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ORIGINAL ARTICLE

Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits

Suresh Chandra · Samsher Singh · Durvesh Kumari

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Abstract The present study was undertaken to develop biscuits from the composite flours. Composite flours were prepared by blending wheat flour with rice flour, green gram flour and potato flour in ratios of 100:0:0:0 (W_{100}), 85:5:5:5 (W_{85}), 70:10:10:10 (W_{70}) and 55:15:15:15 (W_{55}), respectively. The functional properties of composite flours such as swelling capacity, water absorption capacity, oil absorption capacity, emulsion activity, emulsion stability, foam capacity, foam stability, gelatinization temperature, least gelation concentration and bulk density were increased with increase in the incorporation of other flours with wheat flour. Overall acceptability for composite flour biscuits was awarded highest score for W_{55} followed by W_{70} and W_{85} as compared to control biscuits. All biscuits coincided in the range of 'like moderately' to 'like very much' for composite flours biscuits while 'like slightly' to like moderately' for control biscuits.

Keywords Composite flour · Swelling capacity · Oil absorption · Gelatinization temperature · Least gelation concentration · Sensorial attributes

Introduction

Composite flours may be considered firstly as blends of wheat and other flours for the production of (i) leavened breads, (ii) unleavened baked products, (iii) pastas, (iv) porridges, and (v) snack foods; or, secondly, wholly non-wheat blends of flours or meals, for the same purpose. Sometimes, only flour is used as replacement-for example, tortillas and wheat-less bread from sorghum, pastas from sorghum or maize. The composite flour for staple foods such as baking items, it should be noted that there are two reasons for mixing the wheat with other flours i.e. economic and nutritional. Like that soy flour to increase the protein content of the baked products, or adding vitamins, is of marginal economic relevance and of debatable use in the health context. Using blends, now called composite flours (CF), of wheat and other flours for biscuit making has always occurred in times of scarcity of wheat, from whatever cause, climatic or economic. As an ingredients being blends in composite flour may be cassava, maize, rice, sorghum, the millets, potato, barley, sweet potato and yam. In selecting raw materials for use as alternatives one must consider such as (a) Compatibility - that is to say, suitability for end use and (b) availability and cost at point of use (Dendy 1993). Composite flours are quite different from the ready-mixed flours familiar to millers and bakers. Whereas ready-mixed flours contain all the non-perishable constituents of the recipe for certain baked products. Composite flours are only a mixture of different vegetables flours rich in starch or protein, with or without wheat flour, for certain groups of bakery products. This gives rise to the following definition: "Composite flours are a mixture of flours from tubers rich in starch (e.g. cassava, yam, sweet potato) and/or protein rich flours (e.g. soy, peanut) and / or cereals (e.g. maize, rice, millet, buckwheat), with or without wheat flour." In another words, "A flour made by blending or mixing varying proportion of more than one non-wheat flour with or without wheat flour and used for production of leavened or unleavened baked or snack products that are traditionally made from wheat flour and increase the essential nutrients in human diet is called composite flour." Functional properties are the fundamental physico-chemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components together with the nature of environment in

S. Chandra (✉) · S. Singh
Department of Agric. Engineering and Food Technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut 250110, UP, India
e-mail: chandra21778@yahoo.co.in

D. Kumari
GDUSS (Parag dairy) Partapur, Meerut 250001, UP, India

which these are associated and measured (Kinsella 1976). Functional characteristics are required to evaluate and possibly help to predict how new proteins, fat, fibre and carbohydrates may behave in specific systems as well as demonstrate whether or not such protein can be used to stimulate or replace conventional protein (Mattil 1971).

The biscuits available in market are prepared from wheat flour (whole/refined) which lacks in good quality protein because of its deficiency in lysine; and dietary fibre contents. Rice flour, mung flour and potato flour which are highly nutritious in protein, vitamin, minerals and lysine content has been found for its incorporation into preparation of biscuit. The study provides the information about a commercially viable application of increasing protein and fibre content in biscuits and also these can be solve the problem of malnutrition and other essential macro and micro nutrients deficiency among the population. The objective of the present study was also to expand the utility of rice flour, green gram flour and potato flour by value addition through incorporating with wheat flour to prepare the composite flour and used to develop the biscuit and their characterization. Little work has been reported on to study the functional properties of flours and biscuits made from composite flour incorporating wheat flour, rice flour, green gram flour and potato flour. It is clear as per cited literature that wheat and rice flours are superior source of carbohydrate and starch content, green gram flour is rich in protein content while potato flour is rich source of macro and micro mineral and vitamin contents. Present study was conducted to assess the functional properties of wheat and composite flours and also evaluate the consumer acceptability.

Material and methods

The experiments were conducted in Bakery Lab and Food Analysis Laboratory in the Department of Agricultural Engineering and Food Technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (India). Raw materials viz., wheat flour (maida or refined flour), rice flour, green gram flour, potato etc. were procured from the local market for the present study. Initial moisture content of flours and biscuits were determined by hot air oven drying method as recommended by AOAC (2000).

Evaluation of functional properties of flours

The functional properties of flours were analyzed i.e. Swelling capacity (ml), water absorption capacity (WAC, %), oil absorption capacity (OAC, %), Emulsion activity (EA, %), Emulsion stability (ES, %), Foam capacity (FC, %), Foam stability (FS, %), Gelatinization temperature (GT, °C), Least gelatinization concentration (LGC, %) and Bulk density (g/cc).

The swelling capacity was determined by the method described by Okaka and Potter (1977). 100 mL graduated cylinder was filled with the sample 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 sample was taken after the 8th min.

The water absorption capacity of the flours was determine by the method of Sosulski et al. (1976). One gram of sample mixed with 10 mL distilled water and allow to stand at ambient temperature (30±2 °C) for 30 min, the centrifuged for 30 min at 3,000 rpm or 2000 × g. Water absorption was examined as per cent water bound per gram flour. The oil absorption capacity was also determine by the method of Sosulski et al. (1976). One gram of sample mixed with 10 mL soybean oil (Sp. Gravity: 0.9092) and allow to stand at ambient temperature (30±2 °C) for 30 min, the centrifuged for 30 min at 300 rpm or 2000 × g. Water absorption was examined as percent water bound per gram flour.

The emulsion activity and stability by Yasumatsu et al. (1972) described and followed as method for the emulsion in present study (1 g sample, 10 mL distilled water and 10 mL soybean oil) was prepared in calibrated centrifuge tube. The emulsion was centrifuged at 2000 × g 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, cooling for 15 min under running tap water and centrifuging at 2000 × g 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.

The foam capacity (FC) and Foam stability (FS) by (Narayana and Narsinga Rao 1982) were determined as described with slight 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. The volume of foam at 30 s after whipping was expressed as foam capacity using the formula:

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

Where, AW=after whipping, BW=before whipping

The volume of foam was recorded 1 hour after whipping to determine foam stability as per percent of initial foam volume.

The least gelation concentration (LGC) was evaluated using a method of Coffman and Garcia (1977) with modification. The flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 30 % (w/v) prepared in 5 mL distilled water was heated at 90 °C for 1 h in water bath. The contents were cooled under tap water and kept for 2 h at 10±2 °C. The least gelation concentration was determined method given as that concentration when the sample from inverted tube did not slip.

Gelatinization temperature was determined by Shinde (2001). One gram flour sample was weighed accurately in triplicate and transferred to 20 mL screw capped tubes. Ten mL of water was added to each sample. The samples were heated slowly in a water bath until they formed a solid gel. At complete gel formation, the respective temperature was measured and taken as gelatinization temperature.

The volume of 100 g of the flour 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 weight and volume, the apparent (bulk) density was calculated (Jones et al. 2000).

Biscuit development

The composite flour biscuits were prepared from various combinations of wheat flour, rice flour, green gram flour and potato flour in ratio of 100:0:0:0, 85:5:5:5, 70:10:10:10 and 55:15:15:15, respectively. The standardized formulations for biscuit had ingredients as 100 g flour, 45 g sugar, 45 g hydrogenated fat, 1.25 g sodium bicarbonate, 1.25 g baking powder and 1.0 g curry leave powder. Hot liquid Hydrogenated fat and sugar were taken and creamed to a uniform consistency. The flour, required amount of water, baking powder and sodium bicarbonate were added to creamed mixture and mixed for 10 min at medium speed in dough mixer to obtain a homogeneous mixture. The dough was rolled out into thin sheet of uniform thickness and was cut into desired shape using mould. The cut pieces were placed over perforated tray and transferred into convective baking oven at 180 °C for 10–15 min till baked. The well baked biscuits were removed from the oven, cooled to room temperature, packed and stored at room temperature for further studies.

Sensorial evaluation

A semi trained panel consisting of both gender more than 10 judges of different age groups having different eating habits were constituted to evaluate the quality. The judges were selected from the faculty staff and students of Department of Agricultural Engineering & Food Technology, SVPUA&T, Meerut (U.P.). Samples were served to the panelists and they were asked to rate the acceptability of the product through sense of organs. The overall acceptability of biscuits were rated on the basis of 9- point hedonic scale ranging from 1 (extremely dislike) to 9 (extremely like).

The data obtained from the various experiments were recorded during the study and were subjected to statistical analysis as per method of "Analysis of Variance" by Factorial Randomized Block Design (factorial R.B.D.). The significant 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

In this research, different functional properties of composite flours were analyzed with using standard procedures (Table 1). Functional properties or characteristics are the intrinsic physico-chemical properties that reflect the complex interaction between the composition, structure, confirmation and physico-chemical properties of protein and other food components and the nature of environment in which these are associated and measured (Kinsella 1976). The effect of incorporation proportions of different flours on the functional properties of composite flours are discussed as follows.

Moisture content Before preparation of composite flour, moisture content of wheat flour, rice flour, green gram and potato flour were analyzed and found as 13.28 %, 11.22 %, 9.60 % and 8.05 %, respectively. The moisture content (w.b.) for wheat and composite flours are presented in Table 1 which ranged from 10.93 % to 13.28 % depending upon the blending ratio. The moisture content of composite flours i.e. W_{100} (13.28 %), W_{85} (11.670 %), W_{70} (11.342 %) and W_{55} (10.928 %) were also determined. From the Table 1, it is clear that the moisture content of composite flours decreased with increase in proportions of other flours. The moisture content of composite flour was highly affected by blending of green gram and potato flours. The highest moisture content was observed for W_{85} (11.67 %) and lowest for W_{55} (10.928 %) in the composite flours. The study revealed that moisture content of composite flours decreased with decrease in proportions of wheat flour from 100 % to 55 %. Similar trends were reported by Kaushal et al. (2012). They used the blends of taro, rice and pigeon pea flour which resulted in reduction of moisture content of composite flours.

Swelling capacity The swelling capacity of different flours ranged between 16.00 to 22.30 ml. From Table 1, it is clear that lowest value of swelling capacity was observed in W_{85} (16.00 ml) whereas the maximum in W_{55} (22.30 ml). The value of swelling capacity was found for W_{100} (17.60 ml) and W_{70} (20.00 ml). The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations. As per literature, the flour of parboiled rice has more swelling capacity as compared to raw rice. Swelling capacity of composite flours increased with increase in the level of incorporation ratio of rice, green gram

Table 1 Functional properties of different flours

Functional Properties	Wheat flour	Composite flours			$CD_{0.05}$
	W_{100}	W_{85}	W_{70}	W_{55}	
Moisture, %	13.28±1.47	11.67±0.43	11.34±0.24	10.93±0.09	0.831
SC (ml)	17.60±1.85	16.00±0.71	20.00±0.71	22.30±0.91	1.854
WAC, %	140.00±12.25	132.00±22.80	142.00±14.83	176.00±16.73	22.103
OAC, %	146.00±08.94	130.0±10.00	156.00±26.08	156.00±16.73	19.360
EA, %	43.88±4.12	41.49±1.96	44.00±2.45	44.69±0.96	3.627
ES, %	38.38±4.78	47.27±2.49	48.40±2.97	48.65±3.74	4.870
FC, %	12.92±5.03	14.10±0.29	16.40±2.61	17.60±1.67	3.260
FS, %	1.94±0.05	4.00±0.16	9.20±1.79	13.40±1.09	1.898
GT, °C	59.22±0.15	56.22±0.57	59.42±0.11	60.56±0.06	0.288
LGC, %	8	8	10	10	-
BD (g/cc)	0.762±0.00	0.774±0.00	0.786±0.00	0.820±0.00	0.010

Value=mean±SE, n=5

SC=Swelling capacity, WAC=Water absorption capacity, OAC=Oil absorption capacity, EA=Emulsion activity, ES=Emulsion stability, FC=Foam capacity, FS=Foam stability, GT=Gelatinization temperature

LGC=Least gelation concentration, BD=Bulk density, SE=Standard error

W_{100} : Wheat flour (100 %) or control

W_{85} : Wheat flour (85 %)+rice flour (5 %)+green gram flour (5 %)+potato flour (5 %)

W_{70} : Wheat flour (70 %)+rice flour (10 %)+green gram flour (10 %)+potato flour (10 %)

W_{55} : Wheat flour (55 %)+rice flour (15 %)+green gram flour (15 %)+potato flour (15 %)

and potato flour and decreased with level of wheat flour. The composite flour (W_{55}) had the highest swelling capacity (22.30 ml) while W_{85} (16.00 ml) had lowest values. It is explicit that the swelling capacity of composite flours highly affected by the level of potato flour, because potato flour was pre-gelatinized and rich source of starch content.

Water absorption capacity (WAC, %) The water absorption capacity for composite flours is given in Table 1. The WAC ranged between 132 to 176% for all flours. The WAC was observed highest in W_{55} (176 %) and lowest in W_{85} (132 %). While composite flours W_{70} and wheat flour (W_{100}) had 142 and 140% WAC. From the present study, potato flour had highest WAC (752 %). The result suggests that addition of rice, green gram and potato flour to wheat flour affected the amount of water absorption. This could be due to molecular structure of the rice, green gram and potato starch which inhibited water absorption, as could be seen from the lower values of WAC, with increase in proportions of other flours to wheat flours. Similar observation was reported by Kaushal et al. (2012). Kuntz (1971) reported that lower WAC in some flours may be due to less availability of polar amino acids in flours. The increase in WAC of blends after incorporating potato flour may be due to increase in the amylose leaching and solubility and loss of starch crystalline structure.

High WAC of composite flours suggests that the flours can be used in formulation of some foods such as sausage, dough, processed cheese and bakery products. The increase in the WAC has always been associated with increase in the amylose leaching and solubility, and loss of starch crystalline structure. The flour with high water absorption may have more hydrophilic constituents such as polysaccharides. Protein has both hydrophilic and hydrophobic nature and therefore they can interact with water in foods. The good WAC of composite flour (W_{55}) may prove useful in products where good viscosity is required such soups and gravies. The observed variation in different flours may be due to different protein concentration, their degree of interaction with water and conformational characteristics (Butt and Batool 2010).

Oil absorption capacity (OAC, %) The OAC ranged between 130 to 156% among all the flours. The composite flours (W_{85} and W_{55}) had highest OAC (156 % for both) and lowest for W_{70} (130 %) as compared to wheat flour (146 %). It is clear that the OAC of composite flours (W_{85} and W_{55}) increased with increase in the proportion of other flours. The presence of high fat content in flours might have affected adversely the OAC of the composite flours. The OAC was found to be insignificant to each other at $p \leq 0.05$ level of significance. Therefore, the possible reason for increase in the OAC of composite flours after incorporation of potato and green gram flour and is the variations in the presence of non-polar side chain, which might bind the hydrocarbon side chain of the oil among the flours. Similar findings were observed by Kaushal et al. (2012). However, the flours in the present study are potentially useful in structural interaction in food specially in flavor retention, improvement of palatability and extension of shelf life particularly in bakery or meet products where fat absorption is desired (Aremu et al. 2007). The major chemical component affecting OAC is protein which is composed of both hydrophilic and hydrophobic parts. Non-polar amino acid side chains can form hydrophobic interaction with hydrocarbon chains of lipids (Jitngarmkusol et al. 2008).

Emulsion activity and stability (%) Protein being the surface active agents can form and stabilize the emulsion by creating electrostatic repulsion on oil droplet surface (Kaushal et al. 2012). The EA and ES of flours are shown in Table 1. EA of different flours ranged between 41.49 and 44.69%. The highest EA for W_{55} flour (44.69 %) and lowest for W_{85} (41.49 %) were observed. Emulsion stability (ES) for different flours varied from 38.38 to 48.65% (Table 1). Highest ES was observed for W_{55} flour (48.65 %) followed by W_{70} flour (48.40 %), W_{85} flour, (47.27 %) and lowest for wheat flour (38.38 %). The EA and ES of composite flours were found to be significantly increased with decreasing in the proportions of wheat flour up to 55%. Emulsion stability can be greatly increased when highly cohesive films are formed by the absorption of rigid globular protein molecules that are more resistant to mechanical deformation (Graham and Phillips 1980). Increasing emulsion activity (EA), emulsion stability (ES) and fat binding during processing are primary functional properties of protein in such foods as comminuted meat products, salad dressing, frozen desserts and mayonnaise. All composite flours showed relatively good capacity of emulsion activity.

Foam capacity (FC, %) and Foam stability (FS, %) Foam capacity of protein refers to the amount of interfacial area that can be created by the protein (Fennama 1996). Foam is a colloidal of many gas bubbles trapped in a liquid or solid. Small air bubbles are surrounded by thin liquid films. Foam capacity of different flours varied from 12.92 to 17.60%. The highest foam capacity was observed for W_{55} flour (17.60 %), W_{70} flour (16.40 %), W_{85} flour (14.10 %), and lowest W_{100} (12.92 %). The foam stability (FS) refers to the ability of protein to stabilize against gravitational and mechanical stresses (Fennama 1996). The foam stability varied from 1.94 to 13.40% among the flours. The highest FS was observed for W_{55} flour (13.40 %) followed by W_{70} flour (9.20 %), W_{85} flour (4.00 %), and lowest for wheat flour (1.94 %). FC and FS of composite flours was increased with increasing in the blending ratio of different flours. There was an inverse relationship between foam capacity and foam stability. Flours with high foaming ability could form large air bubbles surrounded by thinner a less flexible protein film. This air bubbles might be easier to collapse and consequently lowered the foam stability (Jitngarmkusol et al. 2008).

Gelatinization temperature (GT, °C) The temperature at which gelatinization of starch take place is known as the gelatinization temperature (Sahay and Singh 1996). GT of flours ranged 56.22 °C to 60.56 °C. Highest GT was found for W_{55} flours (60.56 °C) followed by W_{70} (59.42 °C) and lowest for W_{85} (56.22 °C). GT was increased with increase in the incorporation of rice, green gram and potato flour with wheat flour. The study revealed that the flour which was higher in starch content took lowest temperature for gelatinization. As rice and potato flour was took less time for gelatinization due to higher starch while green gram flour took more time due to lower starch content. The GT of composite flours was significantly increased with increase in the incorporation of different flours except wheat flour. Therefore, GT of composite flours increased with decrease in the incorporation ratio of wheat flour. The gelatinization temperature of W_{85} flour was lower than that from W_{100} (wheat flour).

Least gelation concentration (LGC, %) The least gelation concentration (LGC) which is defined as the lowest protein concentration at which gel remained in the inverted tube was used as index of gelation capacity. The data for LGC of different flours are given in Table 1. Composite flours W_{70} and W_{55} formed a gel at a significantly higher concentration (10 g/ 100 ml). W_{100} and W_{85} flour formed gel quickly at very lowest concentration (8 g/100 ml). Pulse/legume flours contain high protein and starch content and the gelation capacity of flours is influenced by physical competition for water between protein gelation and starch gelatinization (Kaushal et al. 2012). The lower the LGC, the better the gelating ability of the protein ingredient (Akintayo et al. 1999) and the swelling ability of the flour was enhanced (Kaushal et al. 2012). (Vautsinas and Nakai 1983) reported that protein gelation was significantly affected by exposed hydrophobicity and square of sulfhydryls of proteins. As the percentage of incorporation of green gram, potato and rice flour in wheat flour (composite flour) increased, gelling properties decreased.

The low gelation concentration of W_{85} flour as composite flour may be added an asset for the formation of curd or as an additive to other gel forming materials in food products. The variation in the gelling properties may be ascribed to ratios of the different constituents such as protein, carbohydrates and lipids in different pulse/legume flours, suggesting that interaction between such components may also have a significant role in functional properties (Aremu et al. 2007). Least gelation concentration values were compared favorable with those reported for African yam bean (16 to 20%) by Abbey and Ayuk (1991). However, lower values were recorded for several *Phaseolus* species and Lablab bean by Chau and

Cheung (1997), and Deshpande et al. (1982). Sathe et al. (1983) also reported a LGC of 12 % for black gram flour. The LGC for other flour such as lupin (Sathe et al. 1982), cowpea (Akubor et al. 2003b), plantain (Akubor et al. 2003a), safflower and maize flour (Akubor 2007) were 14, 6, 6, 8 and 6% (w/v). The composite flours (W_{85}, W_{70} and W_{55}) would be useful in food system such as puddings, sauce and other foods which require thickening and gelling (Alobo 2003).

Bulk density The bulk density (g/cm^3) of flour is the density measured without the influence of any compression. The bulk densities of flours ranged from 0.762 g/cc to 0.820 g/cc. The highest highest bulk density was observed W_{55} flour (0.820 g/cc) followed by W_{70} flour (0.786 g/cc), W_{85} flour (0.774 g/cc) and lowest for wheat flour (0.762 g/cc). The present study revealed that bulk density depends on the particle size and initial moisture content of flours. Bulk density of composite flour increased with increase in the incorporation of different flours with wheat flour. It is clear that decreased the proportion of wheat flour increase the bulk density of composite flours. The high bulk density of flour suggests their suitability for use in food preparations. On contrast, low bulk density would be an advantage in the formulation of complementary foods (Akapata and Akubor 1999). Therefore, present study suggests that highest bulk density of composite flour (W_{55}) suggests its suitability to be used as thickener in food products and for use in food preparation since it help to reduce paste thickness which is an important factor in convalescent and child feeding. Bulk density of composite flours increased significantly with increase in the incorporation of rice, green gram and potato flour with wheat flour. Similar findings were reported by Eltayeb et al. (2011).

Sensorial attributes of composite flour biscuits Biscuits were subjected to a panel of 10 semi-trained judges comprising male and female (of teenager group) using 9-point Hedonic rating scale (ISI 1971; Swaminathan 1987; and Ranganna 1995) of different eating habits (Goyal 2008). Sensorial attributes viz., colour, flavour, taste, crispiness, texture and overall acceptability are shown in Table 2. Overall acceptability was calculated by taking average of all the scores of sensorial attributes. The order of presentation of sample to the panel was place in random position.

The sensory data for colour scores of composite flours and wheat flour (as control) biscuits are presented in Table 2. The highest colour score was awarded for fresh biscuits made from W_{55} (8.90) followed by W_{70} and control biscuits (8.60 for both) and lowest for W_{85} (8.10). The study revealed that colour scores were increased with increasing incorporation of rice, green gram and potato flour with wheat flour. The desired colour of biscuits is obtained mainly due to the mallard browning during baking. Highest flavour scores were observed for W_{85} biscuits (8.20) followed by W_{55} (8.10) and lowest for W_{70} (7.70) and control (7.70 %) just after baking and cooling. The flavour scores decreased rapidly with increasing incorporation of flours with wheat flour in the range of 5 to 15 %. With increase incorporation of rice, green gram and potato flour with wheat flour in biscuits formulation, the sensory score for flavour decreased. Similar research finding was reported by (Masur Shakuntala et al. 2009).

Results of the study revealed that fresh biscuits made from W_{55} flour were observed highest taste score of 8.90 followed by W_{70} (8.60) and W_{85} (8.20) while lowest for W_{100} (8.10) toward between ‘like very much’ to ‘like extremely’ among all the samples. Taste score decreased with increasing incorporation of different flours like rice, green gram and potato flour with wheat flour in the formulation of biscuits. Crispiness is perceived when food is chewed between molars, and is usually expressed in terms of hardness and factorability (Noor Aziah and Komathi 2009). Highest crispiness score was rated for fresh biscuits prepared from W_{55} (8.70) followed by W_{70} (8.60), W_{85} (8.60) and lowest for W_{100} (8.00). Crispiness of biscuits increased with increasing incorporation of different flours with wheat flour from 5 to 15 percent for each. The measurement of crispiness by sensory mean is not a straight forward process. The difference between a sensory concept (i.e. the collection of perception identified as relevant to the same class) and its label (i.e. the word used by a community to refer to it) should be acknowledged. Thus, the use of the same label in different studies, especially with trained panelists, is not a guarantee that the same sensory concept is measured. So, crispiness is a complex attributed resulting on the one hand from multiple sensations and on the other

Table 2 Sensorial attributes of composite flour biscuits

Biscuits	Colour	Flavour	Taste	Crispiness	Texture	Overall Acceptability
W_{100}	8.60±0.099	7.70±0.120	8.10±0.102	8.00±0.110	8.30±0.132	8.14±0.212
W_{85}	8.10±0.132	8.20±0.098	8.20±0.201	8.60±0.214	8.20±0.321	8.26±0.321
W_{70}	8.60±0.234	7.70±0.102	8.60±0.220	8.60±0.220	8.50±0.211	8.40±0.214
W_{55}	8.90±0.221	8.10±0.321	8.90±0.098	8.70±0.230	8.40±0.200	8.60±0.056

Value=mean±SE, *n*=5

from multiple physical parameters, combining molecular, structural and manufacturing processes, as well as storage conditions (Roudaut et al. 2002).

Sensory score of texture was awarded highest for W_{70} biscuits (8.50) followed by W_{55} (8.40) and control biscuits (8.30) whereas lowest for W_{85} biscuits (8.20) just after preparation. From present study, it is clear that texture score of biscuits increased with increasing the incorporation of rice, green gram and potato flour with wheat flour. The sensorial data for effect on overall acceptability (OAA) of biscuits are given in Table 2. Highest OAA was scored for W_{55} biscuits (8.60) followed by W_{70} (8.40) and W_{85} (8.26) while lowest for control biscuits (8.14) just after baking and cooling. Sensorial data revealed that OAA of biscuits increased with increasing incorporation of rice, green gram and potato flour with wheat flour in the formulation of biscuits. In general, OAA of biscuits depends on the individual data of different sensory attributes like colour, flavor, taste, crispiness and texture. In case of composite flour biscuits, OAA was awarded highest for W_{55} followed by W_{70} and W_{85} as compared to control biscuits. All biscuits coincided in the range of 'like moderately' to 'like very much' for biscuits made from composite flours, while 'like slightly' to like moderately' for control biscuits.

Conclusion

The functional properties of wheat flour and composite flours such as swelling capacity, water absorption capacity, oil absorption capacity, emulsion activity, emulsion stability, foam capacity, foam stability, gelatinization temperature, least gelation concentration and bulk density were increased with increase in the incorporation of other flours with wheat flour. The result showed that the addition of rice flour, green gram flour and potato flour to wheat flour in the proportion of 5 to 15 % for each produced acceptable biscuits and also functionality of the flour was not affected. Sensorial data revealed that Overall acceptability (OAA) of biscuits increased with increasing in the incorporation of rice, green gram and potato flour with wheat flour in the formulation of biscuits. The biscuits prepared with the flour ratio of 55:15:15:15 liked most of the panelists. Incorporation of above flours to wheat flour would therefore be an effective method of cost reduction of biscuits and other allied products and solving malnutrition problems in children in India.

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