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Physicochemical and nutritional composition of composite flour enriched with spinach leaves powder for development of value-added baked products

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Abstract

The present study was conducted to see the effect of supplementation of spinach leaves in commonly consumed baked and traditional products. Five types of composite flours were formulated by using wheat flour, bengal gram flour and spinach leaves powder at (4, 6, 8, 10 and 12% levels). Control-I (100% wheat flour), Control-II (100% bengal gram flour), Type-I composite flour (48:48:4), Type-II composite flour (47:47:6), Type-III composite flour (46:46:8), Type-IV composite flour (45:45:10), and Type-V composite flour (44:44:12), respectively. All the formulated composite flour samples were analyzed for their physico-chemical properties. It was observed that water absorption capacity, oil absorption capacity, swelling power, bulk density and least gelation capacity of composite flours increased significantly with increase in the level of incorporation of spinach powder. While solubility and flour dispersability were found to be decreased with increase in the level of spinach powder. Type-I composite flour showed highest values containing 4 per cent level of spinach powder while Type-V composite flour showed lower values containing 12 per cent level of incorporation. Moisture, crude protein, crude fat, crude fibre and ash content of all five types of composite flour samples were found significantly higher than the control sample (wheat flour) while in comparison to bengal gram flour (control), crude protein content in all five types of composite flour samples decreased due to replacement of bengal gram flour with wheat flour. Total iron, calcium, zinc, phosphorus, β -carotene, dietary fibre and anti-oxidant activity of all five types of composite flour found significantly higher than control sample.

Keywords: Composite flour, physico-chemical properties, baked products, nutritional composition

Introduction

The average diet in most of the Asian countries including India is predominantly cereal based. These diets have poor bioavailability of micronutrients leading to wide prevalence of iron-deficiency, anaemia and vitamin 'A'. Certain green leafy vegetables are a rich source of β -carotene, a precursor of vitamin 'A' and grown abundantly in India. The most commonly used leafy vegetables are spinach, fenugreek, drumstick leaves, *shepu*, coriander, mint, *chakota* and curry leaves etc. Since these have short life, suitable processing and preservation can prevent wastage and increase availability in the diet during off season. In developing countries multiple micronutrient deficiency are more common than single deficiency and the cause for their high prevalence is due to poor consumption and poor bioavailability of micronutrients (Gupta and Prakash 2011)^[6].

The nutritive value of staple food can be enhanced through a mutual complementation of their restrictive micronutrients with value added ingredients. Green leafy vegetables and legumes are among the value added ingredients and multi-cultural components used ubiquitously in Indian cuisine. Green leafy vegetables and legumes are rich source of protein, micronutrients and dietary fibre (Galla *et al.* 2017; Longvah *et al.* 2017; Singh *et al.* 2018)^[4, 12, 18].

Today due to urbanisation and lack of time to prepare food, there is a demand to have nutritious premixes which are ready to reconstitute and ready to prepare. There are various types of premixes like *idli*, *dosa*, *gulab jamoon* premixes etc. are available in market, *chapati* premix fortified with nutrient rich green leafy vegetables are not available. Therefore, attempts were made to develop *chapati* premixes by fortifying wheat flour with dehydrated spinach powder and to evaluate their effect on physico-chemical, rheological, nutritional and sensory characteristics.

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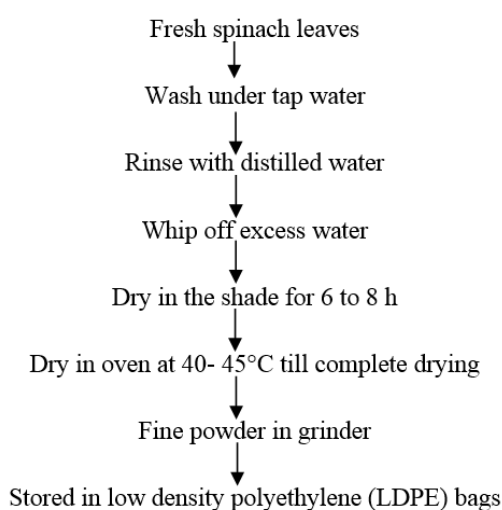
2. Material and Methods

2.1 Procurement of materials

Grain samples of a wheat variety (WH-1105) and a bengal gram variety (HC-1) were procured from the Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. The grain samples were cleaned, bengal gram seeds were dehulled and ground into flour. The ground samples were stored in plastic container till further use.

Spinach leaves (*Spinacia oleracea L.*) were procured in a single lot from local market of Hisar. Healthy mature and disease-free leaves were selected and washed under running tap water followed by distilled water. Excess water were wiped off with muslin cloth. Then the leaves were dried in the shade for 6 to 8 h to remove excess moisture followed by oven drying at 40-45°C till complete drying. The dried leaves were ground in an electric grinder to obtain a fine powder. The ground powder were stored in low density polyethylene (LDPE) bags for further use.

2.2 Preparation of spinach leaves powder



2.3 Formulation of composite flour

Different proportions of wheat flour, bengal gram flour and spinach leaves powder were used for formulation of composite flour. Five types of composite flour were prepared by using wheat flour, bengal gram flour and spinach leaves powder i.e in the ratio of 48:48:4 (Type-I), 47:47:6 (Type-II), 46:46:8 (Type-III), 45:45:10 (Type-IV) and 44:44:12 (Type-V).

2.4 Nutritional evaluation

The five types of composite flour samples were evaluated for physico chemical property by using different methods, proximate composition (AOAC, 2000) [2]. For mineral estimation, the samples were wet acid digested, using a nitric acid and perchloric acid mixture (HNO₃:HClO₄, 5:1 w/v). The total amounts of Ca, Mg, P, Fe and Zn in the digested samples were determined by Atomic Absorption Spectrophotometry (Lindsey and Norwell, 1969) [11]. Antioxidant activity was estimated by the method of Prieto *et al.*, 1999 [15] and β-carotene was estimated by the method of AOAC (2000) [2].

3. Results and discussion

3.1 Physico-chemical properties of composite flour

The data on physico-chemical properties of wheat flour, bengal gram flour and formulated composite flours by incorporating spinach powder, bengal gram flour in wheat flour at different levels *viz.*, Type-I (WF:BGF:SP::48:48:4), Type-II (WF:BGF:SP::47:47:6), Type-III

(WF:BGF:SP::46:46:8), Type-IV (WF:BGF:SP::45:45:10) and Type-V (WF:BGF:SP::44:44:12) are presented in Table 1.

Water absorption capacity and oil absorption capacity of wheat flour were (0.98 ml/g) and (1.23 g/g) while bengal gram flour had significantly lower water absorption capacity (0.67 ml/g) and oil absorption capacity (0.78 g/g). In all types of composite flour, water absorption capacity and oil absorption capacity increased significantly from 1.50 to 3.20 ml/g and 1.40 to 2.90 g/g, respectively as compared to control samples. Galla *et al.* (2017) [4] reported that the increase in water absorption may be attributed to the fact that hydroxyl groups present in the fibre structure allow more water interaction through hydrogen bonding. Gomez *et al.* (2003) [5] and Dachana *et al.* (2010) [3] also reported addition of fibre increase the water absorption in composite flour made cookies and bread flour due to hydroxyl groups present in fibre. Similar results of water and oil absorption capacity were also reported by other workers in composite flours Ritika *et al.* (2016) [16]. High water and oil absorption capacity of composite flour can positively influenced the flavour, moisture and fat content of food (Prajapati *et al.* 2015) [14]. Swelling power of wheat flour and bengal gram flour was 7.85 and 5.28 g/g while bulk density was 0.64 g/ml for wheat flour and 0.68 g/ml for bengal gram flour as these values were found to significantly and gradually increased in all five types of composite flour samples containing spinach leaves powder at 4, 6, 8, 10 and 12 per cent. Other workers also reported higher swelling power and bulk density in flour supplemented with green leafy vegetables (Ajibola *et al.* 2015; Galla *et al.* 2017) [1, 4].

Solubility and flour dispersability of wheat flour (control) were 0.72 g/g and 19.76 g/100 ml which was found to be significantly decreased in all the five types of composite flour might be due to addition of spinach leaves powder. Flour dispersability is an index that measure how well flour or flour blends can be rehydrated with water Kulkarni *et al.* (1991) [9]. On other hand, least gelation capacity of control flours were found to be increased on supplementation of spinach leaves powder in wheat-bengal gram flour blends. Least gelation capacity of all five types of composite flour were in the range of 9.50 to 12.40 g/100ml. Similar results were also reported by Prajapati *et al.* (2015) [14] and Ritika *et al.* (2016) [16] in composite flour (14.00 to 18.70 g/100 ml) as these results are in close agreement with the present results.

3.2 Nutritional composition of composite flour

Proximate composition: The table 2 is furnished with the results of proximate composition of composite flour.

Moisture content of control flour increased significantly with increase in incorporation level of spinach powder in wheat-bengal gram flour blends. Other workers also reported higher moisture content in composite flour containing green leafy vegetables powder (Lakshmi & Vimla 2000; Singh & Grover 2014; Singh *et al.* 2018) [10, 17, 18]. In the present study crude protein, crude fat, crude fibre and ash content of five types of composite flour samples were in the range of 15.09 to 17.50, 3.41 to 3.98, 1.87 to 2.79 and 2.11 to 3.52 per cent, respectively. As these contents were found to be significantly increased as compared to wheat flour (control) which might be due to addition of bengal gram flour and spinach powder in wheat flour (Table 2). Singh & Grover (2014) [17] also reported higher crude protein, fat, fibre and ash content in composite flour containing wheat-bengal gram flour and bengal gram leaves powder. As these results are similar as reported in present study. Other workers also reported higher crude protein, fat, fibre in composite flour containing green

leafy vegetables (Pant *et al.* 2012; Ajibola *et al.* 2015; Singh *et al.* 2018) [13, 1, 18].

Total minerals: Total minerals content of composite flour given in table 3.

Total minerals (Fe, Ca, Zn and P), anti-oxidant activity and β -carotene content for all five types of composite flour were found to be significantly higher than control flour which might be due to addition of spinach powder up to 12 per cent levels. Type-I composite flour (containing 4 per cent level of spinach powder) exhibited lower content while Type-V composite flour (containing 12 per cent level of spinach powder) had higher content of Ca, P, Fe, Zn (Table 3). Other workers also reported higher content of Ca, P, Fe, Zn, β -

carotene and anti-oxidant activity composite flour containing green leafy vegetables powders. (Umma Khair *et al.* 2012; Pant *et al.* 2012; Kavitha & Ramadas 2013; Galla *et al.* 2017) [20, 13, 7, 4] reported that fresh spinach leaves are rich source of calcium (1336 mg/100g), iron (30 mg/100g) and phosphorus (336 mg/100g). Anti-oxidant activity (1.4 mg/ml) was also found higher in spinach leaves powder (Suresh & Kalaivani 2016) [19]. Khan *et al.* (2015) [8] reported 1019.00 mg calcium, 68.92 mg iron, 5.06 mg zinc, 32.59 mg phosphorus and 2605 μ g β -carotene content in per 100 g of spinach leaves powder which contributed higher level of minerals and β -carotene in the composite flour. These results are in close agreement with results reported in present study in formulated composite flour samples (Table 4).

Table 1: Physico-chemical properties of different flours

Physico-chemical properties	WF (100%)	BGF (100%)	Composite flours					C.D (P=0.05)
			Type-I	Type-II	Type-III	Type-IV	Type-V	
Water absorption capacity(ml/g)	0.98±0.01*	0.67±0.01	1.50±0.01	1.96±0.01	2.50±0.04	2.90±0.04	3.20±0.06	0.11
Oil absorption capacity(g/g)	1.23±0.02	0.78±0.02	1.40±0.03	1.88±0.04	2.24±0.05	2.56±0.01	2.90±0.07	0.13
Swelling power (g/g)	7.85±0.12	5.28±0.04	7.95±0.16	8.05±0.03	8.43±0.17	8.89±0.09	9.06±0.08	0.39
Bulk density (g/ml)	0.64±0.01	0.68±0.01	0.70±0.01	0.75±0.02	0.79±0.01	0.84±0.02	0.94±0.01	0.03
Solubility (g/g)	0.72±0.01	0.52±0.01	0.68±0.01	0.61±0.01	0.55±0.01	0.42±0.01	0.35±0.01	0.02
Least gelation capacity(g/100 ml)	9.00	8.50	9.50	10.50	11.00	11.50	12.40	0.42
Flour dispersability (g/100 ml)	19.76±0.26	15.54±0.15	18.02±0.39	16.56±0.06	15.34±0.11	14.79±0.34	13.50±23	0.89

*Values are mean \pm SE of three independent determinations

Type-I: WF: BGF: SP (48:48:4) Type-II: WF: BGF: SP (47:47:6)

Type-III: WF: BGF: SP (46:46:8) Type-IV: WF: BGF: SP (45:45:10)

Type-V: WF: BGF: SP (44:44:12)

WF: Wheat flour BGF: Bengal gram flour SP: Spinach powder

Table 2: Proximate composition of different flour supplemented with spinach powder (% , on dry matter basis)

Proximate Composition	WF 100%	BGF 100%	Composite flours					CD (P=0.05)
			Type-I	Type-II	Type-III	Type-IV	Type-V	
Moisture**	9.89±0.01*	8.90±0.21	10.03±0.14	10.45±0.15	11.10±0.06	11.49±0.14	11.80±0.01	0.42
Crude protein	12.03±0.01	20.25±0.02	15.09±0.01	15.99±0.12	16.20±0.18	16.60±0.39	17.50±0.08	0.53
Crude fat	2.56±0.04	4.98±0.01	3.41±0.06	3.52±0.06	3.65±0.04	3.80±0.05	3.98±0.08	0.16
Crude fibre	1.58±0.04	1.60±0.01	1.87±0.03	1.98±0.03	2.23±0.04	2.45±0.05	2.79±0.02	0.10
Ash	1.89±0.01	2.25±0.03	2.11±0.02	2.40±0.05	2.90±0.02	3.20±0.01	3.52±0.05	0.14

**On wet matter basis *Values are mean \pm SE of three independent determinations

Type-I: WF: BGF: SP (48:48:4) Type-II: WF: BGF: SP (47:47:6)

Type-III: WF: BGF: SP (46:46:8) Type-IV: WF: BGF: SP (45:45:10)

Type-V: WF: BGF: SP (44:44:12)

WF: Wheat flour BGF: Bengal gram flour SP: Spinach powder

Table 3: Total mineral content of different flour supplemented with spinach powder (mg/100 g, on dry matter basis)

Total minerals	WF 100%	BGF m100%	Composite flours					CD (P=0.05)
			Type-I	Type-II	Type-III	Type-IV	Type-V	
Iron	3.55±0.02*	4.99±0.11	5.14±0.07	6.78±0.07	7.89±0.02	8.18±0.09	8.89±0.08	0.27
Calcium	43.55±0.79	58.00±0.23	85.76±0.01	123.14±3.01	152.11±0.47	193.26±0.40	240.31±0.11	4.32
Zinc	1.98±0.02	2.00±0.01	2.34±0.05	2.82±0.07	3.01±0.02	3.29±0.05	3.63±0.07	0.13
Phosphorus	334.59±1.42	339.25±1.15	342.25±1.27	354.10±1.84	368.60±1.85	374.52±2.11	384.53±1.34	5.35

Table 4: Anti-oxidant activity and β -carotene content of different flour supplemented with spinach powder (on dry matter basis)

Types of flours	Anti-oxidant activity (%)	β -carotene(μ g/100g)
WF (100%)	12.03±0.25*	3.87±0.23
BGF (100%)	15.32±0.14	159.89±0.58
Type-I	19.23±0.46	172.29±0.94
Type-II	22.48±0.26	240.69±0.28
Type-III	25.84±0.55	265.42±0.69
Type-IV	29.76±0.24	290.35±0.30
Type-V	33.61±0.71	331.55±0.69
CD(P=0.05)	1.52	1.27

*Values are mean \pm SE of three independent determinations

Type-I: WF: BGF: SP (48:48:4) Type-II: WF: BGF: SP (47:47:6)

Type-III: WF: BGF: SP (46:46:8) Type-IV: WF: BGF: SP (45:45:10)

Type-V: WF: BGF: SP (44:44:12)

WF: Wheat flour BGF: Bengal gram flour SP: Spinach powder

4. Conclusion

It can be concluded that physico-chemical properties of composite flour such as water absorption capacity, oil absorption capacity, swelling power, bulk density and least gelation capacity of five types of composite flours increased significantly with increase in the level of incorporation of spinach powder. On the other hand, crude protein, crude fat, crude fiber, ash and mineral contents increased significantly in all five types of composite flour. Antioxidant activity and β -carotene content also increased significantly. Thus, dehydrated spinach powder have the potential to serve the valuable source of calcium, iron, fibre, vitamin 'C' and carotenoids in the diet of the population in India and other developing countries.

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