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Evaluation of various properties of composite flour from oats, sorghum, amaranth and wheat flour and production of cookies thereof

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Abstract

Amaranth, sorghum and oats flour was used to prepare mix flour (MF). Composite flour (CF) was prepared by replacing wheat flour with MF at various proportions i.e. 5%, 10%, 15%, 20% and 25%. The physical and functional properties of different blends of composite flour were studied. Cookies were prepared by using different ratios of composite flour. The various properties of multigrain cookies were investigated. In composite flour, with increase in blending proportion, fat and carbohydrate content increased. Water absorption capacity (WAC) increased as the blending proportion was increased. Foaming stability (FS) gradually decreased with increase in blending proportions. In cookies, it was found that that the diameter of the cookies decreased with increasing level of supplementation, whereas with increase in level of supplementation, hardness of cookies increased. The cookies made from 10% supplementation obtained highest overall acceptability scores.

Introduction

The diet plays an important role in the prevention of many diseases. The increasing awareness about the health benefits of natural dietary constituents has led to the development of a range of functional foods. The food industry is facing the challenge of developing new food products with special health enhancing characteristics. Sources of these materials come from a wide variety of plant consumable products. A food is considered functional if it provides benefits over and above the nutrients required for normal health (Goldberg, 1994). Several developing countries have encouraged the initiation of programs to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour. Many efforts have been carried out to promote the use of composite flours, in which a portion of wheat flour is replaced by locally grown crops to be used in baked goods, thereby decreasing the cost associated with imported wheat (Olaoye *et al*., 2006).

Composite flour technology has been widely adopted round the globe for development of functional foods with the desired prophylactic or therapeutic value. Composite flour bakery products have many fold advantages apart from extending the availability of wheat flour and they are looked upon as carriers of nutrition. Composite flours have been attempted for bread making where a combination of wheat and non-wheat flour was used to impart proper dough consistency (Chavan and Kadam, 1993). Various types of composite flours have been successfully used in the preparation of bread (Ho *et al*., 2013; Asta *et al*., 2013), pasta (Seczyk *et al*., 2016) and cookies (Cheng and Bhat, 2016; Zouari *et al*., 2016).

Cookie is a principal food throughout the world which gives more nutrients than any other single food source. Cookie is mainly made from cereals, sweeteners, shortenings and leavening agents. Cookie formulations have been attempted by several workers using legume or cereal fortification with wheat (Singh *et al*., 1993). Cassava flour and starch have also been utilized in composite flour to develop small baked goods (Akubor and Ukwuru, 2003). In the present study, an effort has been made to prepare cookies from composite flour. The present study was undertaken to study the physical and functional properties of composite flour prepared by supplementing wheat flour with oats, sorghum and amaranth flour. The composite flour was further utilized to prepare cookies, which were evaluated for physical and sensory characteristics.

Materials and Methods

Raw materials

Wheat, amaranth, sorghum and oats grains were purchased from local market of Sangrur, Punjab,

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India. All the grains were made into flour by dry milling process. Wheat, amaranth, sorghum and oats flour was sieved through 30 mm mesh sieve. Mix flour was made by 5 parts of amaranth flour (AF), 2.5 parts of sorghum flour (SF), 2.5 parts of oats flour (OF) and the remaining wheat flour (WF). Composite flour (CF) was prepared by replacing wheat flour with MF at various proportions i.e. 5% (C_1), 10% (C_2), 15% (C_3), 20% (C_4) and 25% (C_5). Composite flours was then packed in air tight polythene packets and kept for further use. Wheat flour in which there was no addition of amaranth flour, sorghum flour and oats flour was regarded as control sample.

Proximate analysis of composite flour

Moisture, protein, fat, ash and crude fiber were determined according to AOAC (2000). The carbohydrate content in the material was determined by difference method i.e. by subtracting the sum of the percentages of crude protein, lipid, crude fiber and ash content from 100 (Mathew *et al*., 2006). The energy value (KJ) of material was calculated by method of Paul and Southgate (1978).

Physical properties of composite flour

The bulk density was calculated as weight of the grounded flour (g) divided by its volume (ml) (Oladele and Aina, 2007). The tap density of flour was determined by the method of Deshpande and Poshadri (2011). True Density was calculated according to method of Deshpande and Poshadri (2011). Porosity was measured with a pycnometer (Mohsenin, 1986).

Porosity (fraction) was calculated as:

$$\varphi = 1 - (\rho / \rho \max) \quad (1)$$

where ρ = bulk density and ρ max = maximum bulk density when all voids are removed.

Functional properties of composite flour

Water absorption capacity (WAC) and oil absorption capacity (OAC) was determined using the procedure described by Youngs *et al.* (1995). Foaming capacity (FC) and foam stability (FS) were determined by method as described by Okaka and Potter (1977). The sodium dodecyl sulphate (SDS) sedimentation volume (SV) of flour samples was estimated according to the method of Axford *et al.* (1979). The swelling power (SP) and solubility index (SI) for flour were estimated by method of AACC (2000). The flour samples were tested for their alkaline water retention capacity (AWRC) according to the procedure outlined in AACC (2000) method.

Cookies formation

The cookies were prepared with combinations of 75:25, 80:20, 85:15, 90:10, 95:5 and 100:0 (control sample) of WF: MF respectively. Therefore, since oat, amaranth and sorghum are short of gluten, sugar snap cookie formulation was chosen for the study. Similar amount of sugar, shortening, salt, water and other ingredients were used for each proportion in the preparation of the dough based on the standard AACC formulation for baking quality of cookie flour (AACC, 2000). Cookies were prepared using mixed flour, fat, sugar powder, sodium bicarbonate, ammonium salt and water. Moisture, protein, fat, ash and crude fiber of cookies were estimated by according to AACC (2000). Carbohydrate and energy content were determined in the same way as in flour content.

Physical analysis of cookies

For the determination of diameter (width), thickness and spread factor, method of AACC (2000) was followed. Spread ratio was determined from the diameter and thickness using the formula:

$$\text{Spread ratio: } D/T \quad (2)$$

where, D is the diameter and T is the thickness of cookies.

Breaking strength of cookie was measured using the HDP/BS blade.

Sensory evaluation

Sensory evaluation of cookies was performed on the basis of acceptability of their color, flavour, texture and overall acceptability by a 9-point hedonic scale. A nine point hedonic scale with 1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely was used (Ranganna, 1994).

Statistical evaluation

Data were analyzed using one-way and two way analysis of variance (ANOVA) procedures in a completely randomized design (CRD) with three replications. Statistical analysis was performed using the OPSTAT software version opstat1.exe (Hisar, India). A 5% level of significance was chosen to interpret the results after statistical analysis. Critical difference (CD) was calculated to find out the significance between the samples for each parameter.

Table 1. Proximate analysis of different blends of composite flour

Parameters	WF	C_1	C_2	C_3	C_4	C_5	CD ($p<0.05$)
Moisture (%)	13.80± 0.21	12.54±0.12	12.06±1.21	12.23±0.92	12.14±1.20	12.82±0.22	N/A
Protein (%)	13.20± 0.075	13.56±0.125	13.65±0.175	13.65±0.015	14.108±0.275	14.42±0.325	0.218
Fat (%)	1.80± 0.063	2.2±0.07	2.33±0.12	2.56±0.072	2.69±1.22	2.84±1.06	0.234
Ash (%)	0.75± 0.025	0.67±0.015	0.69±0.065	0.90±0.012	1.04±0.122	1.09±0.047	0.109
Crude fiber (%)	0.62± 0.005	1.01±0.012	1.42±0.12	1.74±0.225	2.07±0.029	2.48±0.024	0.186
Carbohydrate (%)	69.90	69.71	70.31	70.54	70.66	71.22	
Energyvalue (KJ)	292.8	314.12	320.66	329.44	342.17	353.17	

WF= wheat flour; C1=5% blend; C2=10% blend; C3=15% blend; C4=20% blend; C5=25% blend; CD = critical difference

Results and Discussion

Proximate composition of refined wheat flour and composite flour

Moisture content is one of the important parameter which influences shelf life or storage stability of flours. Flours having moisture content more than 14% are prone to mould growth and infestation by insects (Manley, 2000). When moisture content was statistically analyzed, it was observed that there was no significant difference between the various compositions of flour blend (Table 1). Similar results were reported by Singh *et al.* (2008) for sweet potato flour. It is affected by the type of milling and moisture percentage used for wheat conditioning. The protein is the main ingredient on which flour specification and quality of the product depends. It varies from 6-20% in different wheat varieties (Kent, 1983). The protein content of the composite flour was found to have higher amount of protein than WF. Table 1 shows that the protein content in composite flour varied from 13.56% to 14.42% which was more than the soft wheat flour (7-9%). With the combination of these flours the total protein content of flour increased. During statistical analysis, it was observed that protein content of composite flour at all percentage differs significantly from the control sample (WF). Fat content of blended flour were more than the wheat flour. Fat content of composite flour varied from 2.20 to 2.84%. The fat content was found to increase in flour with increase in blending proportion. It was due to high fat content of amaranth flour present in composite flour. During statistical analysis, critical difference (CD) was calculated and it was observed that at all level of blending, fat content of wheat flour was significantly different from composite flour blends. The ash content of composite flour varied from 0.67-1.09%. With the increase in blending proportion, the ash content of the flour was also increased. Thus, 75:25 combination contains the highest ash content of 1.09% as compared to the other proportions. The purity of flour can be assessed by the amount of ash content. The fiber content of blended flour varied from 1.01-2.48%. The fiber content also increased with increase in the blending proportion in composite flour. High fiber intake helps reduce the risk of irritable bowel syndrome and colon cancer. Other benefit is its ability to control blood sugar levels. Proximate analysis of composite flour has been done and compared with proximate composition of refined wheat flour. In every aspect, composite flour is advantageous over the refined wheat flour. Thus the replacement of refined wheat flour with these mix flours will be advantageous and also results in low cost product. Since the carbohydrate content for flours was calculated by difference method, the variation in carbohydrate content may be attributed to the differences in other constituents. Carbohydrate content varied from 69.71 to 71.22%. Carbohydrate content was gradually increased with increase in high proportion of composite flour. The energy value (KJ) increased with increase in percentage of composite flour and decrease in wheat flour content. This was due to increase in protein and fat content in increasing amount of composite flour.

Physical properties of composite flour

As more and more composite flour was incorporated into WF, the bulk density decreased. The values for the composite flour ranged between 0.43 to 0.50 g/ml with sample C_5 (75:25) recording the least value (Table 2). Bulk density is generally affected by the particle size and density of the flour and it is very important in determining the packaging requirement, material handling and application in wet processing in the food industry. It was found that tap density decreased with increase in the percentage of composite flour and decrease of wheat flour content. This may be due to the fineness of the flour mix. Wheat flour was having the true density (TD) of 0.75 g/ml

Table 2. Physical properties of different blends of composite flour

Parameters	WF	C_1	C_2	C_3	C_4	C_5	CD ($p<0.05$)
Bulk density (gml^{-1})	0.52±0.11	0.50±0.03	0.49±0.02	0.48±0.05	0.45±0.17	0.43±0.31	N/A
Tap density (gml^{-1})	0.74±0.26	0.71±0.06	0.71±0.11	0.70±0.07	0.69±0.31	0.68±0.09	N/A
True density (gml^{-1})	0.75±0.17	0.74±0.12	0.73±0.18	0.69±0.24	0.68±0.31	0.65±0.42	N/A
Porosity (%)	30.95±0.13	33.46±1.2	33.28±1.02	30.53±0.28	32.82±1.45	33.45±1.52	1.962

Table 3. Functional properties of different blends of composite flour

Parameters	WF	C_1	C_2	C_3	C_4	C_5	CD ($p<0.05$)
WAC (mlg^{-1})	0.66±0.12	0.7±0.06	0.77±0.04	0.84±0.09	0.90±0.11	0.97±0.07	N/A
OAC (mlg^{-1})	1.10±.014	0.93±0.17	0.99±0.15	1.04±0.12	1.09±0.57	1.15±0.54	N/A
FC (%)	38.2±0.21	12.4±0.05	13.7±0.14	23.53±0.09	26.5±1.07	30±0.15	0.818
FS (%)	31.5±0.31	58.33±0.4	42.86±0.24	33.35±0.31	28.20±0.22	23.33±0.58	0.654
SV (ml)	23±0.23	24.42±0.18	23.5±0.16	21.45±0.25	19.5±0.18	18.2±1.06	0.847
SP (%)	6.25±1.2	8.52±0.09	9.07±0.17	9.19±1.04	9.43±0.09	9.47±1.08	1.419
SI (%)	15.45±1.54	6.94±1.06	9.56±0.08	10.03±1.21	10.56±0.14	10.97±1.22	3.65
AWRC (%)	57.45±0.33	57.63±1.71	57.87±1.28	58.31±1.44	58.33±1.98	58.47±1.87	0.526

whereas the true density varied from 0.74 to 0.65 g/ml in composite flour. TD decreased with increase of blending proportion. This may be due less void space available in the composite flour which was made up of oat, amaranth and sorghum flour. The porosity in composite flour varied from 30.53 to 33.46±1.2%, where C_3 obtained the least value. During statistically evaluation, it was noticed that there was significant difference between wheat flour and others blend of the flour ($p<0.05$).

Functional properties of composite flour

From Table 3, it was observed that the water absorption capacity (WAC) increased as the blending proportion was increased. WAC of 5% blend was 0.70 ml/g which increased up to 0.97 ml/g in 25% of multigrain blend. The possible explanation for this phenomenon includes dilution and disruption of the gluten matrix by fibers of the incorporated flours as well as increased dough water absorption (Seetharaman *et al*., 1998). Water absorption in wheat dough increases with increased fiber (Wang *et al*., 2002) and non-gluten proteins (Ribotta *et al*., 2005). Fiber molecules contain many hydroxyl groups which facilitate water interactions through hydrogen bonding (Wang *et al*., 2002). (Lorimer *et al*., 1991) found that the incorporation of non-gluten proteins results in the disruption of starch-protein complexes and disulphide interchange with the non gluten proteins. It was found that oil absorption capacity in blended flour was less than the wheat flour and after that with the increase of the blending proportion of composite flour, the oil absorption capacity increased. Foaming Capacity (FC) and foaming stability (FS) are the important parameters of the baking flour. Proteins in flour are surface active, soluble protein can reduce the surface tension thus the coalescence of the bubbles is obstructed. Protein molecules can unfold and interact with one another to form multilayer protein film with an increased flexibility at the air and liquid interface. So it is more difficult to air bubbles to break and the foam is more stabilized. When blended with composite flour (5%), it was found that the FC decreased to 12.45% and after that FC of flour gradually increased. It was observed when blended with 15%, foaming capacity suddenly increased. Foaming stability (FS) gradually decreased with increase in blending proportions. Sedimentation value (SV) is the indirect measurement of quality and composition of gluten protein. As composite flour does not contain any gluten content, so with the increase of blending proportion of composite flour with wheat flour i.e. with the decrease in wheat flour content, the sedimentation volume also decreased. It was observed that with the increase of blending proportion of composite flour with wheat flour, the swelling power increased gradually. Swelling power is an indication of the water absorption index of

Table 4. Comparative studies of proximate analysis between multigrain cookies and wheat cookies

Parameters	Wheat cookies	Multigrain cookies					CD (p<0.05)
		C_1	C_2	C_3	C_4	C_5	
Moisture (%)	2.48±0.07	2.61±0.21	2.13±0.12	2.09±0.06	3.01±0.10	3.91±0.02	0.204
Protein (%)	6.34±0.025	6.50±0.26	6.12±0.17	5.46±0.29	6.05±0.16	5.95±0.34	0.461
Fat (%)	21.57±0.28	21.6±0.17	22.5±0.36	23.08±0.41	24.5±0.21	24.71±0.69	0.706
Ash (%)	0.94±0.12	0.94±0.22	0.98±0.07	0.99±0.17	1.07±0.03	1.08±0.14	N/A
Crude fiber (%)	0.67±0.05	0.89±0.24	0.97±0.09	1.32±0.25	1.87±0.22	1.96±0.19	0.341
Carbohydrate (%)	68.01	67.46	67.30	67.06	63.50	62.39	
Energy value (KJ)	927.355	931.3782	958.9788	969.8923	1033.8126	1040.062	

the granules during heating. Solubility Index (SI) is the measure of soluble starch content in flour. SI gradually increased with increase in blending proportion. Higher AWRC indicates the smaller cookie diameter. It was found that AWRC in wheat flour was 57.45±0.33%, whereas in case of blended flour, AWRC increased in 5% to 25% of blend, i.e. from 57.63 to 58.47%.

Development of multigrain cookies

Lesser is the moisture content of the cookies, better its storage stability. According to Table 4, with an increase in the composite flour proportion in the cookies, there was a change in the moisture content from average value 2.09% of the C_3 to 3.91% of the C_5 flour cookie. This increase could be attributed to the water binding capacity of composite flour. The water binding capacity of composite flour was observed to be high than the wheat flour. Blend proportion and its interaction were observed to have a significant effect on the protein content. The protein content of the composite-wheat blend cookies ranged from 5.46 to 6.50%. This is in close agreement to the cookies of taro-wheat blend (Ojinnaka *et al*., 2009). The fat content of the cookies was observed to be significantly affected ($p<0.05$) by blend proportion and their interaction. As the amounts of composite flour in the formulation increased, the amount of fat in the cookie also increased. This is may be due to the presence of high fat in the oat and amaranth flour than is present in wheat flour. With the increase of substitution of composite flour, the ash content also increased. This may be due to presence of high mineral content amaranth flour in the composite flour mix which was used to make cookies.

Since composite flour having amaranth flour was found to have higher ash content than wheat flour, this could be responsible for the higher ash contents of cookies with higher proportion of composite flour. Ash is indicative of the amount of minerals contained in any food sample. In composite flour blend cookies, the fiber content varied from 0.89 to 1.96%. The mean crude fiber content of the cookies has increased with an increase in amounts of composite flour in blend. An increase in the crude fiber content of cookies was also reported by Nassar *et al*. (2008) in blending of citrus by-products flour with wheat flour. Inyang and Wayo (2005) also have mentioned an increase in crude fiber content in their sesame fortified cookies from 0.46 to 1.09%. The carbohydrate contents were found to be highest for the cookies with respect to all the parameters determined in this study. This was expected as the ingredients were composed of mainly carbohydrate rich materials, which are wheat, oat, amaranth and sorghum flour. This result is in close agreement with the cookies made from cocoyam-wheat blends (Ojinnaka *et al*., 2009). The energy values of the composite-wheat flour cookies ranged from 931 to 1040 KJ/100g. With an increase in the proportion of composite flour, increase in the gross energy level was observed. This is may be due to the fact that with an increase in the composite flour proportion, the increase in fat and protein content outweighs the decrease of carbohydrate content.

Physical analyses of multigrain cookies

Physical characteristics of the cookies are presented in Table 5. It was found that that the diameter of the cookies decreased with increasing level of supplementation. These findings were on the same lines as observed by Claughton and Pearce (1989). During statistical analysis no significant difference was obtained among the diameter of various cookies made from WF and other composite flour.

There was a decrease in the thickness by increasing levels of supplementation. With the increase of composite flour percentage in wheat flour, the spread ratio also increased gradually. Spread factor also

Table 5. Physical analyses of multigrain cookies

Parameters	Wheat cookies	Multigrain cookies					CD (p<0.05)
		C_1	C_2	C_3	C_4	C_5	
Diameter (cm)	3.9±0.21	3.86±0.17	3.80±0.24	3.75±0.26	3.73±0.12	3.64±0.08	N/A
Thickness (cm)	1.13±0.17	1.33±0.12	1.27±0.14	1.19±0.07	1.18±0.19	1.15±0.15	N/A
Spread Ratio	3.45±0.28	2.9±0.23	2.99±0.19	3.15±0.18	3.16±0.21	3.17±0.18	N/A
Spread factor	34.51±0.46	29.02±0.33	29.92±0.27	31.51±0.26	31.61±0.22	31.65±0.36	0.587
Hardness (N)	30.6±1.26	31.43±0.89	32.94±1.17	45.99±1.54	47.81±1.21	48.28±1.67	2.365

increased with increasing levels of supplementation. These results were in close agreement with those of Hoojjat and Zabik (1984). The hardness of the cookies increased with increase in the supplementation. In control cookies, hardness was observed as 30.6 N and then gradually increased to 48.28 N in 25% supplementation. These results were similar to those reported for cookies prepared from wheat-cowpea (McWatters *et al*., 2003) and wheat–soybean (Shrestha and Noomhorm, 2002) flour blends. There are several views on the mechanisms by which the diameter of cookies (i.e. spread) is reduced when wheat flour is supplemented with non-wheat flours. However, it has been suggested that spread ratio is affected by the competition of ingredients for the available water, flour or any other ingredient which absorbs water during dough mixing (Fuhr, 1962). C_2 (10% blend) was preferred by the judges because it gave the desired colour and flavor to the cookies which distinguished it from others, yet all other samples were also acceptable. C_2 (10% blends) got the maximum score for overall acceptability (OA).

Conclusion

The protein content of the composite flour was higher than wheat flour. The fat and carbohydrate and ash content were found to increase in composite flour with increase in blending proportion. The energy value (KJ) increased with increase in percentage of composite flour and decrease in wheat flour content. In physical properties, it was observed that wheat flour was having the true density (TD) of 0.75±0.17 g/ml whereas the true density varied from 0.74±0.12 to 0.65±0.42 g/ml in composite flour. TD decreased with increase of blend. It was found that oil absorption capacity in blended flour was less than the wheat flour and after that with the increase of the blending proportion of composite flour, the oil absorption capacity increased. When blended with composite flour at 5%, it was found that the FC decreased to 12.4±0.05% and after that FC of flour increased. With increase of blending proportion of composite flour, the swelling power increased gradually. AWRC increased in 5% to 25% of blend, i.e. from 57.63±1.71to 58.47±1.87 %. The lightness of flour decreased with increasing percentage of composite flour, because amaranth flour was having the yellowish colour in composite flour. In cookies, there was a decrease in the thickness by increasing levels of supplementation. On the other hand, hardness of the cookies increased with increase in the supplementation. With the increase of composite flour, the darkness of cookies also increased. Cookies made from 10% blend was preferred by the judges as it gave the desired colour and flavor to the cookies which distinguished it from others, yet all other samples were also acceptable. Cookies prepared from 10% blend got the maximum score for OA. Thus, the replacement of refined wheat flour with these mix flours will be advantageous and also results in low cost product.

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