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Optimization and Textural properties of set Yoghurt prepared with Hydrocolloids, Milk and Tender Coconut Water

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ABSTRACT: New and innovative type of yoghurt products are being marketed resulting in a phenomenal increase in the per-capita consumption of this product. Recently, there is a great demand for functional yoghurts by consumer, especially those produced through the incorporation of food of plant origin or its bioactive components. Set yoghurt was prepared by addition of different levels of 10:90, 20:80, 30:70 (v/v) of tender coconut water and milk respectively and the control yoghurt was prepared from 100% cow milk. Different hydrocolloids were used namely carrageenan, sodium alginate and modified starch at 0.05-0.25% and cultures (1 & 2%) in the preparation of set yoghurt. Textural properties of prepared set yoghurt were analyzed using texture analyzer. The firmness of the product improved at all the levels tried by using modified starch. In preliminary trails, carrageenan and sodium alginate had increased the wheying off in TCW–milk blended yoghurt considerably, especially at higher concentration (0.25%). The results showed the beneficial effect of carrageenan and sodium alginate in improving the firmness of set yoghurt when it is used at a lower level (0.05-0.15%). Fortification of yoghurt with 10:90 TCW – milk blends with 0.15% of modified starch using 1% culture improved the textural properties when compared with the control yoghurt. Thus, it could be recommended from this study that adding tender coconut water increases the health benefits of yoghurt.

Keywords: Tender coconut water, set yoghurt, optimization, hydrocolloids, firmness and texture.

INTRODUCTION

Yoghurt is a very popular fermented milk product produced by lactic acid fermentation of milk by the addition of a starter culture such as *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. Yoghurt has nutritional benefits beyond those of milk; people who are moderately lactose-intolerant can enjoy yoghurt without ill effects, because the lactose in the milk precursor is converted to lactic acid by the bacterial culture (Akeem *et al*., 2018). Yoghurt has many forms including drinkable or solid, low fat or fat free, fruity or cereal flavored, and is a healthy and nutritious food. Yoghurt is being transformed into an exhilarating range of wholesome and natural food with the supplementation of additives such as sweeteners, jams, jellies and various fruit preparations to increase the nutritive value and additional health benefits (Jimoh Kolapo, 2007). Different varieties of yoghurt have been produced by incorporating soy milk, fruit pulp, fruit juice to enhance the nutritional and health benefits for the consumers. Kabir *et al*., (2021) developed banana peel extract yoghurt, and found up to 600 µl /100 g of banana extract addition in yoghurt showed acceptable sensory score. Incorporation of 4% avocado or 6% kiwi pastes to stirred yoghurt produced a higher quality and acceptable product (Soliman and Shehata, 2019). Addition of carrot pulp (10%) and orange juice (10%) showed no effect on sensory properties of yoghurt (Senarathne and Wickramasinghe, 2019). Pumpkin at 15% showed an increasing effect on yoghurt consumption (Barakat and Hassan, 2017). Bioyoghurt prepared with mixing of 5% honey with cow and coconut milk produced high nutritional value with acceptable sensory scores (Ismail *et al*., 2017). Addition of coconut water in filled yoghurt showed no effect on physico-chemical and sensory properties (Malarkannan *et al*., 2012).

Texture is one of the most important characteristics that defines the quality of yoghurt and affects its appearance, mouthfeel and overall acceptability. Thickeners and dairy ingredients have been widely added to the milk base in order to provide an acceptably, firm texture and to reduce syneresis

(Bhattarai *et al*., 2016). Several hydrocolloids like gelatin, gums, starches, alginates and other derivatives have been tried in fermented milk products to improve their body & texture characteristics and reduce wheying off (Olorunnisomo *et al*., 2015).

Tender coconut water (TCW) is the most nutritious wholesome beverage that the nature has provided. The water of fresh tender coconut, which is the liquid endosperm, has been usually drunk by people with no ill effects (Zulaikhah, 2019). TCW is not only a thirst quenching fluid but also a mineral drink that cures most of the diseases. According to Ayurveda, tender coconut water is sweet, increases semen production, increases digestion, clears the urinary path and strengthens the muscles of cardiovascular system. TCW is good for feeding infants suffering from intestinal disturbances and to check urinary infections. TCW is a diuretic, effective in the treatment of kidney and urethral stones and cures malnourishment (Chidambaram *et al*., 2013).

As tender coconut, water has its own healing and therapeutic properties it's blending with the milk in the development of yoghurt in the presence of hydrocolloids will have a better nutritive value. The yoghurt incorporated with hydrocolloids and tender coconut water may be useful to alleviate intestinal disturbances, malnourishments, to reduce obesity, for oral rehydration in the instances like diarrhea, maintenance of acid –base balance and to reduce risk of cancer (Shubhashree *et al*., 2014). No studies have been carried out so far on the incorporation of TCW in the preparation of set yoghurt for enhancement of nutritive value and functional properties. Keeping this in view, a study was carried out to fortify milk with different levels of tender coconut water to prepare set yoghurt and investigate the effect of hydrocolloids viz: modified starch, carrageenan and sodium alginate on textural properties of prepared set yoghurt.

MATERIALS AND METHODS

Fresh cow milk was procured from the Karnataka Veterinary, Animal and Fisheries Science University's dairy farm, Hebbal, Bangalore. Tender coconut water was vaccum extracted from tender coconuts and immediately used in the preparation of yoghurt. For standardization of cow milk (fat 4.5% and SNF 9.5%), Nandini butter and spray dried Nestle skim milk powder were used to standardize the milk. Sodium alginate, Modified corn starch (HiMedia Laboratories Pvt .Ltd), k- Carrageenan (Otto Laboratories Pvt.Ltd) were used for the study. The packaging cups of 50 ml capacity with lids, purchased from local market. The cups were cleaned with teepol and sanitized by dipping in to 50 ppm chlorine solution and immersed in hot water at 80° C for 10 min, and cooled to room temperature before use. All the glassware were cleaned properly, washed, cleaned and dried in hot air oven before use.

The mixed starter culture consisting *Streptococcus thermophilus* and *Lactobacillus bulgaricus* in the ratio of 1:1 were procured from the Dept. of Dairy Microbiology, KVAFSU, Bangalore, was used for the production of yoghurt. The culture propagation was done by using sterilized skim milk in 10 mL test tubes, being inoculated with culture and allowed them for setting at temperature of 42°C for 4-4 ½ h in an incubator. Culture propagation was carried out once in a week.

Preparation of set yoghurt prepared by using TCW and milk blends

Yoghurt samples were prepared by addition of TCW-cow milk blends (10:90, 20:80, 30:70 (v/v)), hydrocolloids viz. modified corn starch, k- carrageenan and sodium alginate (0.15-0.25%) and 1 & 2% of yoghurt cultures. The blends of TCW - cows milk viz: 10:90, 20:80, 30:70 were adjusted to get 4.5% fat and 14% total solids by using skim milk powder and butter. Hydrocolloids at 0.15-0.25% were added in a small volume of warm milk separately to disperse it thoroughly, and then added to milk sample at 50-60°C. The mix was homogenized at 2500 psi at first stage and 500 psi at second stage. The milk samples were heated at 90°C for 10 min and cooled to 42°C and inoculated with yoghurt culture at the level of 1& 2%. The sample was filled in polystyrene cups and were incubated at 42°C for 4-4 ½ h for setting. The product was immediately cooled to 5 °C and stored in refrigerator at 5°C. The control yoghurt was also prepared without the addition of tender coconut water and hydrocolloids.

Analysis of Textural properties of prepared set yoghurt: TA.XT.plus Texture Analyzer (Stable Micro Systems, Surrey, England) was used for measuring firmness, consistency and index of viscosity of dahi/yoghurt samples. P/25 probe (25 mm diameter, cylinder, aluminum) was used in the experiment. The trigger force was set to 2 g. The temperature of sample was maintained between 5–10°C.

STATISTICAL ANALYSIS

All experiments were performed at least in triplicate, and the results were summarized as mean values ± standard deviation.

RESULTS AND DISCUSSION

Optimization of different levels of hydrocolloids, tender coconut water – milk blends for preparation of set yoghurt.

The results pertaining with respect to the firmness of set yoghurt are depicted in Table 1. The data showed that, firmness of the yoghurt improved at all the levels tried by using modified starch at 1 and 2% culture, very firm curd was obtained at 0.25% of the modified starch at 10:90 TCW – milk blends at 1% culture and 0.15% of modified starch at 30:70 TCW – milk blends at 2% culture when compared with the control. The increase in firmness may be attributed to the interaction of modified starch with the casein micelles of yoghurt, developing a stronger three dimensional network. And also due to high water binding capacity of modified starch which binds free water firmly thus imparting firmness to the product. Modified starch by cross-linking with phosphates and other edible products so that it doesn't break down in acid products. Starch granules imbibe water and swell to many times their original size, resulting in increased viscosity of the solution (Kumar and Khatkar, 2017). Saleh *et al*., (2020) reported addition of different types of native starches (potato, sweet potato, corn, chickpea, and turkish beans) at 1% significantly reduced syneresis and improved yoghurt firmness. Agyemang *et al*., (2020) incorporated three starch samples of *Abrabopa*, *Bankye hemaa and AGRA* at 2.5, 5.0 and 7.5%, to prepare yoghurt, from fully-skimmed, partially-skimmed and whole milk and found best taste, mouthfeel and sourness scores to yoghurt made from whole milk in which *Abrabopa* cassava starch at 7.5% had been incorporated. Similar studies were also reported by Gaston *et al*., (2007), who observed stirred yoghurt prepared with addition of starch at 1, 5 and 10 mg/g significantly improved the textural properties, creaminess and mouthfeel when compared with control.

Table 1: Optimization of different levels of hydrocolloids, tender coconut water-milk blends for preparation of set yoghurt.

Stabilizers	Level of culture (%)	Control	10:90			20:80			30:70		
			Hydrocolloids (%)								
			0.05	0.15	0.25	0.05	0.15	0.25	0.05	0.15	0.25
Modified starch	1	+++	+++	+++	++++	+++	+++	+++	+++	+++	+++
	2	+++	+++	+++	+++	+++	+++	+++	+++	++++	++
Carrageenan	1	+++	++++	+++	++	++	++	+	++	+	-
	2	+++	++	++	-	++++	++	-	+	+	-
Sodium alginate	1	+++	+++	+++	-	++++	+++	-	++	+	-
	2	+++	++++	++	+	++	+	-	+	-	-

Note: Average of three trials
++++: Very firm curd, +++: Firm curd, ++: Slightly Firm curd, +: Weak curd, - : Very weak curd

In the preliminary trails, carrageenan and sodium alginate increased the wheying off in TCW- milk blended yoghurt considerably, especially at higher levels of blends (30:70) and concentration of hydrocolloid (0.25%). This could be attributed to the development of higher acidity resulting in the separation of whey and also carrageenan, in the presence of potassium ions contributed from TCW, resulting into decreased firmness due to the higher content of 3, 6- anhydrogalactose and low content of sulfate and the hydrophobic nature (Oliveira *et al*., 2015). But the results showed the beneficial effect of carrageenan and sodium alginate in improving the firmness of set yoghurt when these were used at lower levels (0.05-0.15%) because carrageenan is an anionic hydrocolloid capable of interacting with casein micelles resulting effective three dimensional gel network as well increased hydration and free water (Pratama *et al*., 2018). Carrageenan and sodium alginate at higher levels it may interact with higher levels of minerals contributed by TCW and leads to harder gels. The firmness improved at 0.05% of the carrageenan at 10:90 TCW – milk blends at 1% culture and 0.05% of carrageenan at 20:80 TCW – milk blends at 2% culture when compared to the control. The lower levels of 0.05% sodium alginate improved the firmness of yoghurt at 20:80 TCW – milk blends at 1% culture and 10:90 TCW –milk blends at 2% culture when compared with the control. These findings are inconsistent with the results reported by Lunardello *et al*., (2012), who prepared nonfat set yoghurt by addition of carrageenan (0.10%, 0.30%), xanthan gum (0.15%, 0.35%) and sodium alginate (0.05%, 0.15%) and observed that sodium alginate showed a negative effect with increase in its concentration over firmness. The same negative effect was also observed for its interaction with carrageenan. Yoghurt prepared with four plant based polysaccharides including sodium alginate (SA), okra polysaccharide (OP), konjac glucomannan (KGM) and apple pectin (AP) enhanced the water-holding capacity, firmness and elasticity of yoghurt with OP, KGM and AP while SA resulted the opposite effect with increasing concentrations (Xu *et al*., 2019).

Textural characteristics of prepared set yoghurt: It was observed from the Table (2), the firmness and consistency was higher for modified starch at 0.25% and carrageenan at 0.05% for 10:90 TCW – milk blend yoghurt samples, followed by sodium alginate at 0.05% for 20:80 TCW – milk blend yoghurt samples and control yoghurt using 1% culture level. Similar observations have been reported by Nguyen *et al*., (2017), who studied the effect of hydrocolloids namely xanthan gum (0.005–0.015%), carrageenan (0.01–0.08%), gelatin (0.5–1.5%) and modified starch (0.5–1.5%) on sensory and textural properties of low fat pot yoghurt. They concluded that addition of xanthan gum and carrageenan increased the firmness and viscosity, gelatin and modified starch improved the thickness, texture and gel strength of skim yoghurt. Damian *et al*. (2017), observed the use of modified starch resulted into creation of a creamier texture. Ibrahim and Khalifa, (2015) added three stabilizers, A (gelatin E441, mono

& diglyceride of fatty acids E471), B(guar gum E412, sodium carboxymethyl cellulose E466 and mono & diglyceride of fatty acids E471) and C (modified starch E1422 and mono and diglyceride of fatty acids E471) at 0.5%, 1.0% and 1.5%, w/w to camel milk yoghurt. Addition of stabilizers significantly increased viscosity and water holding capacity of camel milk yoghurt also enhanced their sensory acceptability. Isanga and Zhang, (2008) who observed carrageenan (0.2%), resulting in to a firm gel with little or no whey at the top in peanut milk based set yoghurt. When compared with addition of 1% culture, the firmness using 2% culture levels were higher in all the samples. Modified starch at 0.15% for 30:70 TCW - milk blends and control yoghurt was shown higher, followed by the sodium alginate at 0.05% for 20:80 TCW - milk blends and carrageenan at 0.05% for 10:90 TCW - milk blends. These results are inconsistent to the previous results. The effect of culture level (1.5–3.5%) and incubation time (4–8 h) on functional and sensory property of yoghurt was studied by Mudgil *et al*., (2016) and reported the optimum culture level and incubation time obtained were 2.33% and 5.28 h, respectively.

Table 2: Effect of hydrocolloids on textural characteristics of set yoghurt prepared using TCW – milk blends.

Yoghurt samples	Level of culture (%)	Firmness (N)	Consistency (N.s)
Control	1	0.99±0.11[a]	7.6±0.6[a]
	2	1.12±0.11[a]	7.8±0.5[a]
A	1	0.99±0.21[b]	7.7±0.3[b]
B	2	1.01±0.35[b]	7.9±0.2[a]
C	1	1.00±0.21[b]	7.8±0.3[c]
D	2	0.98±0.24[b]	7.6±0.6[b]
E	1	0.98±0.11[b]	7.6±0.9[b]
F	2	0.96±0.21[b]	7.5±0.4[b]

All values are average of five trials.
The values bearing different alphabets significantly differ (***P<0.001, **P<0.01, *P< 0.05) among the rows.
A: Modified starch at 0.25% for 10:90 TCW-milk blends with 1% culture.
B: Modified starch at 0.15% for 30:70 TCW-milk blends with 2% culture.
C: Carrageenan at 0.05% for 10:90 TCW-milk blends with 1% culture.
D: Carrageenan at 0.05% for 20:80 TCW-milk blends with 2% culture.
E: Sodium alginate at 0.05% for 20:80 TCW-milk blends with 1% culture.
F: Sodium alginate at 0.05% for 10:90 TCW-milk blends with 2% culture.

CONCLUSION

From this experimental study it was concluded that tender coconut water can be successfully incorporated in set yoghurt by addition of hydrocolloids. The results showed that addition of modified starch at 10:90-TCW-milk blends gave better results when compared with control. Firmness of yoghurt prepared with sodium alginate and carageenan had negative effect with increase in concentration. In addition, the level of 2% culture showed good results than those of 1% culture. Hydrocolloids plays an important role for improving textural properties of set yoghurt incorporated with tender coconut water.

FUTURE SCOPE

The set yoghurt prepared with tender coconut water with different hydrocolloids needs further to investigate its effect on composition, physico-chemical properties and microbiological analysis which is under progress in our project. Evaluation of its morphological, functional properties of TCW-Milk blended set yoghurt and study of consumer acceptance about the possible commercialization could be carried out in future.

Conflict of Interest. The authors report no conflicts of interest in this research work or in manuscript preparation.

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