Rheology, fatty acid profile and quality characteristics of nutrient enriched pizza base

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Revised: 26 February 2014 / Accepted: 25 March 2014 / Published online: 14 April 2014
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Abstract Enrichment of thick bread type pizza base (PZB) was done by substituting wheat flour (WF) with 5, 10 and 15 % soya protein isolate (SPI). The rheological characteristics of WF showed that water absorption increased, extensibility and peak viscosity decreased when level of SPI increased from 5 to 15 %. Baking studies showed that spread ratio decreased and hardness values of PZB increased with the increase in amount of SPI from 5 to 15 %. Beyond 10 % SPI, the overall quality of PZB was adversely affected. To the optimal blend of 10 % SPI, 5 % psyllium husk (PH) was added and the hydrogenated fat was replaced by canola oil (CAN) in enriched PZB. The enriched PZB treated with combination of additives had 1.7 and 1.6 times more protein and dietary fiber than the control PZB. Fatty acid analysis showed that the enriched PZB had 58.65 % oleic, 6.58 % linolenic acid and 31.28 % polyunsaturated fatty acid and no Trans fat was present.

Keywords Pizza base · Soy protein isolate · *Psyllium* husk · Canola oil · Rheology · Fatty acid profile

Introduction

Pizza, very popular flat bread is being increasingly consumed by people of all age groups all over the world. Pizza crusts can

be divided into two types: thin crust or cracker type and thick bread type crusts. (Lehmann and Dubois 1980; Spooner 1989). Soybean is nature's one of the wonderful nutritional gifts. The composition of soy protein isolate is as follows—Ash - 3.5 %, fat and fiber -0.1 %, protein -96 %, carbohydrates (soluble) -0. Genistein, daidzein, and glycitein are the important isoflavones present in the range of 103–145 mg/100 g of isolate and have got anti-cancerous properties, combats osteoporosis and is used in estrogen replacement therapy (Elridge 1982). The soy protein isolates also possess functional properties like emulsification ability, water holding properties, cohesive properties etc. and is used in bakery products as a functional ingredient and source of protein enrichment (Khan and Lawhon 1980; Dubois and Hoover 1981; Mohamed et al. 2006).

The *Psyllium* husk is obtained from *Plantago ovata*, grown in India and is the outer coat of the seeds referred to as Isabgol in India. It is used as a source of dietary fiber and reduces the cholesterol level. It contains 84–87 % fibre (Liangli et al. 2003). It contains about 85 g soluble fibre per 100 g of *Psyllium* husk and possesses considerable gelling and water absorbing capacity. The effect of *Psyllium* addition in bakery products has been studied by researchers (Park et al. 1997; Mariotti et al. 2009).

Edible canola oil is extracted from whole seeds of varieties from *Brassica campestris* and *Brassica napus* species with low levels of erucic acids and glucosinolates. The fatty acid composition of canola oil is as follows: palmitic acid (16:0) 2–5 %, stearic acid (18:0) 1–3 %, oleic acid (18:1) 53–58 %, linoleic acid (18:2) 19–23 % and linolenic acid (18:3) 8–12 % (Kramer et al. 1983; Gunstone 2004). Canola oil has also been reported to perform well in sponge-type chiffon cakes and brownies (Vaisey-Genser and Ylimaki 1989). Studies on the use of canola oil as replacement for hydrogenated fat in bakery products have been carried out using response surface methodology (Vaisey-Genser et al. 1987).

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The scientific reports on pizza bases are scanty. Quality evaluation of pizza using computer vision and effect of fibre on frozen pizzas have been reported (Sun and Brosnan 2003; Cheng-Jin and Sun 2004; Delahaye et al. 2005). Owing to the popularity of pizza in India, the present study was done with an aim of enhancing the nutritive value of PZB and also to investigate the effect of SPI and PH on the rheology of wheat flour and quality characteristics of thick bread type PZB.

Materials and methods

The refined wheat flour (WF) was substituted by Soy Protein Isolate (SPI) at 0, 5, 10 and 15 %. Preliminary lab trials were carried out using 5 and 10 % *Psyllium* husk (PH) in blend containing 10 % SPI. Results showed that addition of 10 % PH had an adverse effect on the PZB and it was unacceptable. Hence, further studies were carried out using 5 % PH.

Ingredients

Commercial WF obtained from the local market was used for the studies. Compressed yeast (AB Mauri India Pvt. Ltd., Ratnagiri, Maharashtra, India), hydrogenated fat (Dalda, Bunge India Pvt. Ltd., Mumbai, India), skim milk powder (Gujarat Co-operative Milk Marketing Federation Ltd., Anand, Gujarat, India), food grade sodium chloride (Merc Company, Mumbai, India), baking powder (Rex brand, Hindustan Unilever Limited, Mumbai, India) and sugar powder procured from the local market was used in the experiments. Soy Protein Isolate, SPI (SUPRO 640, Du Pont Solae Company, Gurgaon, India), *Psyllium* husk, PH (Sat-Isabgol, Sidhpur, Gujarat, India) and Canola oil, CAN (Hudson Canola Oil, Bunge Ltd, Alberta, Canada) were used in the studies. Protease enzyme (PRO) from *Aspergillus oryzae*, 30,000 HUT/g and Fungal Alpha Amylase (AMY) from *Aspergillus oryzae*, 50,000 SKB units/g obtained from Biocon India Pvt Ltd., Bengaluru Sodium Stearoyl –2-Lactylate (SSL) and vital gluten (GLU) obtained from P.D. Fine Chemicals, Bengaluru, India were used. The SSL gel was prepared using emulsifier and water in the ratio of 1:4. The water temperature was maintained at 60 °C to which SSL was added with continuous stirring to obtain a homogenous gel. Later it was cooled and SSL was used at the level of 0.5 % in the studies. Initial baking trials carried out on the effect of AMY (0.01 and 0.02 g), PRO (0.02 and 0.04 g), GLU (1 and 2 g) for 100 g of flour on quality of enriched PZB showed that 0.02 g of AMY, 0.04 g PRO and 2 g GLU per 100 g of flour were optimal to improve the quality of enriched PZB with 10 % SPI + 5 % PH + CAN. Further studies were carried out using these levels of additives.

Physico-chemical and rheological characteristics of WF-SPI blends

The Wheat Flour (WF) was analysed for moisture, ash, gluten, Zeleny's sedimentation value, protein, Hagberg's falling number and damaged starch. SPI was analyzed for moisture, ash and protein. Moisture, ash, fat, protein and dietary fibre were estimated in PH. WF-SPI blends were analyzed for moisture, ash and protein. All the analyses were carried out as per the AACC methods (2000) and dietary fibre by AOAC method (2000).

The rheological characteristics of the blends were studied using Brabender Farinograph (Model No. 810108004, Duisburg, Germany), Brabender Extensograph (Model No. 996035, Duisburg, Germany) and Brabender Micro Visco-Amylograph (Model No. D-47055 OHG Duisburg, Germany) according to the methods of AACC (2000).

PZB preparation

The formulation used for PZB preparation is as follows-WF: SPI, 100:0 g, 95:5 g, 90:10 g, 85:15 g; compressed yeast 3.5 g, sugar powder 2.5 g, hydrogenated fat/canola oil 4.5 g, skim milk powder 1.0 g, sodium chloride 1.5 g, baking powder 1.5 g; water-farinograph water absorption.

Baking powder, SPI and PH were sieved along with the flour. Yeast, milk powder, sugar and salt were weighed separately and dissolved in part of water. All the ingredients were mixed in a Hobart mixer (Model N-50, Hobart, Germany) for 4 min at 61 rpm. The dough was fermented in a fermentation cabinet maintained at 30 °C at 75 % relative humidity (RH) for 30 min. It was remixed, scaled to 150 g piece, rounded and rested for 5 min. Later the dough was sheeted to 5 mm thickness and cut into circular discs of 15 cm diameter. It was again proofed for 20 min at 30 °C at 85 % RH in a cabinet. The PZB was baked for 7 min at 180 °C, was cooled thoroughly and packed.

Pizza dough characteristics

The sheeting characteristics of pizza dough were evaluated according to Williams et al. (1988). The pizza doughs were scored out of 5 by experienced baking technologists at sheeting as follows: 1 – very weak and fragile/very strong and too elastic springs back when sheeted; 2 – weak and fragile, 3 – fair handling; 4 – good handling and 5 – very good handling properties/flow, extensible and non sticky.

Physical characteristics of PZB

The PZBs were analysed for physical characteristics such as diameter (D) and thickness (T). The spread ratio was

calculated using the formula D/T. The average value of three experiments is presented.

Sensory characteristics of PZB

The sensory analysis of PZBs made by using different levels of SPI was carried out. Seven experienced panel members in the field of baking science and technology carried out the sensory analysis. Different scores were given for crust colour (1 = dark brown, 5 = light brown tinge), crumb grain (1 = coarse grain, 10 = fine uniform grain), texture (1 = hard, 10 = soft), mouth feel (1 = gritty, gummy, chewy, 5 = No residue in mouth, clean mouth feel). Overall quality score, out of 30 is the combined score of all these parameters.

Texture of PZB

Texture Profile Analysis (TPA) of baked PZBs for square shaped samples of 4 × 4 cms was performed using LR-5 K Texture Analyzer (Lloyd Instruments Limited, Hampshire, England). The following conditions were used: Load cell – 5 kgs, Cross head speed – 50 mm/min, Diameter of the probe (circular) – 80 mm, Compression – 50 % of the product height. Each sample was compressed two times in a reciprocating motion to obtain a two-bite texture profile curve. The data were analysed to measure PZB hardness, springiness, gumminess and chewiness as described by Bourne (1978) by using Nexygen Version 4.0 software (Lloyd Instruments Limited, Hampshire, England).

Composition and in vitro protein digestibility of PZB

The moisture, ash, fat, and protein determinations for control and enriched PZB were carried out according to the AACC methods (2000). The dietary fiber estimation was done according to AOAC methods (2000). The in vitro protein digestibility was estimated according to the method of Akeson and Stahman (1964).

Fatty acid analysis of PZB

The fat samples from the control and enriched PZBs were extracted with petroleum ether using a Soxhlet extractor. The fatty acid composition of the control and enriched PZB was determined by analyzing the fatty acid methyl esters by gas-liquid chromatography. The methyl esters were prepared using sodium methoxide according to the method of AOCS (2003) and were analyzed using a Fisons GC 8000 series (Milan, Italy) equipped with a flame ionization detector. Following conditions were used: fused silica capillary column of size 30 m × 0.25 mm (SP2340; Supelco, Bellefonte, PA, USA), column temperature 180 °C, injector temperature

220 °C, detector temperature 230 °C, carrier gas nitrogen 1 ml/min and splitless injector. The peaks obtained in the sample were identified by comparing the retention times with standards and the composition is represented as the relative percentage of individual peaks (Jeyarani and Yella Reddy 2005). Triplicate injections were made and the average value is reported.

Statistical analysis

The data pertaining to chemical characteristics of blends, composition and fatty acid profile of PZBs are expressed as mean ± standard deviation. Statistical analysis of data was done by using Duncan's New Multiple Range Test as described by Steel and Torrie (1960). A completely randomized design was followed with each set of data. The significance level was established at $P \leq 0.05$.

Results and discussions

Chemical characteristics of WF, SPI, PH and WF-SPI blends

The flour had 11.43 % moisture, 0.60 % ash, dry gluten content of 9.45 % and 23 ml Zeleny's sedimentation value, falling number 475 s, damaged starch 8.50 % and protein content of 10.60 %. The SPI had 5.70 % moisture, 4.20 % ash, and 88 % protein content. The PH had 9.80 % moisture, 2.00 % ash and dietary fibre content of 82 %.

The ash and protein contents showed an increasing trend with the increase in the level of SPI in blend (Table 1). This observation is in line with the results of study of Mashayekh et al. (2008) on the substitution of wheat flour by defatted soy flour at 3, 7 and 12 %.

Effect of SPI on the rheological characteristics of wheat flour

Farinograph characteristics The data showed that the water absorption of the WF was 60.4, whereas it increased to 64.8,

Table 1 Chemical characteristics [†] of WF-SPI blends

SPI in blend (%)	Moisture (%)	Protein ^a (%)	Ash ^a (%)
Control	11.43±0.03	10.32±0.02	0.60±0.01
5	10.65±0.032	14.00±0.03	0.77±0.02
10	10.72±0.02	18.10±0.03	0.90±0.02
15	10.25±0.02	21.80±0.03	1.00±0.03
10%SPI + 5 % PH	10.50±0.02	17.60±0.03	1.10±0.03

Values are means of three replicates ± standard deviation

WF wheat flour, SPI soy protein isolate, PH *Psyllium* husk

^a Values on dry basis

Blends ratio of WF: SPI – 100:0; 95:5; 90:10; 85:15

74 and 75 % with 5, 10 and 15 % SPI respectively in the blends. The water absorption was the highest (86.9 %) in blend with 10 % SPI + 5 % PH (Fig. 1). Ribotta et al. (2005) studied the effect of 3 and 5 % addition of SPI in bread making and opined that the water absorption increased with SPI incorporation when compared to wheat doughs due to increase in total protein and also because of the higher water absorption capacity of soy protein. The dough development time increased from 5.3 of that of control to 6.0–7.3 min for blends containing SPI from 5 to 15 %. The dough development time was 13.4 min for blend with 10 % SPI + 5 % PH. Ribotta et al. (2005) stated in their studies on the use of different forms of soya in bread and reported that soya proteins interfere with gluten formation in two ways. One is related to the effect on water availability and the other is the interaction between soy and gluten proteins. Owing to the water absorbing capacity of soy proteins, they compete for water with other constituents. In the present study, a decrease in dough stability was observed as the SPI level increased in the blend and also on the addition of the PH. Basman and Köksel (1999) incorporated barley flour and wheat bran into Bazlama, a Turkish flat bread in order to increase the fiber content and they reported that there was an increase in water absorption with the addition of fibers. A decrease in dough stability upon soya protein fortification has been observed in other studies as well (Mohamed et al. 2006; Mashayekh et al. 2008).

Extensograph characteristics The results indicated that there was an increase in resistance to extension with increase in SPI in blends from 5 to 15 % (Fig. 2). The extensibility and area values showed a decrease with the level of SPI in blend. With the addition of 5 % PH to a blend containing 10 % SPI a

Fig. 1 Effect of SPI blends on the farinograph characteristics of wheat flour. *SPI* soy protein isolate, *PH* *Psyllium* husk

Fig. 2 Effect of SPI blends on the extensograph characteristics of wheat flour. *SPI* soy protein isolate, *PH* *Psyllium* husk, *B.U.* brabender unit

similar effect was observed. Our results are in line with the earlier observations made on addition of soya bean and fiber sources in bread (Basman et al. 2003; Indrani et al. 2010). The authors of these studies have opined that the deterioration of the extension properties of the dough with soy flour supplementation could be related to the dilution of gluten.

Amylograph characteristics The peak viscosity, hot paste viscosity, cold paste viscosity, break down and set back values showed a decrease with the increase in the level of SPI from 5 to 15 % in the blend (Fig. 3). The decrease in peak viscosity could be due to the reduction in the amount of starch available for gelatinisation. When PH was added to the blend with 10 % SPI an increase in peak viscosity was noticed. Matthews et al. (1970) studied the effect of 25 % replacement of wheat flour with oilseed flours like full-fat soy, peanut and safflower on the amylograph characteristics and observed that the peak viscosity, hot paste viscosity and cold paste viscosity decreased with the replacement of wheat flour with oilseed flours when compared with the values of the control. Authors explained that it could be due to the variations in

Fig. 3 Effect of SPI on the amylograph characteristics of wheat flour. *BU* brabender units, *PV* peak viscosity, *CPV* cold paste viscosity, *HPV* hot paste viscosity, *SB* set back, *BD* break down, *SPI* soy protein isolate, *PH* *Psyllium* husk

starch properties of the oilseeds in combination with the wheat flour. Ahluwalia et al. (1994) stated that the amylograph peak viscosity increased with the addition of *Psyllium* to flour owing to the presence of gums.

Physical and sensory characteristics of PZB

The control PZB dough exhibited very good sheeting characteristics and was flowy and extensible. As the level of SPI increased, the sheeting characteristics were adversely affected. The PZB dough with 10 % SPI + 5 % PH + CAN had inferior sheeting characteristics than control and the dough was weak owing to high fiber content. Use of additives improved the sheeting quality of dough to varying extent with PRO producing maximum improvement. However, the combination of additives had a marked improvement on the sheeting properties of the dough as shown by the high score of 4 (out of 5). The dough was non sticky in nature had good spread ability (Table 2).

The diameter of the control PZB was 200 mm and it decreased to 190–172 mm with addition of SPI from 5 to 15 % levels. PZB with 10 % SPI + 5%PH + CAN had a diameter of 160 mm. The control PZB had the highest spread ratio of 10.0 and possessed light brown tinge with a fine uniform crumb grain, soft texture, clean mouth feel with highest overall quality score of 28.5. As the SPI level increased from 5 to 15 %, the spread ratio decreased from 8.64 to 6.37 (Table 2). The crust colour changed to slightly dark brown, crumb grain became denser, texture harder with altered mouth feel and the overall quality score decreased from 27 to 19. PZB with 10 % SPI was optimum, beyond which the quality was drastically affected. Ribotta et al. (2005) reported that soy flours and SPIs produce a gluten network

more permeable to carbon-di-oxide and stated that these pores may allow the gas to escape during baking. The authors stated that soy flours and SPIs decreased the gas retention capacity of doughs when compared with wheat doughs.

With addition of 5 % PH to a blend with 10 % SPI and replacing hydrogenated fat with canola oil, the quality was adversely affected as indicated by the overall quality score of 19.5 out of 30. The different additives brought about improvement of varying degrees on the quality of PZB. The improvement in sheeting properties was very good with PRO in the PZB made with 10 % SPI + 5 % PH + CAN. However, the combination of SSL, PRO, AMY and GLU exhibited maximum improvement in PZB quality with spread ratio of 7.80 and also overall quality score of 26 out of 30. These PZBs had medium fine crumb grain and soft texture. Singh and Katragadda (1980) stated that owing to the action of proteases on properties of flour proteins, the volume of breads increase with positive effects on crumb structure. Indrani et al. (2003) reported that the extensibility increased in dough containing PRO. Kamel and Ponte (1993) concluded that emulsifier may bind to the protein hydrophobic surface promoting aggregation of gluten proteins in dough. A strong protein network results in better texture and increased volume of bread. Serna-Saldivar et al. (1988) used SSL to improve the texture and volume of defatted soya bean and sesame meal breads. Chung (1986) stated that the bread volume improved as SSL interacts with starch, glutenin, gliadin and the soya bean protein resulting in a more extensible dough with better gas retention capacity.

Use of the canola oil in optimised blend of 10 % SPI + 5 % PH produced denser cells as evident by lowest score for crumb grain in sensory characteristics. The texture was soft in case of control PZB and the lowest texture score of 6.5 (out of 10) was

Table 2 Quality characteristics of pizza bases made with different levels of SPI and additives

	Sheeting quality of pizza dough (5)	Diameter (mm)	Thickness (mm)	Spread ratio (D/T)	Crust colour (5)	Crumb (10)	Texture (10)	Mouthfeel (5)	OQS ^a (30)
Control	4.5	200	20	10.00	5 d	9.5 f	9.5 h	4.5e	28.5i
5 % SPI	4	190	22	8.64	5 d	9 e	9 g	4d	27.0 h
10 % SPI	3.5	180	24	7.50	4.5c	7.5 d	7.5d	4d	25.5f
15%SPI	2.5	172	27	6.37	3.5 a	7 b	5.5a	2.5a	19.0a
10%SPI + 5%PH + CAN	2	160	31	5.16	3.5 a	6.5 a	6.5b	3b	19.5b
10%SPI + 5 % PH + CAN + SSL	3.5	165	28	5.89	4 b	7.5 c	7c	4.5e	23.0e
10%SPI + 5 % PH + CAN + PRO	3.5	175	25	7.00	4.5 c	7.5 c	7c	3.5c	22.5d
10%SPI + 5 % PH + CAN + AMY	3	170	26	6.54	4 b	7 b	8e	4d	23.0e
10%SPI + 5 % PH + CAN + GLU	3	173	26	6.65	4 b	7 b	7c	4d	22.0c
10%SPI + 5 % PH + CAN + CAD	4	179	23	7.80	4.5 c	8.5 d	8.5f	4.5e	26.0 g

^a OQS overall quality score (30) is the combined score of crust colour, crumb grain, texture and mouthfeel. SPI soy protein isolate, PH *Psyllium* husk, CAN canola oil, CAD combination of additives (SSL sodium stearoyl -2-lactylate+2 % Gluten, PRO protease, AMY amylase); Means in the same row followed by different letter differ significantly ($P \leq 0.05$)

recorded for PZB containing 15 % SPI and also 10%SPI + 5%PH + CAN indicating a hard texture.

Maleki et al. (1981) studied the effect of emulsifier, sugar and shortening on the Barbari flat bread. The authors reported that the best result was obtained when 0.5 % SSL, 3 % shortening and 12 % full fat soy flour was used in the formulation. Delahaye et al. (2005) used stabilised rice bran flour in the production of frozen pizza dough and stated that the sensory characteristics of pizza dough with an enrichment level of 5 % rice bran flour was well accepted by the panel. Basman and Köksel (1999) supplemented Turkish flat bread-Bazlama with wheat bran and barley flour and reported the acceptability of all samples without any statistically significant differences in attributes such as taste, odour and external appearance than the control. Kamel (1992) studied the characteristics of bread and rolls made with lard and vegetable oils like canola, soya and palm. The breads and rolls made using canola oil had a higher crumb compressibility values than the products made with lard. Use of a combination of surfactants consisting of monoglycerides and SSL in breads with canola oil gave better specific volumes and texture of breads were softer than the breads and rolls made entirely with canola oil only.

Texture of PZB

Figure 4a and b represents the Texture Profile Analysis of PZBs with different levels of SPI and additives. As the level of SPI in blend increased from 5 to 15 %, hardness, gumminess and chewiness values increased, whereas the springiness values decreased. With the addition of 5 % PH and CAN to a optimum blend of 10 % SPI the pizza base hardness values increased and produced a hard textured PZB. Ribotta et al. (2005) in their studies on effect of various forms of soya flour in bread stated that the soy-wheat breads resulted in low specific volumes and hence higher crumb firmness than the control. The use of different additives in this blend brought about improvement decreasing hardness, gumminess and chewiness values. There was an increase in springiness values. Among the additives, PRO produced maximum softness in pizza base by bringing about decrease in hardness values. The combination of additives (CAD), (PRO + AMY + SSL + GLU) brought about maximum improvement in texture of enriched PZB. This enriched PZB had lower hardness, gumminess, chewiness and higher springiness values in comparison with the control PZB.

Clarke and Farrell (2000) studied the effect of recipe formulation on the textural characteristics of microwave-reheated pizza bases. They assessed the impact of water binding agents like pea fibre, oat fibre, locust bean gum, emulsifiers-Panodan (DATEM), Nutrisoft (Mono-and di-glycerides), and fungal protease on the texture profile analysis of microwave-

Fig. 4 a and b. Texture Profile Analysis of pizza bases. *SPI* soy protein isolate, *PH* Psyllium husk, *CAN* canola oil, *OB* optimum blend (10 SPI + 5 PH + CAN), *SSL* sodium stearyl lactylate, *PRO* protease, *AMY* amylase, *GLU* gluten, *CAD* combination of additives (GLU + SSL + PRO + AMY)

reheated pizza bases. The authors concluded that the combination of emulsifier Panodan + oat fibre yielded product with best textural characteristics.

Composition of PZB and In vitro protein digestibility of PZB

The moisture content was 39 and 41 % for control and enriched PZB respectively. There was not much variation in ash and fat contents of control and enriched PZB. The protein and dietary fibre contents of the enriched PZB with 10 % SPI + 5%PH + CAN + CAD was 1.7 and 1.6 times more than the control value (Table 3). Dhingra and Sudesh (2001) stated that when barley flour was replaced separately or in combination with full and defatted soy flours at 15 % level in bread making, it resulted in a marked increase in protein, total lysine, dietary fibre and beta glucan contents.

The protein digestibility was 88.5 % for the control PZB and was 85 % for the PZB made with 10 % SPI + 5%PH +

Table 3 Composition ^Ψ of Pizza bases

	Control PZB	PZB with 10 % SPI + 5 % PH + CAN + CAD
Moisture (%)	39.00±0.03	41.00±0.04
Ash (%)	2.50±0.02	2.80±0.03
Fat (%)	4.20±0.02	4.00±0.02
Protein (%)	8.50±0.02	14.50±0.03
Dietary fiber (%)	4.90±0.02	8.00±0.04

Values are means of three replicates ± standard deviation

SPI soy protein isolate, *PH* *Psyllium* husk, *CAN* canola oil, *CAD* combination of additives (*SSL* sodium stearoyl –2-lactylate + 2 % Gluten, *PRO* protease, *AMY* amylase)

CAN + combination of additives. Lathia and Koch (1989) studied the in vitro protein digestibility of different types of flat breads. They reported protein digestibility values of 81.6 %, 87.6 % and 80.0 %, for pita, naan and chapati respectively and stated that addition of soya flour increases the protein digestibility of bread. Use of yeast also has a positive effect on the protein digestibility. According to Betschart (1982) the true protein digestibility depends upon the crude fibre content of the flour and reported that white bread had only 0.6 % of crude fibre and a protein digestibility of 92.2 % whereas the whole wheat bread had a value of 87 %.

Fatty acid profile of PZB

The replacement of equivalent amount of hydrogenated fat by canola oil in PZB made with 10 % SPI + 5 % PH showed that the major fatty acid in control PZB was palmitic acid (44.5 %) whereas the enriched PZB had oleic acid (58.65 %) in highest amount (Table 4). The control PZB made with hydrogenated fat had no linolenic acid (0 %) whereas the enriched PZB had 6.58 % linolenic acid, an omega-3-fatty acid. The enriched PZB had quite a high PUFA content of 31.28 % when compared to the control value of 4.73 %. Saturated fats and cholesterol represent most established risk factor for cardiovascular disease and there is convincing evidence that replacing saturated fats with PUFA decreases LDL cholesterol concentration (Benatti et al. 2004) and thus has a beneficial effect. The enriched PZB did not contain any trans fat while control PZB had 20.36 % elaidic acid (a trans fatty acid). The main component of TFA formed in processed fats is elaidic (IFST 2007). FDA (1999) assessed TFA consumption by food groups and reported that foods containing partially hydrogenated oils are a major source of TFA. FDA added that main contributors of TFA intake were margarine (16.56 %), cakes and related products (23.82 %), cookies and

Table 4 Fatty acid composition ^{*} of fat extracted from pizza bases (relative percentage)

Fatty acids	Control PZB	Enriched PZB
Myristic acid, C14:0	1.00±0.12	0.63±0.1
Palmitic acid, C16:0	44.51±1.01	6.33±0.49
Stearic acid, C18:0	4.53±0.45	1.83±0.19
Oleic acid, C18:1	24.87±1.16	58.65±2.48
Elaidic acid, C18:1 <i>trans</i>	20.36±1.03	0
Linoleic acid, C18:2	4.73±0.12	24.70±0.93
Linolenic acid, C18:3	0	6.58±0.96
Gondoic acid, C20:1	0	1.28±0.24
Σ Saturated FA	50.04	8.79
Σ Unsaturated FA	49.96	91.21
MUFA	45.22	59.93
PUFA	4.73	31.28

Values are means of three replicates ± standard deviation

FA fatty acids, *MUFA* mono unsaturated fatty acids, *PUFA* poly unsaturated fatty acids

Control PZB made with hydrogenated fat; Enriched PZB made with 10 % SPI + 5%PH + CAN + CAD; *SPI* soy protein isolate, *PH* *Psyllium* husk, *CAN* canola oil, *CAD* combination of additives (*SSL* sodium stearoyl –2-lactylate + 2 % Gluten, *PRO* protease, *AMY* amylase)

crackers (9.78 %), fried potatoes (8.32 %). Thus enriched PZB devoid of TFA is nutritionally superior to control PZB.

Conclusions

Owing to the increased consumption and popularity of pizza base, it can be exploited as a functional ingredients carrier with health benefits. Studies showed that addition of 10%SPI was optimum in bread type pizza base. Addition of 5 % PH and canola oil to this blend affected the overall quality. A judicious combination of additives improved the quality of enriched pizza base and produced an acceptable quality product. Addition of canola oil to enriched pizza base changed the fatty acid profile to a healthy composition by increasing to the oleic, linolenic and polyunsaturated fatty acids than the control pizza base. The enriched pizza base had no trans fat content at all. Also it had increased protein and dietary fibre contents. Thus a popular flat bread can be enriched to produce a nutritious pizza base.

Acknowledgments The authors are very thankful to Dr.U. Purnachand, DuPont Solae Company India Pvt Ltd, Haryana, India for sparing the soya protein isolate sample for our studies.

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