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ORIGINAL ARTICLE

Influence of processing on total and extractable mineral content of products prepared from potato flour

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Abstract Potato (*Solanum tuberosum*) flour developed was used for preparing doughnuts, *sevian,* cutlet, *kofta* and *vadi* along with defatted soy (*Glycine max*) flour and corn (*Zea mays*) flour. Frying and fermentation were the major processing techniques employed for the development of these products. Significant differences in protein, ash and fat contents of all the products were observed due to their compositional differences. Processing did not affect on total mineral content. Processing increased ($p<0.05$) mineral availability. Processed products had lower amount of anti nutrients as compared to raw counterparts and thus, higher mineral availability.

Keywords Potato flour · Defatted soy flour · Corn flour · Frying · Fermentation · Mineral availability

Introduction

Potatoes are rich in carbohydrate, making them a good source of energy. They have around 2.1% protein, with an amino acid pattern that is well matched to human requirement. They also contain many micronutrients, including vitamin C, B_1, B_2, B_6 and minerals such as Fe, K, P and Mg (Prokop and Albert 2008). Bulkiness makes fresh potatoes expensive to store and the simple common storage methods leads to high post harvest losses (Horten 1987). Conversion of potato to potato flour extends the shelf life of potatoes and lowers storage cost. To increase its protein content, it is desirable to use potato in combination with other protein rich source. Soybean with 43% protein and 20% fat content is an ideal and cheap source of calories and protein (Gopalan et al. 2007). Defatted soy flour can be incorporated in various food preparations (Ugarcic et al. 1991). To improve the taste, texture and product appeal of products made from potato flour and soy flour, corn flour can be incorporated in small amounts.

Cereals and pulses constitute important sources of dietary calorie and protein for many segments of the world's population. Because of the presence of anti-nutritional factors such as phytic acid and polyphenols (Chauhan et al. 1986), the HCl-extractability of minerals, an index of their bio-availability from cereals and pulses, may be poor (Nolan and Duffin 1987) as they complex with divalent cations. The levels of phytic acid (Awadha et al. 2005) and polyphenols decline (Sindhu and Khetarpaul 2003) and availability of minerals improve (Idris et al. 2005) following domestic processing like heat treatment and fermentation.

Keeping all these facts in view, a study was undertaken to formulate products utilizing potato flour, defatted soy flour and corn flour. Frying and fermentation as processing techniques were used in the development of these products and their quality studied.

Materials and methods

Potatoes (*Solanum tuberosum*) of variety 'Kufri Badshah' were procured from vegetable crops department of the

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university. Potatoes were washed to remove adhering dirt. Unpeeled potatoes (1 kg) were cut into four quarters and pressure cooked in water (1 l) containing 0.5% potassium metabisulphite. Boiled pieces were peeled and mashed and dried overnight in the oven (60 °C) by spreading as a thin film. Dried powder was then ground to fine powder.

Soybean was procured from plant breeding department the university. One kg soybean was boiled in water for 10 min. Husk was removed by rubbing. Dehulled soybean was dried at 60 °C overnight. Dried soy bean was then milled. For defatting, 1 g of soybean was soaked in a 20 ml mixture of chloroform and methanol (2:1) in a conical flask and allowed for overnight. Next day the flask was warmed in water bath for 2 min. It was then filtered and dried on filter paper in the oven at 60 °C for 2 h.

Corn was procured from local market in a single lot and milled.

Preparation of products Various proportions of raw ingredients for different recipes were tried. Proportion of ingredients which was liked best sensorily was selected for the development of final products.

The following products were developed by mixing ingredients in different ratios and following the methods as indicated below.

Potato flour: Defatted soy flour: Corn flour blending ratios are as shown in brackets.

1. Doughnuts (50: 30: 20)
   Sugar (40 g) and ghee (15 g) were creamed and added to beaten egg (30 g). All three flours were mixed with baking powder and sieved. The sieved flours were then added to the creamed mixture. Hard dough was prepared and balls of 8 g were made out of it. The balls were flattened and cut with cutter, deep fried and rolled in sugar.
2. *Sevian* (80: 15: 15)
   All the three flours were mixed and salt (0.5%) was added. Stiff dough was prepared and extruded through the mould. *Sevian* were then fried in refined oil to golden yellow on low flame.
3. Cutlet (60: 25: 15)
   All the three flours were mixed. Boiled with 200 ml of water and mashed peas (20 g), chopped onion (20 g), grated cheese (20 g) and salt was added to the flours. Dough was prepared using water. Balls of 8 g from the prepared dough were made, flattened and fried.
4. *Kofta* (60: 25: 15) were prepared as mentioned for cutlet.
5. *Vadi* (60: 25: 15)

All the three flours were mixed and salt (0.5%) was added. Dough was prepared by adding water and allowed to ferment for 12 h at 27 °C. Small balls of 5 g were prepared from fermented dough and dried in an oven.

Unprocessed formulations were prepared by mixing the raw ingredients in the same proportions and these served as control samples for their respective products.

Table 1 Proximate composition (% dwb) of raw ingredients

	Protein	Ash	Fat
Potato flour	9.5±0.22	5.8±0.28	1.0±0.28
Raw Potato	9.6±0.43	6.0±0.20	1.0±0.50
Defatted soy Flour	42.6±0.10	4.8±0.28	0.7±0.28
Corn flour	10.0±0.21	2.3±0.28	1.8±0.28
SE(d)	0.23	0.20	0.26
CD($p<0.05$)($n=3$)	0.53	0.47	0.61

Table 2 Proximate composition (%dwb) of products

	Protein	Ash	Fat
Doughnuts (R)	17.4±0.15	5.0±0.28	18.3±0.28
(P)	17.5±0.12	4.8±0.28	18.4±0.28
Sevian (R)	12.2±0.21	5.8±0.28	18.5±0.50
(P)	12.2±0.28	5.7±0.28	18.5±1.04
Cutlet (R)	18.0±0.49	5.3±0.28	19.2±1.04
(P)	18.2±0.38	5.2±0.28	19.2±0.76
Kofta (R)	18.1±0.44	5.1±0.50	19.2±0.25
(P)	18.3±0.29	5.0±0.50	19.3±0.28
Vadi (R)	15.8±0.18	5.0±0.28	1.1±0.28
(P)	15.8±0.19	5.0±0.50	1.3±0.28
SE(d)	0.25	0.24	0.53
CD($p<0.05$)$n=3$	0.51	0.51	1.11

R Raw, *P* Processed

Chemical analysis

The products were analyzed for crude protein, ash and fat as per AOAC (1980) methods. The samples were wet acid-digested using nitric acid and perchloric acid mixture (HNO_3: $HClO_4$, 5:1V/V). The amounts of Fe and Zn in the digested sample were determined by atomic absorption spectrophotometry (Lindsey and Norwell 1969). Ca in the digested sample was determined by titration method (Vogel 1962) employing hydroxylamine hydrochloride, triethanolamine polyvinyl alcohol and using calcon as the indicator. The violet colour was titrated against 0.01N EDTA solution to a bluish green end point.

The minerals in the developed products were extracted in 0.03N HCl by shaking the contents at 37 °C for 3 h (Peterson et al. 1943). The clear extract obtained after filteration with Whatman No: 42 filter paper was oven-

Table 3 Total calcium, iron and zinc and their extractability (%) in raw ingredients

	Total (mg/100 g dwb)			Extractability (%) in HCl		
	Ca	Fe	Zn	Ca	Fe	Zn
Potato flour	86.7±1.25	4.1±0.16	4.9±0.21	56.3±2.06	39.2±1.96	45.9±1.02
Raw Potato	87.3±4.04	4.1±0.23	5.1±0.36	54.9±1.77	38.9±2.12	44.6±1.09
Defatted soy flour	228.3±10.10	10.1±0.75	3.4±0.11	48.4±0.97	34.4±0.75	40.9±0.87
Corn flour	19.7±0.46	2.3±0.27	2.8±0.07	50.0±4.19	35.1±0.78	41.8±2.03
SE(d)	3.18	0.35	4.47	2.08	1.26	1.09
CD ($p<0.05$) ($n=3$)	7.25	0.80	10.32	4.79	2.91	2.52

dried at 100 °C and wet acid-digested as mentioned above. The amounts of extractable Ca,Fe and Zn in the digested samples were determined by the methods described above for estimation of total amounts of the minerals.

$$\text{Mineral extractability (\%)} = \frac{\text{Mineral extractable in 0.03 N HCl} \times 100}{\text{Total minerals}}$$

Statistical analysis Three replicate experiments were carried out. The data was processed for analysis of variance according to the standard methods of statistical analysis (Snedecor and Cochran 1967).

Results and discussion

Protein, ash and fat contents of potato flour was almost similar to raw potatoes which indicated that there was non-significant ($p<0.05$) effect of processing on macronutrients content of potatoes (Table 1).

The protein, ash and fat contents of developed products ranged from 12.2 to 18.3 g, 4.8 to 5.6 g, 1.2% to 19.3%, respectively (Table 2). Cutlet and *koft* contained higher ($p<0.05$) protein content among fried and fermented products. Incorporation of 20% cheese into cutlet and *kofta* resulted in higher ($p<0.05$) protein content. *Sevian* had lowest protein content due to incorporation of higher amount (80%) of potato flour as compared to other products. Deep fat frying of doughnuts, sevian, cutlet and *kofta* could account for their higher ($P<0.05$) level of fat as compared to *vadi*. The differences in protein, ash and fat contents in developed products were due to their compositional differences and not because of the effect of processing. One serving of 100 g of various developed products as snacks at tea time could meet about 1/4 to 1/5th Recommended Dietary Allowances (RDA) of protein and 1/2–3/4th RDA of fat of an adult man (Gopalan et al. 2007).

Table 4 Total calcium, iron and zinc and their extractability in HCl in products

	Total (mg/100 g dwb)			Extractability (%) in HCl		
	Ca	Fe	Zn	Ca	Fe	Zn
Doughnuts (R)	124.0±2.78	5.5±0.18	4.2±0.11	45.7±2.22	35.2±1.05	42.9±1.37
(P)	124.3±2.02	5.5±0.22	4.3±0.13	56.1±2.04	40.8±1.40	48.0±2.48
Sevian (R)	112.0±2.29	4.8±0.21	4.6±0.14	46.7±1.56	36.1±1.61	44.6±1.64
(P)	112.5±4.09	4.8±0.21	4.7±0.13	57.3±2.46	42.0±1.82	50.1±1.26
Cutlet (R)	121.5±2.17	5.3±0.21	4.2±0.11	46.1±2.38	35.3±2.04	44.4±1.90
(P)	120.7±2.75	5.3±0.16	4.2±0.12	57.1±1.68	41.0±1.63	50.6±1.36
Kofta (R)	120.2±2.75	5.2±0.18	4.3±0.12	45.5±2.38	34.9±0.55	44.4±2.32
(P)	119.7±2.84	5.1±0.20	4.2±0.09	56.1±1.87	40.7±1.11	50.2±1.36
Vadi (R)	118.2±5.13	5.2±0.18	4.2±0.15	47.2±1.91	34.8±0.87	45.1±1.18
(P)	119.2±4.76	5.2±0.18	4.2±0.10	63.8±1.82	45.3±1.48	52.8±0.68
SE(d)	2.71	0.16	0.10	1.68	1.16	1.34
CD ($p<0.05$) ($n=3$)	5.67	0.35	0.21	3.51	2.43	2.84

R Raw, *P* Processed

Mineral composition of potato flour and raw potato was almost similar indicating no effect of processing on total mineral content (Table 3). Total Ca and Fe contents of doughnuts were higher ($p<0.05$) than *Sevian* (Table 3). Higher value of Ca in doughnuts was due to egg and incorporation of defatted soy flour at 30% level. *Sevian* contained lower ($p<0.05$) level of Ca and Fe because of less amount of defatted soy flour (15%). Doughnut contained lower ($p<0.05$) level of Zn, whereas *sevian* had higher ($P<0.05$) level of Zn. Differences were attributed to the use of different levels of potato flour in their development. Mineral content of cutlet, *kofta* and *vadi* was similar due to use of raw ingredients in the same ratio.

After cooking and autoclaving, no difference was noticed in Mg, Fe, Mn and Zn content of legumes (Borade et al. 1984). Fermentation of rabadi did not alter the total content of Ca, Fe, Cu, Zn and Mn (Dhanker and Chauhan 1989).

The developed products served as good source of essential minerals. One serving (100 g) of developed products contributed approximately 1/4th of calcium RDA and 1/5th of iron RDA of an adult man (Gopalan et al. 2007).

Potato flour, raw potato, defatted, soy flour and corn flour had 48.4% to 56.3% Ca extractability, 29.2% to 34.4% Fe extractability and 40.9% to 45.9% Zn extractability (Table 3). Vadi had higher ($p<0.05$) Ca (63.8%), Fe (45.3%) and Zn (52.8%) extractability (Table 4). This may be attributed to processing difference. Doughnuts, *sevian,* cutlet and *kofta* had similar mineral extractability. Frying increased the extractability of Ca, Fe and Zn by 22.7% to 23.9%. 15.9% to 16.5% and 12.1% to 13.9%, respectively, whereas fermentation increased the values by 35.1%, 30.1% and 17.0%, respectively.

Duhan et al. (2004) reported higher extractability of Cu and Fe in the cooked pigeon pea seeds indicating decrease in phytic acid, polyphenols, saponins and trypsin inhibitors on cooking. Decrease in phytic acid content, possibly through hydrolysis by phytase of fermenting microflora (Dhanker and Chauhan 1987) may indicate that divalent cations are freed from phytate mineral complex resulting into increased HCl extractability. Decrease in concentration of antinutrients and increase in vitro Fe and Ca availability was reported in some legumes by Ghavidel and Prakash (2007). The improvement in HCl extractability of minerals through fermentation has been reported in *rabadi* (Gupta et al. 1991) and pearl millet (Abdel Rahaman et al. 2005).

Conclusion

Potato flour is a highly versatile raw material that can be used in several products. Frying and fermentation, the common household technologies, are thus effective ways for improving the HCl extractability of minerals of products. These developed products could be recommended for feeding children, pregnant and lactating mothers under supplementary feeding program run by government or non-government agencies.

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