desiccator, water bath, test tube and measuring cylinder etc. Composite flour was made from refined wheat flour, mushroom flour, black gram flour, full fat soya flour and jowar (sorghum) flour. Detailed methodology of development of each flour and composite flour is given below:

Development of flours

Refined wheat flour (maida): Refined wheat flour (Rajdhani brand) was manufactured from Victoria Food (P) Ltd, New Delhi. Refined flour was free from any artificial additives and preservative.

Mushroom flour: Mushroom flour was manufactured from Division of Post Harvest Technology, National Research Centre for Mushroom (NRCM), Chambaghat, Distt. Solan, Himachal Pradesh (India) which was free from any artificial additives and preservatives.

Black gram flour: Black gram bean was procured from the market and removed all the impurities, damaged and infested grain by manual cleaning. The cleaned black gram bean was soaked overnight to destroy the anti-nutritional factor and loosening the husk.

Soaked black gram bean was dried for 3-4 days in sun up to very low moisture content and ground by domestic Atta chakki into two passes. Black gram flour was also sieved.

Soya bean flour: Soya bean was procured, cleaned and soaked overnight to destroy the anti-nutritional factor. Soaked Soya bean was dried for 3-4 days in sun up to very low moisture content and ground by domestic Atta chakki into two passes was also sieved.

Jowar (sorghum) flour: Jowar was procured from the market and cleaned manually. The cleaned Jowar was soaked overnight then dried up to 3-4 days in sunlight desired moisture content and ground by domestic Atta chakki into two passes and sieved also.

Composite flours: Composite flours were prepared from wheat flour incorporating with mushroom flour, black gram flour, soya flour and jowar (sorghum) flour blends in ratios of 100:0:0:0, 90:2.5:2.5:2.5:2.5, 80:5.0:5.0:5.0:5.0 and 70:7.5:7.5:7.5:7.5, respectively. Wheat flour of the ratio of 100:0:0:0:0 were considered as control.

Evaluation of physico-chemical properties of flours

Moisture content (M.C.): Initial moisture content of samples was determined by hot air oven drying method as recommended by AOAC (2000).

Ash content (%): Ash content was determined by the method as recommended by (BIS, 1977), standard methods for the examination of flours and flour products. In a clean silica dish, 5 g of homogenous sample of flour was weighed and 6 ml of nitric acid was added and heated at low fire until the changing of colour was completed. Thereafter, silica dish was transferred to an electric furnace maintained at a temperature of about $850 \pm 20^\circ \text{C}$ and ignite till carbon free. The dish was cooled down in desiccators and weighed. The process was repeated till constant weight was obtained.

$$\text{Ash (\%)} = \frac{W_2 - W_1}{W} \times 100$$

Where,

W = weight of sample, (g), W_1 = weight of silica dish (g), W_2 = weight of silica dish + ash (g)

2.2.3 Bulk density: The volume of 100 g of the flours was measured in a measuring cylinder (250 ml.) after tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, and based on the mass and volume, the apparent (bulk) density was calculated (Jones *et al.*, 2000).

Assessment of functional properties of flours

Swelling capacity: The swelling capacity was determined by the method described by (Okaka and Potter, 1977). 100 ml graduated cylinder was filled with the flour to 10 ml mark. The distilled water was added to give a total volume of 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and left to stand for a further 8 min. The volume occupied by the flour was taken after the 8th min.

Water absorption capacity (mg/100 gm): The water absorption capacity was determined by the method of (Sosulski *et al.*, 1976). One gram of flour mixed with 10 ml distilled water and allow to stand at ambient temperature ($30 \pm 2^\circ \text{C}$) for 30 min and centrifuged for 30 min at 3000 rpm or 2000 x g. Water absorption was examined as percent water bound per gram flour.

Fat (oil) absorption capacity (mg /100 gm): The fat absorption capacity was determined by the method of (Sosulski *et al.*, 1976). One gram of flour mixed with 10 ml soybean oil (Sp. gravity: 0.9092) and allows to stand at ambient temperature ($30 \pm 2^\circ \text{C}$) for 30 min, then centrifuged for 30 min at 3000 rpm or

2000 x g. Fat/oil absorption capacity was examined as percent fat/oil bound per gram flour.

Emulsion activity (%) and Emulsion stability (%): The emulsion activity and stability were determined by the method of (Yasumatsu *et al.*, 1972). The emulsion (1.0 g flour, 10 ml distilled water and 10 ml soybean oil) was mixed in calibrated centrifuged tube. The emulsion was centrifuged at 2000g for 5 min. The ratio of the height of emulsion layer to the total height of the mixture was calculated as emulsion activity in percentage. The emulsion stability was estimated after heating the emulsion contained in calibrated centrifuged tube at 80°C for 30 min in a water-bath, cooled for 15 min under running tap water and centrifuged at 2000g for 15 min. The emulsion stability expressed as percentage was calculated as the ratio of the height of emulsified layer to the total height of the mixture.

Foam capacity (%) and Foam stability (%): The foam capacity (FC) and Foam stability (FS) were determined as described by (Narayana and Narasinga Rao, 1982) with minute modification. The 1.0 g flour sample was added to 50 ml distilled water at 30±2°C in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam development. The volume of foam at 30 sec after whipping was expressed as foam capacity using the formula:

$$\text{Foam capacity (\%)} = \frac{\text{Volume of foam AW} - \text{Volume of foam BW}}{\text{Volume of foam BW}} \times 100$$

Where,

AW = after whipping, BW = before whipping

The volume of foam was recorded one hour after whipping to determine foam stability as per percent of initial foam volume.

Statistical analysis

The data obtained from the various experiments was done by using ANOVA with Factorial Randomized Block Design (factorial R.B.D.). The significance difference between the means was tested against the critical difference at 5 % level of significance (Gomez and Gomez, 1984). STATPAC (OPSTAT) software was used for analyze the recorded data.

Results and Discussion

Physico-chemical properties of flours

The mushroom flour indicated highest moisture content (14.84%) is followed by refined wheat flour show 13.467% but black gram flour showed lowest moisture content 9.903% amongst individual flours. With increase incorporation levels viz., 2.5%, 5% and 7.5% , the moisture content of mixed flour is decreased with values 14.127%, 13.807% and 13.227 % respectively (Table 1).

From Table 1, it can be noticed that the mushroom flour had highest ash content (10.061%) followed by full fatted soya flour (4.193%) but refined wheat flour showed very low ash content (0.75%) as compared to others. If mushroom flour, black gram flour, full fat soya flour and jowar (sorghum) was mixed with refined wheat flour in the composition 2.5%, 5% and 7.5%, the ash content of composite flour increased significantly to 0.943%, 1.217% and 1.555% with increasing the level of incorporation of flours. From the nutritional point of view it is an important parameter for the fortification of cereals products. The similar results have been reported by (Mojisola *et al.*, 2005) for maize soybean blend. The percentage of ash content increased significantly with increases the fortification of flours.

The black gram flour showed highest value of bulk density (0.90 g/cc) followed by

jowar (sorghum) flour (0.842 g/cc) while full fattened soy flour had 0.701 g/cc. The bulk density of composite flours decreased to 0.787 g/cc, 0.790 g/cc and 0.792 g/cc respectively with an increase in the level of flours. The results indicated that the bulk density of

defatted flours is less than full fattened flours. Similar results were reported by (Chau *et al.*, 1997) in legumes. Same work by (Amarjeet *et al.*, 1993) described the bulk densities of different flour blends are lower as compared to wheat blends.

Table 1: Physico-chemical Properties of flours

Samples	Moisture content, %	Ash content, %	Bulk density, g/cc
Individual flours			
M ₁₀₀	14.84±0.06	10.061±0.13	0.725±0.01
B ₁₀₀	9.903±0.12	2.649±0.16	0.901±0.01
S ₁₀₀	10.673±0.57	4.193±0.15	0.701±0.01
J ₁₀₀	12.633±0.32	1.403±0.04	0.842±0.01
W ₁₀₀	13.467±0.53	0.75±0.09	0.84±0.07
Composite flours			
W ₉₀ CF _{2.5}	14.127±0.09	0.943±0.04	0.787±0.01
W ₈₀ CF ₅	13.807±0.35	1.217±0.10	0.790±0.01
W ₇₀ CF _{7.5}	13.227±0.55	1.555±0.12	0.792±0.01
CD _{0.5}	0.609	0.189	0.084
SEm±	0.199	0.062	0.016

Values : Mean ± SD

Functional properties of flours

The flours were prepared and to study the swelling water capacity (SWC), water absorption capacity (WAC), foam capacity, foam stability, fat/oil absorption capacity, emulsion activity and emulsion stability.

Swelling water capacity: Table 2 shows that black gram flour represented maximum swelling water capacity 43% followed by mushroom flour 27.667% and lowest was found in jowar flour 15.667%. If mushroom flour, black gram flour, full fat soya flour and jowar (sorghum) blends with refined wheat flour in the composition of 2.5%, 5% and 7.5%, the swelling water capacity increased 16.333%, 17.333% and 19.333%, respectively. These occur due to hydrophilic interaction between water and protein molecules by hydrogen bonding. Swelling water capacity of the composite flour gives it an advantage of being used as a thickener in liquid and semi-liquids foods since the flours has the ability to

absorb water and swell for improved consistency in biscuits. Similar research were reported by (Osundahunsi *et al.*, 2003) for maize, sweet potato flour blends and for soya flour based blends (Lin *et al.*, 1974).

Water absorption capacity: The mushroom flour showed higher water absorption capacity 29.333% followed by black gram flour 25.333% and refined wheat flour showed lowest water absorption capacity 10.667%. The mixed flour level increased 2.5%, 5% and 7.5% than water absorption capacities also increased 10.333%, 10.643% and 11.667% respectively. It was due to lipophilic environment of fat and protein. Water absorption capacity is a critical function of protein for various food products like dough and biscuits baking. The wheat blends from wheat, soy and cassava flours respectively to increased water absorption with increased soy flour fortification (Amarjeet *et al.*, 1995).

Fat/oil absorption capacity: From Table 2, refined wheat flour showed highest value of

fat/oil absorption capacity (153%) followed by mushroom flour (150%) while black gram flour showed very low fat/oil absorption (106.667%) as compared to other samples. If the mixed flour composition level is increased 2.5%, 5% and 7.5% than the fat/oil absorption is decreased 78.333%, 63.333% and 48.333% respectively. It was observed that the oil absorption capacity of defatted samples was better than full fat samples. It was due to flour blend protein to physically bind with fat by capillary attraction and it is of great importance since fat acts as flavour retainer and increase the mouth feel of foods. The oil absorption capacity of different levels of blend values compared with other flours and described defatted flours have more fat/oil absorption capacity investigated by (Oshodi *et al.*, 1997). The soybean flour had a greater capacity to absorb water and oil was described by (Akubor and Ukwuru, 2005).

Foam capacity and foam stability: Foam capacity of mushroom flour rated highest value (52.667%) followed by black gram flour 42.667% and jowar (sorghum) showed very poor 16%. The mixed flour level was increased 2.5%, 5% and 7.5% than the foam capacity was decreased from 34.667%, 34% and 28% respectively. It was caused by some anti-nutritional factor involved in foam

generation; it is useful functional properties for biscuits and food products development. The good foam ability with flexible protein molecules, which reduces surface tension. Low foam ability on the other hand can be related to highly order the globular proteins, which resists surface of denaturation discussed by (Graham and Phillips, 1976). From Table 2, foam stability of black gram flour was very high 32% followed by full fat soy flour 10.667% but refined wheat flour had very poor foam stability 4.667%. Due increase in the level of mixed flours from 2.5%, 5% and 7.5%, foam stability was also increased 3.0%, 5.333% and 13.333% respectively. This is occurred by some fat and protein interaction. Foam contributes to smoothness; lightness, flavor dispersions and palatability. The results obtained from the current study indicate that the samples could serve as potential replacements of known proteins in food applications requiring high foam ability and stability for cakes, breads and other bakery products. Some research work by (Sathe *et al.*, 1982; Aluko and Yada, 1995) reported pH dependency of foam capacity and stability in lupin, winged bean, sunflower and cowpea seed proteins, the better foam stability in acidic condition and poor foam stability at alkaline or basic condition.

Table 2 Functional properties of the different composition of flour

Sample	SWC (%)	WAC (%)	OAC (%)	FC (%)	FS (%)	EA (%)	ES (%)
Individual flours							
M ₁₀₀	27.66±0.57	29.33±0.57	150.00±10.00	52.66±3.05	10.00±2.00	47.18±1.04	52.28±1.85
B ₁₀₀	43.00±1.00	25.33±0.57	106.66±5.77	42.66±3.05	32.00±2.00	66.53±1.54	63.36±0.90
S ₁₀₀	24.66±0.58	19.66±0.58	126.66±11.55	22.00±2.00	10.66±1.15	81.48±1.74	76.10±2.17
J ₁₀₀	15.66±0.58	18.66±0.58	120.00±10.00	16.00±2.00	8.66±2.31	52.33±1.34	53.83±2.06
W ₁₀₀	16.66±0.58	10.66±1.18	153.33±5.77	33.33±3.05	4.66±1.15	45.04±1.25	58.00±2.00
Composite flours							
W ₉₀ CF _{2.5}	16.33±0.58	10.33±0.58	78.33±2.88	34.66±3.05	3.00±1.00	46.66±1.27	52.91±1.50
W ₈₀ CF ₅	17.33±0.58	10.64±1.00	63.33±5.77	34.00±2.00	5.33±1.15	45.33±1.25	52.63±1.23
W ₇₀ CF _{7.5}	19.33±0.58	11.66±0.58	48.33±7.63	28.00±2.00	13.33±3.05	40.00±1.18	50.51±0.66
CD _{0.5}	1.01	1.38	14.16	3.96	3.05	3.53	2.05
SEm±	0.33	0.45	4.62	0.99	0.99	1.15	0.67

Description:

M₁₀₀: Mushroom flour

B₁₀₀: Black gram flour

S₁₀₀: Soy flour

J₁₀₀: Jowar flour

W₁₀₀: Wheat flour (Control)

W₉₀CF_{2.5}= Wheat flour (90%) + Mushroom flour (2.5%) + Black gram flour (2.5%) + Soybean flour (2.5%) + Jowar flour (2.5%)

W₈₀CF_{5.0}= Wheat flour (80%) + Mushroom flour (5%) + Black gram flour (5%) + Soybean flour (5%) + Jowar flour (5%)

W₇₀CF_{7.5}= Wheat flour (70%) + Mushroom flour (7.5%) + Black gram flour (7.5%) + Soybean flour (7.5%) + Jowar flour (5%)

SWC = Swelling water capacity

WAC = Water absorption capacity

OAC = Oil absorption capacity

FC and FS = Foam capacity and Foam stability

EA and ES = Emulsion activity and Emulsion stability

Emulsion activity and Emulsion Stability:

Emulsion activity (Table 2) of the full fat soya flour found highest value (81.483%) followed by black gram flour (66.537%) but refined wheat flour with minimum (45.043%) as compared to other flour samples. If the mixed flour level is increased the emulsion activity is decreased. The prosperities of emulsion activity were influenced by many factors like capacity of protein, pH, concentration and solubility. These are beneficial for formation and stabilization of emulsions in biscuits baking. From Table 2, The full fat soya flour had highest value of emulsion stability (76.103%) followed by black gram 63.367% but mushroom flour showed lowest stability 52.183% in comparison to taken individual flour. If the flour composition level is increased to 2.5%, 5% and 7.5% then the emulsion stability decreased to 52.91%, 52.633% and 50.513% respectively. Emulsion stability is important phenomena for thick consistency in biscuits baking.

Conclusion

The incorporation of legume to cereal-based products could be a good alternative for increasing the intake of legumes. In addition, legume proteins are rich in lysine and deficient in sulphur containing amino acids, whereas cereal proteins are deficient in lysine. Mushrooms are a low-calorie high protein diet,

with no starch and sugars therefore called the diabetics delight. These are also rich in vitamins and minerals especially B -Complex and iron. Pulses are valued for their protein content as well as their low glycemic index and are commonly included in diets in the Indian subcontinent. Soybeans and soy-based foods are extensively consumed in the Asian diet. In recent years, food legumes have attracted a great deal of attention due to their functional components and health-promoting effects in relation to the prevention of chronic diseases, including cardiovascular diseases, obesity and diabetes. Sorghum grain being an excellent source of many valuable nutrients, such as soluble and insoluble dietary fibers, vitamin B complex, minerals and phenolic compounds, is also a desirable ingredient in baked products.

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