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Development of fortified Biscuit incorporating with mung flour and milk powder and assessment of physical properties

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Abstract

Fortified flour was prepared by blending wheat flour with mung flour and milk powder in ratios of 100:0:0, 90:5:5, 80:10:10 and 70:15:15 respectively and packaged in glass jar for further experiment to develop biscuits. The mass, diameter and thickness of biscuits are important to design the mould and cast of the biscuit. The study revealed that the mass and thickness of fortified biscuits decreased with increase in the incorporation of mung flour and milk powder with wheat flour. The value of mass of control (wheat flour) biscuits was lowest as compared to other fortified biscuits.

Keywords: Fortification, Biscuits, powder, mung flour, physical properties

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Introduction

Food fortification is one way of solving nutrient deficiencies in developing countries, and so far the implementation of those programs has been very successful for correcting nutritional deficiencies within a very short period. In the developing countries, it should be taken into account that the food selected as a vehicle for the nutrient should be stable and consumed by the population at risk, and the amount of nutrient added should be sufficient to correct the possible deficiency.

In general, all the rice-consuming countries have a vitamin A deficiency, which is associated with corneal lesions that can lead to partial or total blindness, and also with reduced resistance to infectious diseases, and in consequence an increased morbidity and mortality. Another deficiency associated with rice-consuming countries cause nutritional anemia due to iron deficiency, which has been linked to reduced resistance to infections and also effects on cognitive development and physiological functions in children, and in severe cases of deficiency causing maternal deaths. Iodine constitutes the third major deficiency in rice-consuming countries. This mineral is necessary for correct fetal development and also for normal physical and mental activities in adults.

Cereals grains contain about 10-14 % moisture, 58-72 % carbohydrates, 8-13% protein, 2-5 % fat, and 2-11 % indigestible fibre. They are also containing 300-350 kcal/100 g of the grain. Cereals grains contain about two-thirds carbohydrates, most of which is in the form of digestible starches and sugars. The operations of milling generally remove much of the indigestible fibre and fat from the grains when they are to be consumed as human food (Potter and HotchKiss, 1996). Cereals do not contain vitamin A or vitamin C (Rama Krishnan and Venkat Rao, 1995). Soft wheat is used in cakes, pastries, cookies, crackers and oriental noodles where as hard wheat is used in breads. When hard wheat and soft wheat dried salt noodles with similar protein content were compared the hard wheat noodles were generally darker and stronger but less firm at the surface (Oh *et al.*, 1985a). Around 1100 large roller flour mills in the country convert about 10.50 million tones of wheat into wheat products. Moreover 2, 60,000 small flour mills are engaged in primary milling of wheat (Malik and Singh, 2010).

Amongst legumes, mung bean (*Vigna radiate* L. Wilczek) is an excellent source of high quality protein and is one of the cheapest and richest sources of plant protein (Akaerue and Onwuka, 2010). Moreover, mung bean is rich in essential fatty acids, antioxidant and minerals (Kolloarova *et al.*, 2010). Therefore, mungbean-wheat flour blends was used as alternate or in combination with other ingredients in many food products (Kenawi *et al.,* 2009). Consumption of mungbean supplemented products can fulfill requirements of essential amino acids (Iqbal et al., 2006). Milk is an important part for manufacturing the biscuits. Thus keeping above all facts, present study has been designed to prepare the wheat-mungbean-milk powder blends. The quality estimation and their potential application in cereal based products are the limelight the manuscript. The outcomes of the present research are important for all stakeholders to devise strategy to culminate the menace of protein energy malnutrition through blending of wheat-mungbean flour with milk powder.

Material and Methods

The entire research work was conducted at Division of Quality Assurance, Gangol Dugdh Utpadak Sagkari Sangh (Parag Dairy) Partapur, Meerut and Food Processing Unit, Department of Agricultural Engineering, S.V.P. University of Agric. & Tech., Meerut (U. P.). Various instruments / equipment namely Deck oven, convective oven, spiral mixer, grinder, electronic balance, hot air oven, muffle furnace, digital pH meter, digital spectrophotometer, etc were used for the research work. Raw materials viz., wheat flour (maida or refined flour), mung flour, potato, other ingredients, packaging materials (glass jar) were procured from the local market of Meerut for the present study.

Development of Biscuit from fortified flour

The fortified flour biscuits were prepared from various combinations of wheat flour, mung flour and milk powder. The standardized formulations for biscuit had ingredients as 100 g flour, 40 g sugar, 25 g hydrogenated fat, 1.5 g sodium bicarbonate, 1.5 g baking powder and 1.0 g antioxidant. Hot liquid Hydrogenated fat and sugar were taken and creamed to a uniform consistency. The flour, required amount of water, baking powder, antioxidant 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 150^0C for 20-30 min till baked. The well baked biscuits were removed from the oven, cooled to room temperature, packaged and stored at room temperature for further studies.

Proximate analysis of Biscuit

The moisture of biscuits was analytically estimated by the methods as recommended by AOAC (2000). The pH, acidity and browning index (optical density) was determined by using the method as recommended by Ranganna (2001).

Assessment of physical properties of biscuits

Diameter: The diameter of biscuits was measured by laying five biscuits edge to edge with the help of a scale rotating those at 90^0 and again measuring the diameter of five biscuits (cm) and finally average value was considered (Chandra *et al.,* 2015).

Thickness: Thickness was measured by stacking five biscuits on a top of each other and average thickness (cm) was considered.

Mass: Mass of biscuits (g) was measured as average of values of five individual biscuits with the help of digital electronic weighing balance.

Spread Ratio: Spread ratio was calculated by dividing the average value of diameter by average value of thickness of biscuits.

Per cent spread: Per cent spread was calculated by dividing the spread ratio of composite biscuit with spread ratio of control biscuits and multiplying with 100.

Bulk Density: The bulk density was determined according to the method described by Okaka and Potter (1977). Fifty (50) g sample of biscuits was put into a 100 ml graduated cylinder. The cylinder was tapped 40-50 times and the bulk density was calculated as weight per unit volume of samples.

Results and Discussion

The present study was undertaken to develop fortified biscuits from the composite flours. The wheat flour (refined flour) was blended with mung flour and milk powder in various combinations to prepare composite flours. The effect of incorporation ratio of flours were observed on moisture content, acidity, pH and non enzymatic browning or optical density); physical attributes (Thickness, mass, diameter, spread ratio, percent spread and bulk density) of fortified biscuits. The reported values are mean of three replications with statistical analysis using OPSTAT software.

Effect on Moisture Content: The moisture content of biscuits samples varied from 2.83 to 3.03 per cent. The values of moisture content for freshly prepared biscuits was highest for W_{70} biscuits (3.03 %) followed by W_{80} (3.01 %) and W_{90} (2.91 %) while lowest for control biscuits (2.83%). The moisture content of fortified biscuits was higher as compared to control biscuits (Table 1). It was increased with increase in the incorporation of mung flour and milk powder with flour. Similar trends were found by Anu *et al.,* (2007). They prepared biscuits from refined flour, pearl millets and mung in the ratio of 50:40:10 (type I) and 30:60:10 (type II). From Table 1 indicated that the control biscuits absorbed higher moisture from the ambient as compared to other samples because of wheat flour had higher hygroscopicity property than others flours.

Effect on Acidity: From Table 1, it could be seen that the acidity decreased with increase the incorporation of mung flour and milk powder with wheat flour. The acidity was measured highest for control biscuits followed by W_{90}, W_{80} and lowest in W_{70} biscuits. Overall range of acidity among all the samples varied 0.153 to 0.182 %. In the view of above, acidity decreased with decreasing in the proportions of wheat flour in biscuit formulation. The effect of incorporation of flours on acidity of biscuits were found to be significant at $p<0.05$ level of significance.

Effect on pH: The effect of incorporation of mung flour and milk powder on pH of biscuits are presented in Table 1. The pH range for fresh biscuits was observed 6.55-6.80 among all the biscuits samples. Highest pH was found for W_{70} biscuits (6.80) followed by W_{80} (6.70), W_{90} (6.60) while lowest for control biscuits (6.55) just after baking. The result of study revealed that the pH of biscuits increased with increasing the incorporation of mung flour and milk powder with wheat flour. The effect of incorporation of flours on pH of biscuits were found to be significant at $p<0.05$ level of significance. Highest pH was observed for W_{70} biscuits while lowest for control biscuits as compared to others.

Table 1: Proximate analysis of fresh fortified biscuits

Proximate composition	Biscuits				$CD_{5\%}$
	W_{100}	W_{90}	W_{80}	W_{70}	
Moisture, %	2.83±0.026	2.91±0.020	3.01±0.034	3.03±0.020	0.053
Acidity, %	0.182±0.002	0.165±0.002	0.160±0.007	0.153±0.005	0.011
pH	6.55±0.053	6.60±0.045	6.70±0.045	06.80±0.026	0.115
NEB (OD)	0.181±0.002	0.193±0.005	0.196±0.007	0.203±0.008	0.009

Description

W_{100} = Wheat flour (100 %)

W_{90} = Wheat flour (90 %) + mung flour (5%) + milk powder (5%)

W_{80} = Wheat flour (80 %) + mung flour (10%) + milk powder (10%)

W_{70} = Wheat flour (70 %) + mung flour (15%) + milk powder (15%)

Effect on Non enzymatic browning (optical density): The effect of incorporation of mung flour and milk powder on Non enzymatic browning (optical density) of biscuits is presented in Table 1. Optical density is the physical property associated to the presence of pigment in any sample. Non enzymatic browning (NEB) of biscuits was found to have increased with increase in the incorporation of mung flour and milk powder with wheat flour. Highest NEB was observed for W_{70} (0.203) followed by W_{80} (0.196), W_{90} (0.193) and lowest for control biscuits (0.181) as a fresh samples. The increase in Non enzymatic browning during baking was due to maillard reaction or interaction between protein and sugar or amino acids and sugar or organic acids and sugars. Mung flour and milk powder led to enhance the browning index of biscuits during baking due to enzymatic reactions and caramelization of sugar.

Physical properties of fortified biscuits

The knowledge of important physical properties such as shape, size, volume, surface area, density, length, thickness, spread ratio, per cent spread and mass of biscuits is necessary for designing of baking equipment, packaging materials, handling and storage systems. These properties are also helping to calculate the energy and mass balance during baking. The mass, diameter and thickness of biscuits are important to design the mild and cast of the biscuit. The effect of incorporation of flours on physical properties of freshly prepared biscuits were analyzed and discussed as follows.

Effect on Mass: The variation in mass (g) of biscuits is given in Table 2. The mass per biscuit ranged 6.80 to 8.40g. The highest mass per biscuit was measured for W_{90} biscuit (8.40g) followed by W_{80} (8.20 g), W_{70} (7.80g) and lowest for wheat flour biscuit (6.80g). The study revealed that the mass of fortified biscuits increased with increase in the incorporation of mung flour and milk powder with wheat flour. The value of mass of control (wheat flour) biscuits was lowest as compared to other fortified biscuits. The mass of biscuits was affected by the mass of dough taken for making the biscuit. The biscuits had variation in the initial weight and size of biscuit due prepared by manually. Similar trends were found by Mridula and Wanjari (2006) and Chandra *et al.*, (2015). They reported that weight of biscuit decreased gradually with increase in proportion of full fat soybean flour from 5 to 20 per cent and decreasing the proportion of wheat flour 100 to 80 per cent. From this, it is clear that the effect of incorporation mung flour and milk powder with wheat flour on mass of biscuit were found to be non-significant at $p<0.05$. The study was accounted that the mass of biscuit increased with increase in the incorporation of other ingredients with wheat flour.

Tables 2: Physical properties of fortified biscuits

Biscuits	Mass (g)	Diameter (cm)	Thickness (cm)	Spread ratio	Per cent spread	Bulk density (g/cc)
W_{100}	6.80	4.25	0.96	4.43	100.00	0.499
W_{90}	8.40	4.40	1.10	4.00	90.29	0.395
W_{80}	8.20	5.58	1.05	5.31	119.86	0.397
W_{70}	7.80	4.80	0.73	6.16	139.05	0.591
$CD_{5\%}$	NS	NS	NS	NS	10.779	NS

Description

W_{100} = Wheat flour (100 %)
W_{90} = Wheat flour (90 %) + mung flour (5%) + milk powder (5%)
W_{80} = Wheat flour (80 %) + mung flour (10%) + milk powder (10%)
W_{70} = Wheat flour (70 %) + mung flour (15%) + milk powder (15%)

Effect on Diameter: The value of diameter of biscuits ranged 4.25 to 5.58 cm. The highest diameter was observed for W_{80} biscuits (5.58 cm) followed by W_{70} (4.80 cm) and W_{90} (4.40 cm) and lowest for control biscuits (4.25 cm). It is clear that the diameter of fortified biscuits had larger as compared to control biscuits (Table 2). The diameter of fortified biscuits increased with increase in the incorporation of mung flour and milk powder with wheat flour. Diameter and spread ratio of biscuits are the important parameter used for evaluation the wheat varieties for biscuits making (Nemeth *et al.*, 1994). Larger biscuit diameter and higher spread ratio are considered as the desirable quality attributes (Yamamoto *et al.*, 1996). Similar findings were observed by Yadav *et al.*, (2012) and Chandra *et al.*, (2015). It could be seen that the incorporation of mung flour and milk powder with wheat flour had non-significant effect at $p<0.05$ level of significance. This study revealed that diameter of biscuits decreased insignificantly with increase in the incorporation of different flours with wheat flour. The control biscuits had smaller diameter (4.25 cm) and larger for W_{80} biscuits (5.58 cm).

Effect on Thickness: Data on the physical parameter like thickness of biscuits as affected by the incorporation of mung flour and milk powder with wheat flour are presented in Table 2. The thickness per biscuit ranged 0.73 to 1.10 cm. The highest thickness per biscuit was measured for W_{90} biscuit (1.10 cm) followed W_{80} (1.05 cm), W_{100} (0.96 cm) and lowest for W_{70} (0.73 cm). From the study revealed that the thickness of biscuits decreased with increase in the incorporation of mung flour and milk powder with wheat flour. Highest value of thickness was observed for W_{90} biscuits as compared to control biscuits. The thickness of biscuits was influenced by the initial mass of the dough ball which was taken for the preparation of biscuits. Decrease in diameter and thickness of fortified biscuits with other flours with wheat flour may be due to dilution of gluten. Similar results were reported by Ajila *et al.,* (2008) and Chandra *et al.,* (2015). It is clear that the incorporation of different flours with wheat flour on thickness of biscuits were found to be non significant at $p<0.05$ level of significance.

Effect on Spread Ratio: The spread ratio is the ratio of diameter to thickness of biscuits. The variation in spread ratio for biscuits is given in Table 2. The spread ratio of biscuits ranged 4.00 to 6.16. The highest spread ratio was evaluated for W_{70} biscuits (6.16) followed by W_{80} (5.31), W_{100} (4.43) and lowest for W_{90} biscuits (4.00). The results indicated that the incorporation of other ingredients with wheat flour increased the spread ratio of biscuits. Spread ratio of W_{90} biscuits was found lower than control biscuits but higher for W_{80} and W_{70} biscuits. Results were also revealed that the spread ratio of fortified biscuits increased with decrease in the incorporation of wheat flour in fortified flours. It is clear that spread ratio is mostly influenced by the diameter and thickness of biscuits. Spread ratio and per cent spread decreased with addition of mung flour and milk powder. Rababah *et al.,* (2006) reported the reduction in spread ratio when chickpea, broad bean and isolate soy protein were substituted for wheat flour in biscuits. Hence, it was observed that the spread ratio of biscuit were found to be non significant as compared to control biscuits at $p<0.05$ level of significance. Spread ratio of the fortified biscuits increased with increase in the incorporation of mung flour and milk powder.

Effect on Per cent Spread: The experimental data for variation in per cent spread of biscuits is shown in Table 2. The per cent spread of biscuits varied 90.29 to 139.05. The highest score of per cent spread were observed for W_{70} biscuits (139.05) followed W_{80} (119.86), control biscuits (100.00) and lowest for W_{90} biscuits (90.29). The study revealed that the per cent spread of biscuit increased with increase in the incorporation of mung flour and milk powder with wheat flour. The per cent spread of biscuits increased with decrease in the incorporation of wheat flour. Per cent spread of biscuits was influenced by the thickness and diameter of biscuits. Adair *et al.,* (2001) found that mung bean paste incorporation reduced cookie spread at all the level of substitutions (25, 50, 75 and 100%) of peanut butter which was not similar to present study. Mandal *et al.,* (2004) reported that incorporation of 25 per cent mung flour in the formulation of biscuit improved height, diameter, spread ratio, colour, texture and flavour. Similar result was quoted by Chandra *et al.,* (2015). Study revealed that the per cent spread of biscuits were affected significantly at $p<0.05$ level of significance. The spread ratio of biscuit was found to be significant as compared to control biscuits.

Effect on Bulk density: The variation in bulk densities of biscuits are reported in Table 2, which shows the effect of incorporation of mung flour and milk powder with wheat flour. Bulk densities of biscuits ranged 0.395 to 0.591 g/cc. The highest bulk density was reported for W_{70} biscuits (0.591 g/cc) followed by W_{100} (0.499g/cc), W_{80} (0.397 g/cc) and lowest for W_{90} biscuits (0.395 g/cc). It was also noticed that level of incorporation of different ingredients was influenced the bulk density of biscuits. From Table 1, it was observed that the bulk densities among all biscuit samples decreased with increase in the incorporation of mung flour and milk powder with wheat flour, while decreased with decrease in the proportions of wheat flour in composite flours. Hence, bulk density of biscuits depends on the particle size of incorporating flours which reduced by coarse size of potato flours in biscuits. Akubor and Obiegbuna (1999) reported that bulk density of sample could be used in determining its packaging requirements as this related to the load the sample being stacked and allowed to rest directly on one another. The density is often noted as an important quality parameter in biscuit making, in particular for predicting crunchiness (Bartalucci and Launay, 2000). Lower density is often suggested as a quality index for biscuits (Fustier *et al.,* 2009). Study also revealed that the bulk density of biscuits were found to be non significant at $p<0.05$ level of significance. It is clear the bulk density decreased non-significantly with increase in the incorporation of different flours with wheat flour. Highest bulk density was found for W_{70} biscuits while lowest for W_{90} biscuits at $p<0.05$ level of significance.

Conclusion

The moisture content, pH, non enzymatic browning (NEB) of fortified biscuits had higher as compared to control biscuits. It was increased with increase in the incorporation of mung flour and milk powder with flour. The acidity decreased with increase the incorporation of mung flour and milk powder with wheat flour. The mass, diameter and thickness of biscuits are important to design the mould and cast of the biscuit. The study revealed that the mass and thickness of fortified biscuits decreased with increase in the incorporation of mung flour and milk powder with wheat flour. The value of mass of control (wheat flour) biscuits was lowest as compared to other fortified biscuits. The diameter, spread ratio, percent spread and bulk density of fortified biscuits increased with increase in the incorporation of mung flour and milk powder with wheat flour. Percent spread of biscuits was influenced by the thickness and diameter of biscuits.

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