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ORIGINAL PAPER

Effect of potato incorporation on the physico-chemical, textural and sensory properties of processed cheese

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Abstract The aim of the present study was to incorporate potato for the development of processed cheese rich in carbohydrates with low fat content and to minimize the cost without affecting the overall quality. A blend of young and old Cheddar cheese was used in the preparation. Boiled and mashed potatoes were incorporated at a level of 20, 30 and 40% and the effect on the physico-chemical, textural and sensory properties were evaluated. Results showed that with the increased level of potato incorporation into the processed cheese, moisture content increased whereas fat and protein content decreased. On textural properties no significant difference ($p > 0.05$) was found till 20 and 30% incorporation, but at 40%, hardness and gumminess was significantly ($p < 0.05$) lower than the control. On sensory properties, flavour intensity decreased with the increased level of potato incorporation but was non-significant ($p > 0.05$) till 30% level but at 40% it was significantly lower ($p < 0.05$) than the control. Cheese samples with 40% potato level were found to be very soft and sticky but those with 20 and 30% were found to have a smooth firm body and a better mouth feel. Colour and appearance was almost similar in all samples. Our results suggest that an acceptable quality processed cheese can be made with up to 30% potato incorporation. However, with slight modification of processing parameters, more than 30% can also be incorporated without any adverse effect on the overall quality of the processed cheese.

Keywords Cheddar cheese · Potato · Processed cheese · Physico-chemical · Texture analysis

Introduction

Processed cheese (PC) is a dairy product which differs from natural cheese in the fact that it is not made directly from milk. It is produced by blending natural cheese of different ages and degrees of maturity in the presence of emulsifying salts and other dairy and non dairy ingredients followed by heating and continuous mixing to form a homogeneous product with an extended shelf life [1–4]. Non-dairy ingredients represent a huge growth potential for the dairy industry, and may be widely explored through the development of new processes, and products. Various non dairy ingredients have been utilized in the production of processed cheese products. These include wheat fibre, mustard oil, egg protein, nuts, decolorized blood protein, extract of concentrated fruit juices and/or fruit pulp [5], spice extracts [6] and oats [7].

Potatoes (*Solanum tuberosum* L.) have a potential to be added as an ingredient in PC as they do not impart any flavour to the product, are low in fat and readily available at a low cost throughout the year. Besides being a carbohydrate and energy source, they are also rich in micronutrients like vitamin C, B vitamins and potassium, as well as carotenoids and antioxidant phenols [8]. India is the third largest producer of potato in the world [9] and the per capita availability has gone up in the recent years [10]. It is a perishable commodity and has either to be consumed within a short period or requires cold storage. Due to inadequate, expensive and unevenly distributed cold store facilities, there are frequent gluts in the market causing substantial economic loss to the farmers and wastage of precious

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food [11]. Therefore, it is essential that potato consumption is increased to sustain increased production and to ensure remunerative prices to the farmers. Under the existing circumstances, processing of the bulky perishable potato or utilizing them as ingredients into various processed products can help to save the wastage of precious food during gluts, solve the problem of storage, serve as a means to increase the supply in off seasons thus maximizing the potato utilization [12]. Incorporation of potato into the PC will help in upgrading this cheap source of nutrition. Moreover, it will produce a low fat, carbohydrate rich cheese which otherwise is lacking in carbohydrates.

Texture is a primary quality attribute of cheese. The overall appearance and mouth feel of cheeses are appreciated before their flavour [13]. Cheese texture is defined in terms of hardness, cohesiveness, gumminess, springiness, adhesiveness, chewiness and so on. All these quality attributes are affected with any alteration in the basic composition of the natural cheese or alteration of ingredients used for processing or any modification of processing parameters. In the current study, potatoes were incorporated into the PC up to a level of 40% and its effect on the physico-chemical, textural and sensory properties were evaluated.

Materials and methods

Materials

Cheddar cheese, both young (1–2 month ripened) and old varieties (6 months ripened) obtained from the dairy plant of NDRI Bengaluru were used for the manufacture of PC. Common salt and potatoes (*Solanum tuberosum* L.) were procured from the local market. Tri-sodium citrate was used as emulsifying salt for PC preparation.

Manufacture of processed cheese

A blend of Cheddar cheese (25% old and 75% young Cheddar cheese) was taken for the preparation of PC. The young and old Cheddar cheeses were cleaned, quartered and milled by using milling motor (WFC and Company USA: Model no 32). Double jacketed steam kettle (Milkmax Engineers Bengaluru) with a capacity of 10 Kgs was used for the preparation of PC. Milled cheese was taken into cheese processing kettle. Calculated amount of salt (1%) and Tri-sodium citrate (3%) as emulsifier were dissolved in calculated amount of hot water and added into the cheese intermittently while heating. When the mass became homogeneous then boiled and mashed potatoes were added (0, 20, 30 and 40%) and mixed thoroughly. The contents in the vessel were heated to 75 to 80 °C for 4–5 min with continuous stirring and scraping of the surface with a steel ladle. Thereafter, the heating was stopped and the hot product was transferred into moulds, cooled for 2–3 h at room temperature, packed and stored at refrigeration temperature till its further use.

Chemical attributes

Moisture content of the PC was determined by gravimetric method [15]. Fat content, tritable acidity and ash contents were determined as per the method described in AOAC [16]. Total protein was determined by micro kjeldhal method according to AOAC [16] with some modification.The pH of cheese was measured as described by Awad et al. [17]. Carbohydrate content was determined by difference method i.e. hundred minus total content of protein, ash, moisture and fat [18].

Texture analysis

Textural properties of the processed cheese were assessed using a TA.XT.plus texture analyzer (Stable Micro Systems Ltd., Godalming, UK). The samples were cut into 2 cm cubes and measurements were performed by two sequential compression events (a trigger force of 2 g, a probe speed of 2 mm/s, 50% compression and time 30 s.) using a 75 mm compression platen probe after tempering the samples for 45 min at 25–30 °C.

Sensory analysis

Sensory analysis was carried out using a 20 point score card. The judged parameters were: appearance (4), body and texture (8) and flavour (8) as described by Meyer [1]. The evaluation was carried out under proper lighting by an expert panel of minimum eight judges.

Statistical analysis

The statistical analysis was executed using the statistical software SPSS 16.0 (Stat Soft Polska Sp. z o. o., Kraków, Poland). One way analysis of variance (ANOVA) was performed and significant differences among samples were reported according to Duncan's test at 5% level ($p < 0.05$).

Results and discussion

Physico-chemical analysis

Proximate composition of control PC and cheese made with different levels of potatoes is depicted in Table 1. It was observed that the increased level of potato addition increased the moisture content and pH of cheese while it

Table 1 Proximate composition of potato incorporated processed cheese along with control processed cheese

Attributes	Control processed cheese	Potato incorporated processed cheese		
		20%	30%	40%
Moisture (%)	42.48 ± 2.23^{a}	43.86 ± 1.26^{ab}	45.88 ± 2.87^{ab}	48.85 ± 0.37^{b}
Fat (%)	30.82 ± 1.08^{a}	25.69 ± 2.39^{b}	24.72 ± 2.47^{b}	23.61 ± 2.65^{b}
Protein (%)	23.57 ± 0.11^{a}	21.45 ± 0.48^{b}	20.12 ± 0.84^{b}	18.30 ± 0.28^{c}
Ash (%)	4.08 ± 0.08^{a}	3.83 ± 0.02^{b}	3.74 ± 0.01^{c}	3.72 ± 0.01^{d}
Carbohydrate (%)	0.03 ± 0.56^{a}	4.41 ± 1.18^{b}	6.61 ± 0.36^{c}	6.74 ± 1.04^{c}
pH	5.35 ± 0.10^{a}	5.45 ± 0.16^{a}	5.47 ± 0.11^{a}	5.52 ± 0.18^{a}
Acidity (% lactic acid)	1.33 ± 0.25^{a}	1.16 ± 0.09^{ab}	0.96 ± 0.21^{ab}	0.9 ± 0.21^{b}

Results are expressed as Mean ± SD; means with different superscripts in a row differ significantly ($p < 0.05$) ($n = 3$)

decreased the acidity, fat, protein and ash contents. The increase of moisture in cheese made with up to 30% potato was non significant ($p > 0.05$) as compared to control. However, cheese with 40% potato showed significantly ($p < 0.05$) higher moisture content (48.85%) than the control (42.48%).

As expected, fat and protein contents decreased significantly ($p < 0.05$) with the increased level of potato incorporation as compared to control. The decrease in fat and protein content could be due to the partial replacement of cheese protein and fat with the potato starch. Since potato was added, carbohydrate content significantly ($p < 0.05$) increased in all potato incorporated samples. Ash content decreased with increased level of potato incorporation. The pH value increased with the increased level of potato incorporation but there was no significant difference ($p > 0.05$) among the samples but the acidity of 40% potato added cheese decreased significantly ($p < 0.05$) to 0.9%. The decrease in acidity and increase in pH could be due to the replacement of 40% of cheese base which is moderately acidic (pH 5.1–5.3) with the potatoes which are low acidic foods with a pH value of 6.1 [13].

Textural properties

It was observed that increasing potato incorporation tended to decrease the measured textural parameters, except adhesiveness which increased with increased potato level (Fig. 1). However, PC made with up to 30% potato did not show any significant difference ($p < 0.05$) in the textural parameters when compared to the control. Texture which is the primary quality attribute of the cheese [14] was not significantly affected by potato incorporation up to 30%. Hardness and gumminess (9.95 N and 3.98 N respectively) of cheese made with 40% potato were significantly ($p < 0.05$) lower than the control (18.2 N and 7.39 N respectively). Cohesiveness, springiness and chewiness decreased whereas adhesiveness increased with incorporation of potatoes but the difference was non significant ($p > 0.05$) when compared to the control.

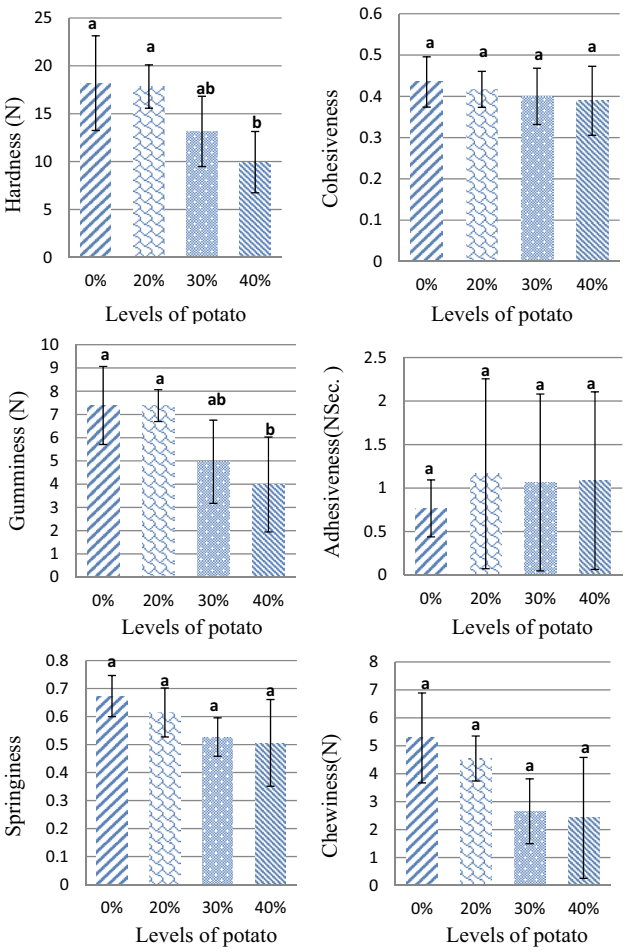

Fig. 1 Effect of different levels of potato on the textural properties of processed cheese; *bars* with different *alphabets* in a *bar chart* are significantly different ($p < 0.05$) ($n = 3$)

The decrease in these textural parameters can be attributed to the increase in the moisture as well as the decrease in protein content of the cheese. Similar results of reduction

in textural properties with the increased moisture and decreased protein content has been reported by Rather et al. [19]. It is well established that greater the moisture content, the softer the cheese as water tends to weaken the protein structure of cheese. According to Hennelly et al. [20] the decrease in hardness that accompanies higher moisture levels could contribute to protein hydration and, consequently, matrix plasticization. Major structure forming constituent in cheese is the casein matrix where fat globules are entrapped; water is bound to casein and fills interstices of the matrix [20, 21]. Decrease in the protein content alters the interactions within the matrix thus reducing the textural properties. Another reason could be the increase in pH caused by potato addition. It is well established that the texture of processed cheeses varies with pH. Published studies on the effect of pH on processed cheese texture showed that low pH cheeses are firm whereas high pH products are moist and spreadable [23, 24]. Effect of moisture content on springiness is not clear, i.e., both increase and decrease in springiness with moisture content have been reported [25–27].

Adhesiveness, which is the tendency of the processed cheese to resist separation from a material it contacts [28, 29], increased with the incorporation of potatoes. This could also be due to the increased moisture content [30]. The increased adhesiveness can also be attributed to the decrease in the fat content as reduced fat cheese tends to be more elastic and more adhesive [26, 31, 32].

Sensory properties

The effect of potato incorporation on sensory characteristics of PC is shown in Fig. 2. It was found that the colour and appearance of the cheese was not affected with up to 30% potato incorporation however, body and texture and flavour scores decreased slightly than that of control. Body and texture score at 20% potato incorporation was similar to that of the control. Flavour score (7.17) decreased but did not differ significantly ($p > 0.05$) from the control. Body and texture and flavour scores of 30% potato incorporated cheese were 7.16 and 7.13, respectively which were not significantly ($p > 0.05$) different from those of the control. Potato incorporation up to 30% resulted in a smooth body with a better mouth feel.

PC with 40% potato lost its colour and appeared to be more white but its score was not significantly different ($p > 0.05$) from the control whereas, body and texture score (6.76) was significantly lower ($p < 0.05$) as compared to that of the control (7.4). Cheese began to lose its firmness and gradually became soft. Flavour intensity also got reduced and the score (6.93) was significantly lower ($p < 0.05$) than the control.

Higher incorporation of potato caused a decrease in the body and texture as well as reduced the flavour intensity which had a negative effect on the overall acceptability of the product. The incorporation of potato at 40% level resulted in a product with soft and loose body in contrast to the control cheese. The decrease in the body and texture could be attributed to the increase in the moisture content with the incorporation of potatoes as shown by the physico-chemical analysis (Table 1). The decrease in the body and texture score was further confirmed from the textural studies (Fig. 1) which showed that with the increased level of potato incorporation into the processed cheese the textural properties decreased. Acidic flavour of the cheese got reduced but was acceptable. The reduction in the flavour score occurred due to the incorporation of potatoes which are rich in starch. Molecular interaction between helical chains of starch and the aroma compounds could cause the decrease in the concentration of aroma compounds [33]. It was confirmed from physico-chemical analysis that acidity decreased which confirms the decreased cheese flavour.

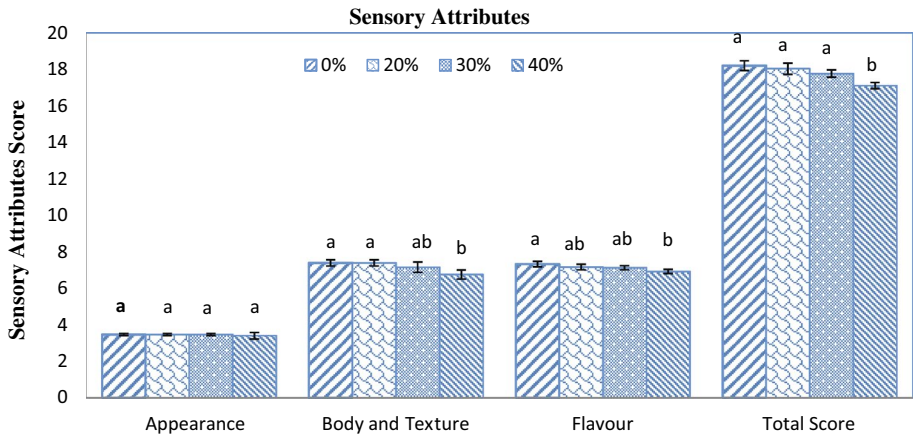

Fig. 2 Effect of different levels of potato on the sensory attributes of processed cheese; *bars* with different *alphabets* in a *bar chart* are significantly different ($p < 0.05$) ($n = 3$)

Conclusion

Potatoes were incorporated into the processed cheese at a level of 20, 30 and 40%. Potato incorporation significantly reduced fat, protein and ash content and increased carbohydrate content. Incorporation of potatoes up to 30% had no significant effect ($p > 0.05$) on the sensory and textural parameters of the processed cheese. It was concluded that an acceptable quality processed cheese can be made with up to 30% potato incorporation. However, with slight modification of processing parameters like decrease in amount of water addition, increase in processing time and temperature, more than 30% can be incorporated without any adverse effect on the overall quality of the PC.

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