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ORIGINAL ARTICLE

Efficacy of soy protein isolate as a fat replacer on physico-chemical and sensory characteristics of low-fat paneer

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Abstract The nutritional and textural properties of low fat paneer using soy protein isolate (SPI) as fat replacer was investigated. The physico-chemical and sensory characteristics of 4 types of paneer made of low-fat milk (3% milk fat (MF) and 10% solids-not-fat (SNF)) and SPI of 0 (T_1), 0.1 (T_2), 0.2 (T_3) and 0.3% SPI (T_4) were compared with high fat paneer (T_C) made of high fat milk (6% MF and 9% SNF). $CaCl_2$ (0.2%, w/v) was used as coagulant at 75±1°C. Increased level of SPI in paneer increased yield, protein, ash, moisture content and decreased fat, moisture protein ratio, lactose and calorie contents. Titratable acidity and pH varied in narrow range. Instrumental firmness was higher ($p \leq 0.05$) in T_1-T_4 than in T_C. The gumminess, chewiness and firmness showed the same trend. Resilience and cohesiveness values showed no significant difference among the samples. Hunter colour L values showed a decreasing, and a and b values increasing trend with increasing levels of SPI. Sensory appearance and colour scores were lower ($p \leq 0.05$) for T_1-T_4 than T_C. More than 0.2% SPI imparted beany flavour to paneer.

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Keywords Low-fat paneer · Soy protein isolate · Physico chemical · Texture · Colour · Sensory quality

Introduction

Paneer (Indian cheese) is a heat-cum-acid coagulated traditional dairy product used in variety of Indian culinary dishes. Paneer preferably prepared from buffalo milk contains high fat (25%). Various fat replacers like soy milk, soy flour, calcium groundnut isolates/ calcium soy isolates and whey protein concentrate were tried to prepare low fat paneer. Calcium groundnut isolates/ calcium soy isolates addition in skim milk and vegetable mixture increased the protein content to 50% (Kanawjia et al. 1990). Addition of 0.1% $CaCl_2$ as a coagulant in cow milk at 85°C improved the quality and yield of cow milk paneer (Singh and Kanawjia 1988). Soy protein isolate (SPI) contains high quality protein and fat less than 1% (no saturated fat). Addition of SPI also improved the texture of the products, flavour and also acts as an emulsifier (SANA 2004). According to Nurcan and Mustafa (2004) fat replacers decrease the textural values like hardness, springiness, gumminess and chewiness but increase cohesiveness. Thus, present study was focused to examine the nutritional and textural properties of low fat paneer prepared by addition of SPI as fat replacer and $CaCl_2$ as coagulant.

Materials and methods

Milk was obtained from dairy farm of the Institute and standardized to 3% milk fat (MF) and 10% solids-not-fat (SNF) by adding skim milk powder (Verka brand)

procured from local market. The SPI was obtained from Du Point India Pvt Ltd., Gurgacon (imported from Solae Company, Hong Hong/US). $CaCl_2$ (extra pure) was procured from Sisco Research Laboratories, Mumbai. Other chemicals used for experiment were of analytical quality grade.

Preparation of paneer Four types of paneer including high fat paneer (HFP) (T_C 6% MF and 9% SNF) and SPI 0% (T_1), 0.1% (T_2), 0.2%, (T_3) and 0.3% (T_4) incorporated low-fat paneer (SLFP) were prepared separately, using $CaCl_2$ (0.2% w/v) as coagulant. The processing technology of paneer was standardized on the basis of preliminary trials. SPI was added at 50°C and 0.2% $CaCl_2$ (w/v) at 60° C continuing heating up to 75±1°C to ensure its complete coagulation.The coagulated mass was pressed in paneer mould kept under 3 kgf static load for 20 min. Paneer was transferred to chilled water and drained for few minutes before packing in low density polyethylene (100 micron) films.

Physico-chemical analysis Protein (micro-Kjeldahl method), fat (ISI 1981), and lactose (ISI 1973), moisture, ash and titratable acidity (AOAC 1995) and pH of paneer O'Keffe et al. (1976) were determined. The processing parameters such as yield, frying loss were determined by weighing samples. Calorie content was calculated on the basis of 4, 9 and 4 formula.

Sensory evaluation All the products were subjected to sensory evaluation using 8- point descriptive scale (Keeton 1983) by a team of 6 panel members in the laboratory.

Texture analysis Texture profile analysis was conducted using Texture analyzer (*TA-HDi*, Stable micro system, UK). Sample size of 2 cm×2 cm × 2 cm was subjected to pre-test speed (2 mm/sec), post-test speed (5 mm/sec) and test speed (1 mm/sec) with a deformation of 3 mm, time (2 sec) having a load cell of 500 N. A compression platform of 25 mm was used as a probe. Firmness, gumminess, springiness, resilience chewiness, and cohesiveness were calculated from the force-time plot.

Colour profile analysis Colour profile was measured using Hunter Colour Lab (Mini XE, portable type, Hunter Color Associates Inc, Reston, VA) having setting of cool white light (D_{65}) and 2°. L (100 brightness/ 0 lightness), a (+redness/−greenness), b (+yellowness/−blueness) values were recorded.

Statistical analysis Each experiment was repeated thrice and analytical parameter was carried out in duplicate (n=6). The mean and standard deviations were calculated using statistical software SPSS following the procedure of Snedecor and Cochran (1994). The statistical significance of the data was determined at $p \leq 0.05$ and was compared using Duncan's multiple range tests.

Results and discussion

Physico-chemical quality Table 1 reveals that fat and fat on dry matter has been reduced ($p \leq 0.05$) from T_C to T_1-T_4. Lower fat and lactose contents in T_2, T_3, and T_4 as compared to T_1 may be due to increased yield. Similar findings were reported in paneer (Chawla et al. 1987; Singh and Kanawjia 1991).

Protein and ash contents of T_1, T_2, T_3, and T_4 were higher ($p \leq 0.05$) than T_C due to increase in SNF content as well as incorporation of higher SPI levels. The moisture protein ratio was higher ($p \leq 0.05$) in T_C than in T_1, T_2, T_3, and T_4. Moisture content in T_1, T_2, T_3, and T_4 was higher ($p \leq 0.05$) than in T_C. Thus moisture and protein contents increased with decrease in fat content of paneer. Similar findings were reported in paneer by Ashraf Pal and Yadav (1992) and Singh and Kanawjia (1988). Higher fat in milk results in lower moisture retention in the final product of paneer. The titratable acidity and pH showed non significant difference for different samples. The paneer yields in T_1-T_4 were comparable to T_C. Lactose content was in the range of 2.3–2.4% in all samples. Similar findings were reported in paneer by Singh and Kanawjia (1988). The calorie content was lower ($p \leq 0.05$) in SLFP than in HFP. The frying losses were lower with the decrease of paneer fat content (Table 1).

Sensory appearance and colour scores were lower ($p \leq 0.05$) for SLFP than for HFP and the values decreased with increase in SPI levels (Table 2). Up to 0.2% SPI (T_2) level low fat paneer did not affect the flavour scores, however beany flavour was perceptible for paneer beyond this level. Fortification with $CaCl_2$ improves mouth feel and appearance (FAO 1995). In 0.3% SPI (T_4), texture and juiciness were decreasing, which might be due to increased levels of protein content, however there was no significant difference as compared to T_3. Texture, juiciness and overall acceptability scores were higher ($p \leq 0.05$) for T_3 than for T_1, but lower as compared to T_C. Functionality of SPI is related to surface-active properties, fat, solubility, gelation, emulsification, dispersibility and viscosity (Ortheofer 1978; Richert and Kolar 1987; SPC 1987; SANA 2004). According to Wilkens et al. (1967), heat denaturation of lipoxygenase reduces beany flavour in soy products.

Texture profile of paneer Firmness of paneer was higher ($p \leq 0.05$) in T_1 than in T_2, T_3, T_4 and T_C (Table 2). Similar

Table 1 Effect of soy protein isolate (SPI) incorporation on the physico-chemical attributes of low fat paneer

	High fat paneer (T_C)	SPI level, %			
		0 (T_1)	0.1 (T_2)	0.2 (T_3)	0.3% (T_4)
Moisture, %	54.8±0.45^{b}	57.7±0.52^{a}	57.7±0.58^{a}	57.8±0.39^{a}	57.9±0.21^{a}
Fat, %, (w/w)	23.1±0.79^{a}	13.2±1.02^{b}	13.0±0.85^{b}	12.7±0.54^{bc}	12.4±0.32^{c}
Fat, %, (db)	56.8±0.41^{a}	31.1±0.90^{b}	30.7±0.84^{b}	30.0±0.81^{c}	29.3±0.71^{c}
Protein, %	17.7±0.38^{c}	23.9±0.51^{b}	24.4±0.32^{ab}	24.7±0.47^{a}	24.9±0.37^{a}
Ash, %	2.2±0.23^{b}	2.5±0.21^{ab}	2.5±0.21^{a}	2.5±0.33^{a}	2.5±0.39^{a}
Lactose, %	2.3±0.33^{b}	2.4±0.23^{a}	2.4±0.15^{a}	2.4±0.23^{a}	2.3±0.23^{ab}
Moisture/Protein ratio	3.1±0.06^{a}	2.4±0.06^{b}	2.4±0.10^{b}	2.3±0.09^{bc}	2.3±0.11^{c}
Calorie (kcal)	287.3±1.24^{a}	236.2±0.79^{b}	223.9±0.86^{c}	222.1±0.86^{c}	220.1±0.86^{c}
Titratable acidity, % lactic acid	0.23±0.02	0.24±0.01	0.23±0.04	0.23±0.01	0.24±0.03
pH	5.5±0.08	5. 5±0.07	5. 5±0.06	5.5±0.05	5.5±0.04
Frying loss, %	14.2±0.35^{a}	13.0±0.18^{b}	13.1±0.12^{b}	13.1±0.21^{b}	13.2±0.27^{b}
Yield, %	21.0±0.76^{a}	19.0±0.74^{c}	19.5±0.61^{b}	20.3±0.48^{a}	20.5±0.36^{a}

Means with different superscripts in the same row differ significantly ($p \leq 0.05$) ($n=6$)

results were reported in paneer by Chawla et al. (1985) and Kanawjia and Rizvi (2003). Nana et al. (1995) reported that higher protein content increased hardness and reverse is true with increased level of moisture, fat, and salt content. Gumminess of T_1 was higher ($p \leq 0.05$) than T_C. Springiness value for T_C (0.98 mm/mm) was higher ($p \leq 0.05$) compared with SPI samples (0.91–0.92 mm/mm). This may be attributed to binding characteristics of SPI causing the formation of a gel matrix which in turn results in a more stable product (El-Nagar et al. 2002). There is no significant difference in resilience and cohesiveness of T_C and SPI samples. Chewiness of SPI samples were higher ($p \leq 0.05$) compared to T_C. The chewiness was marginally higher with lower fat content in paneer. These results correlated with Nurcan and Mustafa (2004).

Table 2 Effect of soy protein isolate (SPI) incorporation on instrumental texture, colour and sensory quality of low fat paneer

Parameters	High fat paneer (T_C)	SPI level, %			
		0 (T_1)	0.1 (T_2)	0.2% (T_3)	0.3% (T_4)
Textural quality					4.9±0.17^{c}
Firmness, N	4.5±0.36^{d}	5.2±0.34^{a}	5.1±0.51^{b}	4.9±0.17^{c}	
Gumminess, N mJ/mJ	2.2±0.33^{c}	2.7±0.16^{a}	2.6±0.43^{b}	2.6±0.24^{b}	2.6±0.23^{b}
Springiness, mm/mm	0.9±0.13^{a}	0.9±0.11^{b}	0.9±0.19^{b}	0.9±0.11^{b}	0.9±0.17^{b}
Resilience, mJ/mJ	0.6±0.17^{a}	0.6±0.18^{a}	0.6±0.14^{a}	0.6±0.17^{a}	0.6±0.16^{a}
Chewiness, N mm	2.2±0.18^{d}	2.5±0.12^{a}	2.4±0.21^{b}	2.3±0.11^{c}	2.4±0.23^{b}
Cohesiveness, mJ/mJ	0.5±0.14^{a}	0.5±0.23^{a}	0.5±0.11^{a}	0.5±0.25^{a}	0.5±0.23^{a}
Hunter colour					88.9±1.43^{c}
L	90.4±1.35^{a}	89.9±1.46^{a}	89.6±0.12^{a}	89.1±1.43^{b}	
a	−1.3±0.18^{c}	−1.3±0.22^{c}	−1.1±0.32^{b}	−1.0±0.17^{a}	−1.0±0.17^{a}
b	9.6±0.29^{d}	10.3±0.22^{c}	10.7±0.31^{b}	11.1±1.99^{a}	11.3±1.99^{a}
Sensory quality					5.9±0.47^{d}
Appearance and colour	7.7±0.41^{a}	6.9±0.0.57^{b}	6.7±0.41^{b}	6.1±0.52^{c}	
Flavour	7.4±0.46^{a}	6.3±0.54^{b}	6.2±0.46^{b}	6.1±0.40^{b}	5.9±0.40^{c}
Texture	7.6±0.49^{a}	5.3±0.63^{d}	5.8±0.49^{c}	6.4±0.43^{b}	6.1±0.33^{b}
Juiciness	7.3±0.48^{a}	5.2±0.84^{d}	5.4±0.48^{c}	5.9±0.43^{b}	5.8±0.56^{b}
Overall acceptability	7.4±0.40^{a}	5.7±0.60^{d}	6.0±0.40^{c}	6.4±0.42^{b}	6.1±0.22^{c}

Means with different superscripts in the same row differ significantly ($p \leq 0.05$)($n=6$)

Colour profile analysis There was a decreasing trend for L value. L value is directly proportional to fat content of paneer, which may be due to light scattering of fat particles (Table 2). The a and b values of SPI samples were higher than control. The SPI incorporation would have increased the amine compounds that react with aldehydes during Maillard reaction to form dark pigments (melanoidins) (Akesowan 2009). Values for a, which signify red (+) and green (−) and b, which signify yellow (+) and blue (−), increased with increasing levels of SPI incorporation, demonstrating that added SPI samples were more green and yellow coloured. This could be attributable to the colour difference between control milk (white colour) and SPI (light brown colour).

Conclusion

Low fat paneer (12.7% fat) containing 0.2% SPI level (T_3) using 0.2% $CaCl_2$ as a coagulant was superior to other levels tested. Addition of higher level than 0.2% of SPI imparted beany flavour to the final product. Instrumental firmness, gumminess, and chewiness values of SPI samples was higher than control (T_c). Springiness values showed decreasing trend with incorporation of SPI. There was no significant difference in cohesiveness and resilience of high fat paneer with SPI enriched low fat paneer. The Hunter colour L value decreased with increase of a and b values of paneer for increased SPI levels incorporations.

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