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QUALITY CHARACTERISTICS OF DOUGHNUTS FROM PEARL MILLET BLENDED COMPOSITE FLOURS

Paramjot Kaur, Monika Sood* and Julie D. Bandral

Division of Food Science and Technology, Faculty of Agriculture, S.K. University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu - 180 009, Jammu & Kashmir (India)
*e-mail: *monikasoodpht@gmail.com*

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ABSTRACT

This study was aimed to evaluate the quality of doughnuts made from pearl millet-wheat-whey protein isolate composite blend. Flour blends of pearl millet and refined wheat flour (RWF) were composite at replacement levels of 10, 20, 30 and 40% with 10% whey protein isolates in each treatment. The nutrient contents of flour blends were determined using standard methods. The products were analyzed for their proximate composition and sensory attributes. The protein content of blends decreased steadily with increasing content of pearl millet flour (PMF) (17.99% in 00:90:10::PMF:RWF:WPI to 14.44% in 40:50:10:: PMF:RWF:WPI) while crude fibre content increased. The highest moisture content of 15.43%, crude fat 24.76%, crude fibre 2.36% and ash content of 2.81% were observed in 40:50:10::PMF: RWF: WPI treatment. However, the treatment 00:90:10::PMF:RWF:WPI yielded highest value of crude protein. On the basis of sensory evaluation, treatment 00:100:00::PMF:RWF:WPI recorded highest score for colour (8.96), texture (8.74), taste (8.87) and overall acceptability (8.87) in doughnuts; whereas treatment 40:50:10::PMF:RWF: WPI recorded lowest score for sensory parameters. In general, incorporation of refined wheat flour and whey protein isolates with pearl millet flour for doughnuts upto 20% level were acceptable.

Key words: Doughnuts, pearl millet, proximate, refined sensory characteristics, wheat flour, whey protein isolates

INTRODUCTION

Doughnut is a fried snack which is one of the most popular fried products throughout the world (Rehman *et al*., 2007). Doughnuts are made by deep-frying dough that is a mixture of flour, water, egg, oil, sugar and milk (Hatae *et al*., 2003). Doughnut made from non-enriched wheat flour lacks other essential nutritional composition such as dietary fibre, vitamins and minerals that are lost during the process of wheat flour refinement.

Composite flour has been defined as a combination of wheat and non-wheat flours for the production of leavened breads, other baked products, and pastas; or wholly non-wheat flour prepared from mixtures of flours from cereals, roots, tubers, legumes or other raw materials, to be used for traditional or novel products (Poongodi and Jemima, 2009). Composite flours have extensively been used in preparation of baked products to primarily identify the functional roles of flour components and test its organoleptic acceptability.

Pearl millet (*Pennisetum glaucum*), being a staple food, is the major source of nutrients in daily diet of large segment of poor population. Pulses are considered “the poor man’s meat” while pearl

millet is termed as "poor man's bread". It is considered as an important substitute for major cereal crops to cope up with worldwide food demands. The nutritive value of pearl millet is comparable to other staple cereals like wheat and rice (Gopalan *et al*., 2000). Pearl millet is a coarse cereal grain cultivated mostly in semi-arid parts of Africa and Asia. The nutritive value of pearl millet is equivalent or even superior to those of other cereals (Obilana and Manyasa, 2002). It has high calcium, iron, zinc and lipids contents. Despite numerous potential benefits, this crop has limited commercial demand especially in urban areas. Several problems associated with pearl millet include various anti-nutritional factors, bitter taste, storability, grittiness or difficulty to cook, etc. In order to realize the full potential of pearl millet as food crop, there are possibilities for alternate uses of pearl millet in the preparation of novel foods, convenience mixes, etc. Thus, standardization and commercialization of alternative food is one of the ways to increase demand for pearl millet.

Nevertheless, the use of millets is limited due to the presence of various anti-nutrients. Pearl millet is often rich in fibre-associated anti-nutrients namely phytate, oxalate and tannins which have negative influence on the bioavailability of minerals and also results in poor digestibility of proteins and carbohydrates (Taylor, 2004). Due to the presence of fibrous seed coat, the flour of pearl millet is coarse and has grey to yellow colour which imparts bitter taste and the products prepared from whole flour have low consumer appeal. This is one of the reasons for its poor acceptability by rice/wheat eaters.

Whey is an insignificant by-product of cheese making, used either in animal feed or discarded (National Dairy Council, 2001). With the advances in technology and recent discoveries of functional and bioactive roles, the whey and whey components are now viewed as valuable ingredients. The recognition of whey as a source of unique physiological and functional attributes has increased incorporation of whey and whey components into variety of foods. Whey protein isolates (WPI) are high protein, low carbohydrate ingredient and are high in lacto-albumin, minerals and vitamins that are currently in demand due to increased awareness of nutrition and alternative methods for weight control. These proteins are well known for high nutritive value and versatile functional properties in food products. Estimates of the worldwide production of whey indicate that about 700,000 t true whey proteins are available as valuable food ingredient (Wit, 1998). Therefore, the present work was planned to develop a convenience food i.e. doughnuts from pearl millet, refined wheat flour and whey protein isolates and to evaluate its shelf-life in order to harness the nutritional potential of this valuable crop.

MATERIALS AND METHODS

Collection of raw material and processing

Pearl millet (*Pennisetum glaucum*) cv. Nandi-61 grains were procured in a single lot from Dryland Research Sub-Station, SKUAST-J, Dhiansar, Jammu & Kashmir. The grains were cleaned manually to remove any dirt and foreign materials and then dehulled and milled in a running flour mill. After milling, the pearl millet flour was passed through 40 mesh sieves and packed in air-tight containers for further use. Refined wheat flour was procured from a local market. Soy protein isolates were obtained from Tara Nutricare Private Limited, Jalandhar (India).

Preparation of composite flour blends for doughnuts

The pearl millet flour and refined wheat flour in different ratios (0: 90, 10: 80, 20: 70, 30: 60 and 40:50) were blended with 10% whey protein isolates. Besides, 100% refined wheat flour was taken as control.

Preparation of doughnuts

The recipe for doughnuts was standardized in laboratory. Initially the recipe was standardized by altering the components like sugar, egg, water, etc. When the recipe was set, the final trials on different levels of pearl millet flour and whey protein isolates were tried. For the preparation of doughnuts, the ingredients were mixed manually so as to have a uniform dough. The dough was rolled out on a floured table, cut with a ring-shaped doughnut cutter and fried. The various treatment-combinations of prepared doughnuts were packed in polyethylene pouches (150 gauge) and then stored for a period of 90 days under refrigerated conditions. The stored products were analyzed for various physicochemical changes and sensory characteristics which were determined at an interval of 30 days.

Physical parameters for composite flour

Water absorption*:* Twenty grams of composite flour was taken and the required quantity of water added to get dough of moderately stiff consistency. The amount of water required was noted and expressed in percent (Austin and Ram, 1971).

Gluten content*:* Standard AACC (2000) procedure was followed for estimating gluten. The pre-weighed samples were taken in Petri-plates and measured quantity of water added to it. Then a smooth dough ball was made and kept as such for 10 min. The ball in a muslin cloth was then washed under running water and all starch and other soluble materials were washed out. A sticky elastic material was left in the end which was the source of gluten.

Falling number*:* Seven grams of composite flour sample was weighed and combined with 25 mL of distilled water in a glass falling number tube with a stirrer and shaken to form slurry (Perten Instruments, AB Sweden, Model number: FN 1500). The slurry was heated in a boiling water bath at 100^{o}C and stirred constantly. The starch gelatinized and formed a thick paste. The time taken by the stirrer to drop through paste was recorded as the falling number value.

Chemical composition of composite flour blended doughnuts

The moisture content, crude protein, ash, crude fat, crude fibre and carbohydrates were estimated by the standard methods described by AOAC (1995).

Sensory evaluation

Sensory evaluation of developed products depends upon the responses given by different sense organs. The samples were evaluated on the basis of overall acceptability by semi-trained panel of 8 judges by using 9-point hedonic scale assigning scores 9- like extremely to 1- dislike extremely. A score of 5.5 and above was considered acceptable (Amerine *et al*., 1965).

Total bacterial count

The nutrient agar medium was prepared and sterilized in an autoclave at 121^{o}C for 15 min. Five grams of flat bread formulation was weighed, aseptically mixed with 90 mL sterile distilled water and thoroughly blended. This provided 10^{-1} dilution and further dilutions were prepared in the same manner under aseptic conditions. Diluted formulations (1 mL) were poured separately in Petri-plates and thoroughly mixed with nutrient agar. After medium solidification, the plates were incubated at 37^{o}C in inverted position for 48 h and colonies counted.

Statistical analysis

All the above experiments were conducted in triplicate. The data collected was analyzed as per one-way and two-way analysis of variance using Opstat software available online at CCS, HAU, Hissar, India (website: *www.hau.ernet.in*).

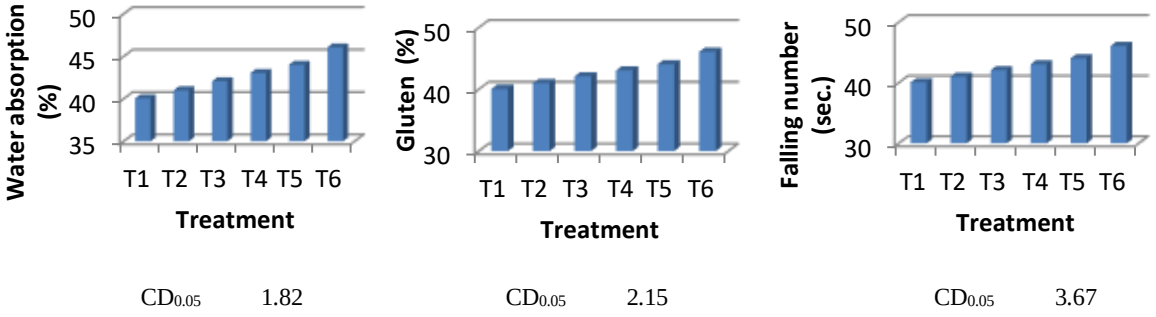
RESULTS AND DISCUSSION

Functional properties of composite flour

Functional properties are the parameters that determine the application and end use of food materials for various food products. Water absorption was highest (46.08%) in treatment 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates and lowest (40.08%) in treatment 100% refined wheat flour (Fig 1a). The per cent water absorption increased with the incorporation of pearl millet flour. The water absorption might have increased due to strong water affinity of fibres in a high fibre food product (Poongodi and Jemima, 2011). Similar increase in water absorption content has been reported by Dogra *et al*. (2001) in flour blends of *Babru* prepared from wheat flour containing different proportions of soybean flours.

Gluten content was maximum (24.0%) in control treatment 100 refined wheat flour and minimum (10.05%) in 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates (Fig 1b). The gluten content might have decreased with the incorporation of pearl millet flour as pearl millet is low in gluten content. Similar results have been reported by Poongodi and Jemima (2009) in pearl millet blends.

Falling number decreased with the increase in pearl millet flour content. The highest falling number (386 sec) was observed in control treatment 100% refined wheat flour and lowest (264 sec) in treatment 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates (Fig 1c). Similar findings have been reported by Legesse (2013) in wheat flour blended with pearl millet.



$CD_{0.05}$ 1.82 $CD_{0.05}$ 2.15 $CD_{0.05}$ 3.67

Fig. 1: Effect of treatment on physical parameters of composite flour a) Water absorption, b) Glutin, and C) Falling number

Physical parameters of composite flour blended doughnuts

The highest value for physical parameters *viz*., diameter and thickness after frying were recorded in control treatment 100% refined wheat flour. However, treatment 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates recorded lowest diameter and thickness (Table 1). The spread ratio decreased with increase in the incorporation of pearl millet flour. The results are in agreement with Poongodi and Jemima (2011) in *dosa* prepared from millet flour blends and Kawas and Moreira (2001) in tortilla chips.

Storability of composite flour blended doughnuts

With the progression of storage period, the moisture content increased from its initial value of 14.55 to 14.78% (Table 2). The maximum mean moisture content of 15.43% was found in treatment 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates and minimum of 14.01% in control treatment 100% refined wheat flour. The moisture content increased significantly with increased pearl millet flour content. The increase in moisture content might have been associated with increase in fibre content (Maneju *et al*., 2011). Similar increase in moisture content has been reported by Poongodi and Jemima (2011) in *dosa* prepared from millet flour blends.

Table 1: Effect of treatment on physical parameters of composite flour blended doughnuts

Treatment combinations* PMF: RWF: WPI	Diameter (cm)		Thickness (cm)		Spread ratio	
	Before frying	After frying	Before frying	After frying	Before frying	After frying
00:100: 00	8.00	8.75	0.12	2.50	66.66	3.50
00:90: 10	8.00	8.73	0.12	2.50	66.66	3.49
10:80: 10	8.00	8.71	0.12	2.30	66.66	3.79
20:70: 10	8.00	8.67	0.12	2.00	66.66	4.34
30:60: 10	8.00	8.63	0.12	1.80	66.66	4.80
40:50: 10	8.00	8.61	0.12	1.60	66.66	5.38
Mean	8.00	8.68	0.12	2.11	66.66	4.21
$CD_{0.05}$	ns	0.03	Ns	0.08	ns	0.08

*PMF = Pearl millet flour, RWF = Refined wheat flour, and WPI = Whey protein isolates

The mean crude protein content during 90 days of storage declined significantly from the initial level of 15.64 to 14.82% (Table 2). The decrease in protein content during storage might be due to the hydrolysis of peptide bonds due to protease enzyme that cause splitting of protein molecules during storage (Premlatha *et al.*, 2010). Maximum mean crude protein content of 17.99% was found in treatment 00:90:10::pearl millet flour: refined wheat flour: whey protein isolates and minimum of 10.62% in control treatment 100% refined wheat flour. Tripathy *et al.* (2003) also reported that with the incorporation of whey protein, concentrate protein content showed increase in in ragi *dosa*.

A general decrease in crude fat content was observed during storage period from the initial mean value of 23.26 to 22.36% after 90 days of storage (Table 3). Decrease in crude fat content might be due to the increase in the activity of lipase enzyme (lipolytic oxidation) leading to decreased fat content (Sharma, 2014). The lowest mean crude fat content of 21.25% was observed in control treatment 100% refined wheat flour and highest of 24.76% in 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates treatment. This might be due to the incorporation of whey protein isolates or deep fat frying of doughnuts (Tripathy *et al*., 2003; Lakra and Sehgal, 2011).

Crude fibre content of different treatments decreased during storage period of 90 days from the initial mean value of 1.95 to 1.82% (Table 3). The decrease in crude fibre might be due to the degradation of hemicelluloses and other structural polysaccharides during storage. However, with the incorporation of pearl millet flour, the crude fibre content increased in all the treatments. At the beginning, the highest crude fibre content of 2.38% was recorded in treatment 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates; whereas the lowest crude fibre content of 1.47%

Table 2: Effect of treatment and storage period on moisture (%) and crude protein content (%) of composite flour blended doughnuts

Treatment combinations* PMF: RWF: WPI		Moisture Storage period (days)					Crude protein Storage period (days)				
		0	30	60	90	Mean	0	30	60	90	Mean
00:100: 00		13.90	13.98	14.04	14.10	14.01	11.08	10.96	10.43	10.02	10.62
00:90: 10		14.13	14.22	14.29	14.36	14.25	18.47	18.10	17.86	17.55	17.99
10:80: 10		14.39	14.44	14.48	14.53	14.46	17.83	17.54	17.39	17.13	17.47
20:70: 10		14.57	14.63	14.78	14.87	14.71	16.18	16.02	15.77	15.52	15.88
30:60: 10		14.96	15.12	15.22	15.29	15.15	15.44	15.16	14.97	14.72	15.07
40:50: 10		15.34	15.41	15.46	15.52	15.43	14.86	14.60	14.31	14.00	14.44
Mean		14.55	14.63	14.71	14.78		15.64	15.40	15.12	14.82	
$CD_{0.05}$	Treatment (T)			0.02					0.01		
	Storage (S)			0.01					0.01		
	T × S			0.03					0.03		

*PMF = Pearl millet flour, RWF = Refined wheat flour, and WPI = Whey protein isolates

Table 3: Effect of treatment and storage period on crude fat (%) and crude fibre content (%) of composite flour blended doughnuts

Treatment combinations*	Crude fat content Storage period (days)					Crude fibre content Storage period (days)				
PMF: RWF: WPI	0	30	60	90	Mean	0	30	60	90	Mean
00:100: 00	21.70	21.50	21.07	20.74	21.25	1.47	1.44	1.38	1.34	1.41
00:90: 10	22.30	22.04	21.79	21.49	21.91	1.52	1.49	1.42	1.39	1.46
10:80: 10	22.90	22.61	22.37	22.06	22.49	1.92	1.86	1.81	1.77	1.84
20:70: 10	23.45	23.11	22.88	22.46	22.98	2.12	2.09	2.04	2.00	2.06
30:60: 10	24.05	23.84	23.42	23.10	23.60	2.30	2.26	2.21	2.16	2.23
40:50: 10	25.15	24.92	24.67	24.28	24.76	2.38	2.34	2.30	2.26	2.32
Mean	23.26	23.00	22.70	22.36		1.95	1.91	1.86	1.82	
$CD_{0.05}$ Treatment (T)		0.02						0.02		
Storage (S)		0.01						0.01		
T × S		0.03						0.03		

*PMF = Pearl millet flour, RWF = Refined wheat flour, and WPI = Whey protein isolates

was noticed in control treatment 100% refined wheat flour. After 90 days of storage, the maximum crude fibre content of 2.26% was observed in treatment 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates; whereas minimum crude fibre of 1.34% was found in control treatment 100% refined wheat flour. This might be due to the higher level of fibre content in pearl millet flour. Similar observations have been reported by Echendu *et al*. (2004) in doughnuts prepared from maize-pigeon pea flour blends and Chong and Noor (2008) in banana flour blended doughnuts.

The ash content is regarded as a general measure of quality and is often useful criterion for identifying the food value. With the advancement of storage period, the ash content decreased from its initial value of 2.39 to 2.27% (Table 4). Decrease in ash content during storage might be due to its interaction with other components like protein and carbohydrates (Akhtar *et al.*, 2013). The highest ash content among treatments was found in treatment 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates. These results are supported by Chong and Noor (2008) in case of banana flour incorporated doughnuts and Echendu *et al.* (2004) in maize-pigeon pea flour blended doughnuts.

The mean carbohydrate content during 90 days of storage increased from the initial level of 42.20 to 43.94% (Table 4). Control treatment (100% refined wheat flour) gave highest mean carbohydrate content of 51.06% and lowest (40.2%) was found in treatment 40:50:10::pearl millet flour: refined wheat flour: whey protein isolates. With the progress in storage period, the carbohydrate content increased significantly due to the breakdown of insoluble polysaccharides into simple sugars.

Table 4: Effect of treatment and storage period on ash (%) and carbohydrate content (%) of composite flour blended doughnuts

Treatment combinations*	Ash content Storage period (days)					Carbohydrate content Storage period (days)				
PMF: RWF: WPI	0	30	60	90	Mean	0	30	60	90	Mean
00:100: 00	1.70	1.67	1.63	1.59	1.65	50.13	50.45	51.45	52.20	51.06
00:90: 10	2.10	2.07	2.04	2.00	2.05	41.48	42.08	42.60	43.21	42.34
10:80: 10	2.32	2.28	2.24	2.19	2.26	40.64	41.27	41.70	42.32	41.48
20:70: 10	2.56	2.51	2.46	2.41	2.48	41.12	41.64	42.07	42.73	41.89
30:60: 10	2.79	2.75	2.71	2.66	2.73	40.46	40.87	41.48	42.06	41.22
40:50: 10	2.88	2.83	2.80	2.75	2.81	39.39	39.86	40.41	41.12	40.20
Mean	2.39	2.35	2.31	2.27		42.20	42.69	43.28	43.94	
$CD_{0.05}$ Treatment (T)		0.02						1.32		
Storage (S)		0.01						1.08		
T × S		ns						ns		

*PMF = Pearl millet flour, RWF = Refined wheat flour, and WPI = Whey protein isolates

Table 5: Effect of treatment and storage period on overall acceptability and total plate count of composite flour blended doughnuts

Treatment combinations*	Overall acceptability Storage period (days)					Total plate count ($\times 10^2$ cfu g^{-1}) Storage period (days)				
PMF: RWF: WPI	0	30	60	90	Mean	0	30	60	90	Mean
00:100: 00	8.89	8.87	8.84	8.80	8.87	0	1.08	2.06	2.56	1.90
00:90: 10	8.76	8.73	8.70	8.66	8.71	0	0.92	1.82	2.22	1.65
10:80: 10	8.60	8.57	8.51	8.43	8.52	0	0.90	1.82	2.11	1.61
20:70: 10	8.32	8.23	8.10	7.86	8.12	0	0.88	1.76	1.98	1.54
30:60: 10	6.98	6.91	6.88	6.80	6.89	0	0.27	1.28	1.94	1.63
40:50: 10	6.81	6.63	6.64	6.28	6.53	0	0.24	1.26	1.89	1.13
Mean	8.06	7.99	7.90	7.80		0	0.71	1.66	2.11	
$CD_{0.05}$										
Treatment (T)			0.01					0.03		
Storage (S)			0.01					0.02		
T × S			0.03					0.06		

*PMF = Pearl millet flour, RWF = Refined wheat flour, and WPI = Whey protein isolates

Similar results have been reported by Poongodi and Jemima (2011) in *dosa* blended with millet flour.

A decrease in overall acceptability score was observed in all the treatments with increase in storage period (Table 5). It decreased from 8.06 at 0 day storage to 7.80 at 90 days storage. Significant differences were observed in treatment-storage interaction. The control treatment 100% refined wheat flour had the highest mean score of 8.87, followed by the treatment 00:90:10::pearl millet flour: refined wheat flour: whey protein isolates with a score of 8.71. The reduced acceptability of doughnuts at 30 and 40% pearl millet flour may be attributed to the poor flavour contributed by pearl millet flour at higher levels. Similar results have been reported by Dogra (2003) in doughnuts and Chong and Noor (2008) in banana flour blended doughnuts.

The freshly prepared doughnuts did not reveal any microbial contamination. The microbial count increased with increase in storage period (Table 5). The increase in total plate count (TPC) after 30 days might be due to growth of microorganisms after adjusting with food medium (Frazier and Westhoff, 1988). There are no microbial standard available for these types of products; however, BIS has specified the standard plate count of 50,000 cfu g^{-1} for ready-to-eat protein rich snacks (Purohit and Rajyalakshmi, 2011). Similar results have been reported by Anitha and Rajyalakshmi (2013) in value-added products from rice varieties.

Conclusion: The bakery products are usually made of refined or whole wheat flour. However, due to the less availability of fibre content, frequent consumption of these materials leads to the constipation problem and colon cancer in consumers. The substitution of pearl millet flour with refined wheat flour finds use of pearl millet in value-added products. The level of 20% pearl millet flour and 10% whey protein isolates against wheat flour (70%) was the optimum proportion to produce the acceptable doughnuts with 49.53% more protein. Hence, it could serve to increase pearl millet utilization and add to the diversification in market which is mostly dependent on products from wheat and rice.

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