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RESEARCH ARTICLE

Optimization of ingredients and processing parameters for the development of Cheddar cheese based beverage

Nikunj Sharma, Ashutosh Upadhyay , Syed Mansha Rafiq (✉), Syed Insha Rafiq

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Abstract: The present study was carried out to develop Cheddar cheese based beverage by optimizing the level of ingredients and the processing parameters to meet the increasing consumer demand for functional foods. Cheddar cheese (5-6 months ripened) was used for the preparation. The effect of varying the Cheddar cheese to water ratios (1:1, 1:2 and 1:3) along with different type of emulsifying salts, TSC (tri-sodium citrate) and STPP (sodium tri-polyphosphate) and processing parameters like cooking time (4 & 6 min) and stages of water addition (2 & 3 times) on the moisture, viscosity and sensory properties of the developed beverage were studied. At cheese to water ratio of 1:3 fat separation was found to occur even after using tri-sodium citrate and sodium tri-polyphosphate as emulsifiers at all processing conditions. Cheese to water ratio of 1:1 resulted in highly viscous product. At cheese to water ratio of 1:2 it was found that the type of emulsifier used, cooking time and stages of water addition had a significant ($p<0.05$) effect on the beverage properties. Acceptable quality cheese beverage was made at cheese: water of 1:2 with sodium tri-polyphosphate as an emulsifier when cooked for 4 minutes with water added at 2 stages. The resultant product showed acceptable moisture content of 71.88$\pm$ 0.17%, viscosity of 2.04 $\pm$ 0.06 Pa s at room temperature with good sensory scores and creamy mouthfeel.

Keywords: Cheddar cheese, Beverage, Emulsifying salts, Sensory, Rheology

National Institute of Food Technology Entrepreneurship and Management, Sonipat, Haryana
Syed Mansha Rafiq (✉)
NIFTEM, Sonipat Haryana
Ph: 9686435524
Email: mansharafiq@gmail.com

Introduction

Functional foods are the foods which at efficacious levels are found to result in potentially positive effects on health beyond basic nutrition (Granato et al. 2020). The market demand for such foods is increasing continuously. Cheese is one among those products and is considered superior to non-fermented dairy products in terms of nutritional attributes as the microflora present produce simple compounds like lactic acid, amino acids and free fatty acids that are easily assimilable. It is an excellent source of calcium and protein and rich in several vitamins. Cheese is a good source of bioactive peptides and conjugated linoleic acid (CLA) which provide many health benefits. Both of these components are reported to be anticarcinogenic and antihypertensive. Cheese contains friendly bacteria that have been shown to promote immune and intestinal health, in addition to their anti-inflammatory effects (Kanawjia et al. 2018). Cheddar cheese is a hard variety of natural cheese produced by acidification of milk and concentration of milk proteins followed by formation of gel by rennet (Banks, 2002). Natural cheeses are processed into different products by heating and continuous agitation with the addition of emulsifiers (Rafiq & Ghosh, 2017) . Various emulsifying salts such as citrates and phosphates have been used in the preparation of processed products from natural cheese (Kapoor et al. 2007).

The beverage market of India is witnessing an interesting transformation. Earlier the sugary beverages and carbonated drinks were popular among the consumers but these are now giving way to health drinks which can be attributed to the changing consumption pattern. Nowadays consumers demand natural and functional products. The studies are focussed on the preparation of dairy beverages based on cheese whey utilization. A number of healthy milk and whey based beverages are available in the market but no attempts have been made so far to develop cheese based beverages. Cheese based beverages have the potential to fill the gap for those consumers who are looking towards healthier options. The cheese market of India is growing @ 20-25% and seeing the current scenario there is a need to diversify the cheese market in India. One of the ways is to process the natural cheese into beverages. In this study, an attempt was made to develop Cheddar cheese based (CB)

beverage for health conscious consumers and diversify the cheese market.

Materials and methods

Materials

Cheddar cheese (5-6 months ripened) procured from the Experimental Dairy of ICAR- National Dairy Research Institute, Karnal was used for the manufacture of cheese beverage (CB). Common salt was procured from the local market. TSC (Tri-sodium citrate) and STPP (Sodium tri-polyphosphate) were used as emulsifying salts for the preparation of CB.

Method of Manufacture of CB

The cheese beverage was prepared using mid ripened variety (5 to 6 months ripened) of Cheddar cheese. Cheddar cheese was cleaned and grated using the grating machine. Grated Cheddar cheese was taken into cooking vessel and mixed with other ingredients. Different cheese and water (1:1, 1:2, 1:3) ratios were used. The common salt (0.5%) and TSC/ STPP (3%) (ES) were dissolved in calculated amount of hot water and added into the cheese initially during mixing. It was then continuously agitated in order to produce a homogenous mass. The remaining water was added once or twice during cooking and heated to 85 ± 2°C for 4 or 6 minutes with continuous stirring and the surface was scraped off with a steel ladle. Heating was then stopped and the product was transferred to clean & sterile glass bottles, cooled for 2-3 hours at room temperature and later kept in the refrigerator.

Physico-chemical analysis

The pH measurement of the raw material and CB was performed as described by Kevany et al. (2015) with slight modification. Acidity was measured by titration method and moisture content was determined by gravimetric method (IS, SP: 18 Part XI, 1981). Fat, protein and ash content were calculated as per the method AOAC (2005).

Rheological analysis

Rheological measurements were done using Modular compact Rheometer (MCR Model 52, Anton Paar, Austria) with a parallel plate attachment of 50 mm diameter and gap size of 1 mm. A total of 100 shear-rate/ shear-stress data points were noted for each sample at an increasing shear rate range of 1-100 $s^{-1}$with mean point duration of 2 s (Bonfim et al. 2019).

Sensory evaluation

Sensory evaluation was conducted according to the methodology described by Balthazar (2018) with slight modification on a score card of 9 point hedonic scale using 8 semi-trained panellists. The cheese drinks of 10–15 ml of each were presented in polypropylene cups covered with aluminium foils. During each session of evaluation, three samples were presented at a time. These were placed in a random manner with coded numbers (1, 2 and 3). The judged parameters were: colour & appearance, mouthfeel & consistency, taste & flavour and overall acceptability.

Statistical analysis

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

Results and discussion

Proximate analysis of the raw material

The proximate analysis of the Cheddar cheese used as raw material for the preparation of CB was performed and the results are tabulated in Table 1. The moisture, protein, fat and ash were found to be 46.73±0.14%, 24.61± 0.07%, 20.95±0.45 and 4.56± 0.01% respectively. Fat content was found to be lower and moisture was found to be higher than other reported studies for Cheddar cheese (Sukumar De, 2001) which could be due to the difference in type of milk used, the ripening time provided during ageing of cheese, climate or season, the method and location of preparation. The pH and acidity of the cheese sample was found to be 5.47± 0.06 and 0.185± 0.72 % LA respectively.

Effect of level of ingredients and processing parameters on the moisture content

The effect of level of ingredients and processing parameters on the moisture content was evaluated and the results are depicted in Table 2. It was found that at higher cheese and water ratio of 1:3 the product got curdled in case of both the emulsifiers and showed fat separation at all processing conditions. This could be because of higher water addition which resulted in higher water phase and lower fat phase thus could not produce a homogeneous emulsion. At cheese and water ratio of 1:1 in case of both TSC and STPP addition the cooking time was found to have a significant effect ($p<0.05$) on the moisture content however

Table 1 Proximate analysis of Cheddar cheese

Attributes	Cheddar cheese
Moisture (%)	46.73± 0.14
Protein (%)	24.61 + 0.07
Ash (%)	4.56 ± 0.01
Fat (%)	20.95 ± 0.45
pH	5.47 ± 0.06
Acidity (% LA)	0.185 ± 0.72

Results are expressed as Mean ± SD; (n = 3)

the stage of water addition had no significant effect ($p>0.05$). The cooking time of 4 minutes resulted in significantly ($p<0.05$) higher moisture content as compared to cooking time of 6 minutes which could be due to the evaporation of more water in the latter case. However among all the samples at cheese and water ratio of 1:1 the maximum moisture attained was 67.36 % which resulted in thick consistency. At cheese and water ratio of 1:2 it was found that in case of TSC addition at all the processing conditions the product got curdled and resulted in fat separation. This could be due to the decreased emulsification property of tri-sodium citrate at higher water phase and lower fat phase. However in case of STPP, water when added at 2 stages and cooked for both 4 and 6 minutes resulted in good quality product with the former showing high acceptable moisture content of 71.88%. In contrast water when added at 3 stages resulted in fat separation which could be due to the altered emulsion properties due to the combined effect of the varying processing conditions and ingredients (Kapoor and Metzger, 2008).

Effect of level of ingredients and processing parameters on the viscosity

The viscosity of the samples was measured using rheometer and the results are depicted in Table 2. It was found that at higher cheese and water ratio of 1:3 the product got curdled in case of both the emulsifiers and showed fat separation at all processing conditions so the viscosity was not measured. At lower cheese and water ratio of 1:1 the product resulted in high viscosity which was not acceptable for a beverage. In general on increasing the amount of water addition the viscosity decreased. Cooking time was found to have a significant effect ($p<0.05$) on the viscosity and at cheese and water ratio of 1:2 in case of STPP, cooking time of 4 minutes resulted in significantly ($p<0.05$) lower viscosity of 2.04±0.06 Pa s compared to the viscosity at 6 minutes (9.76± 0.09 Pa s). This could also be because of the significant difference ($p<0.05$) in the moisture content of these products. At cheese and water ratio of 1:2 water addition at 2 stages resulted in acceptable quality product whereas water addition at 3 stages

Table 2 Effect of level of ingredients and processing parameters on the moisture and viscosity of CB using TSC & STPP

Emulsifying salt	Cheese: water	Cooking Time (minutes)	Stages of water addition	Moisture (%)	Viscosity (Pa s)
TSC	1:1	4	3	66.67 ± 0.20^{bc}	26.32 ± 0.07^{f}
			2	65.99 ± 0.81^{cd}	44.14 ± 0.14^{d}
		6	3	58.38 ± 0.43^{f}	31.34 ± 0.05^{e}
			2	57.50 ± 0.49^{f}	135.91 ± 0.10^{c}
	1:2	4	3	N	N
			2	N	N
		6	3	N	N
			2	N	N
	1:3	4	3	N	N
			2	N	N
		6	3	N	N
			2	N	N
STPP	1:1	4	3	66.36 ± 0.50^{bd}	5.41 ± 0.20^{h}
			2	65.63 ± 0.31^{d}	145.88 ± 0.20^{c}
		6	3	60.61 ± 1.10^{e}	190.16 ± 0.09^{b}
			2	60.51 ± 0.13^{e}	266.69 ± 0.57^{a}
	1:2	4	3	N	N
			2	71.88 ± 0.17^{a}	2.04 ± 0.06^{i}
		6	3	N	N
			2	66.56 ± 0.05^{bc}	9.76 ± 0.09^{g}
	1:3	4	3	N	N
			2	N	N
		6	3	N	N
			2	N	N

Results are expressed as Mean ± SD; means with different superscripts in a column differ significantly ($p < 0.05$) ($n = 3$) N – sample could not be measured; CB- Cheese Beverage; TSC- Tri-sodium Citrate; STPP- Sodium tri-polyphosphate added @ 3%.

Table 3 Effect of level of ingredients and processing parameters on the sensory properties of CB using TSC & STPP

Emulsifing salt	Cheese:Water	Cooking Time (min)	Stages of water addition	Colour	Taste & Flavour	Mouthfeel & consistency	Overall acceptability
TSC	1:1	4	3	6.62±0.51^{a}	6.12± 0.35^{a}	5.87± 0.35^{bc}	5.62± 0.74^{bc}
			2	6.37±0.51^{a}	6.25±0.46^{a}	5.75±0.46^{bc}	5.37± 0.74^{bc}
		6	3	6.50±0.35^{a}	6.59±0.53^{a}	5.75±0.46^{bc}	5.62± 0.51^{bc}
			2	6.75±0.46^{a}	6.58±0.53^{a}	6.52±0.53^{b}	5.37±0.74^{bc}
	1:2	4	3	N	N	N	N
			2	N	N	N	N
		6	3	N	N	N	N
			2	N	N	N	N
	1:3	4	3	N	N	N	N
			2	N	N	N	N
		6	3	N	N	N	N
			2	N	N	N	N
STPP	1:1	4	3	6.75±0.46^{a}	6.50±0.75^{a}	6.25± 0.88^{b}	5.12± 0.64^{c}
			2	6.62±0.51^{a}	6.25±0.46^{a}	5.75± 0.46^{bc}	5.62± 0.51^{bc}
		6	3	6.75±0.46^{a}	6.48±1.06^{a}	6.20± 0.92^{b}	5.37± 0.91^{bc}
			2	6.75±0.46^{a}	6.25±0.46^{a}	5.75± 0.46^{bc}	5.62± 0.51^{bc}
	1:2	4	3	N	N	N	N
			2	6.50±0.64^{a}	6.50±0.53^{a}	7.25 ± 1.03^{a}	7.12 ± 0.83^{a}
		6	3	N	N	N	N
			2	6.75±0.70^{a}	6.25±0.46^{a}	6.37±1.68^{b}	6.00±0.92^{b}
	1:3	4	3	N	N	N	N
			2	N	N	N	N
		6	3	N	N	N	N
			2	N	N	N	N

Results are expressed as Mean ± SD; means with different superscripts in a column differ significantly ($p < 0.05$) ($n = 3$) N– sample could not be measured; CB- Cheese Beverage; TSC- Tri-sodium Citrate; STPP- Sodium tri-polyphosphate added @ 3%.

resulted in fat separation which could be due to the disturbance caused to the formed emulsion. The best combination showing the lowest viscosity (2.04±0.06 Pa s) with good emulsification was observed when the STPP was used along with cheese: water (1:2) cooked for 4 min with water added two times accompanied with continuous stirring.

Effect of processing parameters and level of ingredients on the sensory properties

The effect of processing parameters and level of ingredients on the sensory properties of the product were evaluated and results are depicted in Table 3. On varying the cheese: water, emulsifying salt and the processing conditions it was found that there was no significant effect ($p>0.05$) on the colour and appearance of all the samples. All the samples appeared creamy white to white in colour. Similarly, the taste & flavour was not affected and all samples exhibited similar scores. The flavour resembled mild Cheddar cheese flavour which was liked by the sensory panellists. At cheese and water ratio of 1:1 mouth feel & consistency was similar among all samples. However, at higher cheese and water ratio of 1:2 the scores increased significantly ($p<0.05$). The product produced with STPP using cheese: water (1:2) and cooked for 4 minutes exhibited significantly higher ($p<0.05$) scores of 7.25 ± 1.03 as compared to others. The increased score could be because of the high moisture content and low viscosity of the product at these conditions which resulted in the flowy or thin consistency of the product. The product had a creamy and pleasant mouth feel which was liked by the sensory panellists. The overall acceptability score of 7.12 ± 0.83 was found to be significantly higher ($p<0.05$) in case of product with cheese and water ratio of 1:2 using STTP as emulsifier when cooked for 4 minutes compared to the other samples. Although colour and flavour were similar in all samples and exhibited no significant effect ($p>0.05$) on the overall acceptability the increased acceptability score could be due to the increased mouth feel and consistency score.

Conclusion

In the current study it was found that acceptable quality cheese beverage can be developed from Cheddar cheese aged between 5 to 6 months with addition of water in the ratio 1:2 using sodium tri-polyphosphate as an emulsifier and cooking time of 4 minutes at 85 ± 2°C. The developed beverage may be a better and healthier choice for health conscious consumers who are looking for alternate options for the existing sugary beverages in the market.

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