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Original Article

Development and Quality Evaluation of Non-Dairy Yogurts

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ABSTRACT

Development of fermented vegetarian milk based food will be important to fulfill nutritional value of both elderly and individuals that require more energy intake. **Objective:** To develop non-dairy vegan yogurts from soy milk, oat milk and coconut milk in conjunction with lactic acid fermentation. **Methods:** Soy yogurt, oat yogurt and coconut yogurt was analyzed for crude protein, crude fat, crude fiber, carbohydrates, ash contents, moisture contents, titratable acidity, total soluble solids and pH analysis and to check its quality and acceptability by sensory evaluation for color, aroma, taste, consistency and acidity. **Results:** The mean values of crude protein of yogurts showed that soy yogurt contain more protein contents than other yogurts that was 6.0±0.1. The mean values for crude fat contents showed that maximum value 8.5±0.65 was noticed in the coconut yogurt and lowest value 3.1±0.1 was observed in soy yogurt. Mean values of crude fiber showed that fiber contents are present in more amount in soy yogurt (1.93±0.152). The mean maximum value for moisture contents was 84.43±4.007 that was noticed in soy yogurt and lowest value 66.69±0.164 was observed in oat yogurt. Mean values for carbohydrate in soy, oat and coconut yogurt was 9.28±0.01, 20.76±0.659 and 16.16±1.258. Mean results of overall acceptability of soy yogurt, oat yogurt and coconut yogurt was 7±0.35, 7.25±0.36 and 8±0.4 respectively. **Conclusions:** The study's findings demonstrated that it is possible to make plant-based yoghurt to meet the organoleptic needs of consumers, particularly those who are lactose intolerant or follow a vegan diet.

INTRODUCTION

Development of non-dairy yogurt is important to fulfill nutritional value of both elderly and individuals as there is gap in market of energy dense and protein enriched nutritional food. In recent years, soybean, oat and coconut have been accepted as a functional food as these are source of protein, dietary fiber, minerals, antioxidants, vitamins and energy [1]. Soy bean and oats are good and inexpensive source of protein especially for many vegetarians or vegan and for those who cannot buy meat and milk [2]. Non- dairy yogurt contains unsaturated fatty acid that help to reduce incidences of cardiovascular diseases. In case of lactose intolerance, consumption of vegan milk is beneficial. Non-dairy yogurts have high nutrients and minerals level and it will work as a synbiotic food which is important for human gut, intestine and increase antibodies in human body so it boosts immunity [3]. Soya milk, oat milk and coconut milk can replace animal milk, in the manufacturing of dairy products. Fermentation of milk reported to reduce antinutritional factors and increase mineral's bioavailability [4, 5]. Yogurt is a fermented dairy product and probiotic carrier. It is rich in protein, magnesium, potassium, fat and vitamins [6]. Yogurt have many health benefits than simple milk, like it can be use by lactose intolerance patients that have allergy to lactose which is sugar of milk as in yogurt lactose is transformed into lactic acid and do not cause allergy in lactose intolerance people. It has probiotic characteristics so prevent antibiotic associated diarrhea, help to improve

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gastrointestinal conditions. On the other hand, calcium of yogurt is absorbed faster than milk in body, as lactic acid turns calcium to solution. It contains vitamins of A, B, C, D, all ingredients of milk that help in digestion of food, strengthen abdomen and relax nerves. Yogurt is recommended to use with antibiotics as majority of antibiotic are fatal for beneficial bacteria of digestive system [7]. Non-dairy yogurts have low fat milk that coagulates to a custard like consistency. It contains *Lactobacillus bulgaricus* and *Streptococcus thermophilus* cultures [8]. Soy yogurt fermentation is done with friendly bacteria mainly *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. It contains other sugars such as starchyose and raffinose not lactose. Soy protein have equal nutrients that are present in meat and eggs and require for human health [2]. Animal milk have more saturated fats and cholesterol level while vegan milk have less saturated fats and cholesterol which is good for human health so this is also a factor that promote selection of vegetable substitute for animal milk [9]. Fibers in oat yogurt act as prebiotics that improve beneficial bacterial growth while lactic acid bacteria act as probiotics that improve human intestinal balance and have antagonistic action against pathogens. Oat milk yogurt is free of many allergens found in other milk. Oat yogurt contains protein, fat, carbohydrates, dietary fibers, riboflavin, calcium, phosphorus, iron, potassium, calories, vitamin A and D [10]. Oat milk yogurt have many health benefits such as it is vegan, lactose free, nut free, gluten free so it can be use by people that have gluten intolerance or celiac people. It contains vitamin B2 and B12, low blood cholesterol so good for heart health as well as bone health. Coconut milk contain protein, fats, fiber, carbohydrates, iron, folate, magnesium, potassium, copper, manganese, selenium, vitamin C and vitamin content calories [11]. Coconut yogurt have many health benefits like it reduce inflammation as it has anti-inflammatory effect, decrease stomach ulcer size, fight viruses and bacteria, improve heart health. Coconut milk yogurt contain healthy fatty acids, it reduces LDL and raises HDL which is good for health. It also improves brain functions in Alzheimer's disease and burn abdominal fat. Non-dairy yogurts can be produce in large scale on industry level and chances of jobs will be increase. Moreover, investors can use and enjoy the benefit produce by soy yogurt, oat yogurt and coconut yogurt on large scale [12].

METHODS

The current study was conducted in the central laboratories of MNS-University of Agriculture, Multan. Soybeans and oats was procured from department of Agronomy, MNSUAM. Belle-bella company's non-dairy yogurt starter was taken from market. Unripen coconut was purchased from local market. Soybeans was washed and soaked in water overnight. It was then boiled for 5 minutes. After blanching, the soybeans were crushed in a blender, and the resulting slurry was filtered through cheese cloth at a ratio of 7:1 water to slurry. The filtrate was then boiled for 20 minutes to produce soymilk [2]. 5g of yogurt culture was added in 1 liter of milk that has been heated to 82℃ for 15 minutes and quickly cooled to 43℃. To generate proper acidity, the inoculation mix was incubated for 4 hours at 40-45°C. After that, it was cooled and stored at a temperature of 6°C [13]. To begin, rolled oats was milled into finely granulated oat flour. Then a slurry was formed with the oat flour and water. To obtain oat milk, this slurry was filtered through muslin fabric [10]. First, oat milk was cooked for 5 minutes at 70℃. It was then chilled to 40℃ and injected with 2 percent yogurt culture or probiotic pills. This sample was kept at 39°C for 16 hours until it coagulates. The fermented samples were stored at 4℃ [14]. Coconut milk was made by shattering the shells of coconuts and removing the nuts with a knife. Nuts skin was removed and washed. Then for 20 minutes, mixed these nuts with warm water to homogenize it. The extract was discarded after passing through muslin cloth [15]. The extracted coconut milk was cooked for 10 minutes at 90℃ and then allowed to cool gradually. Yogurt culture was introduced and incubated at 39°C for 12 hours or until coagulation occurs. Fermented probiotic yoghurt was kept at 4℃ [16]. Crude protein of yogurts was analyzed by kjeldhal method as explained by AOAC (2005). It was analyzed by Gerber method as explained by AOAC (2005). It was analyzed by same protocol as explained by AOAC (2005). Moisture contents in non-dairy yogurts was analyzed by using oven at 105℃ for 6 hours as explained by AOAC (2005). Ash contents was analyzed by heating yogurt samples in muffle furnace at 630℃ for 3 hours as described by AOAC (2005). It was determined by calculating percentage remaining after subtraction of protein, fat, moisture and ash contents from hundred as explained by AOAC (2005) [17]. In this titratable acidity, pH and total soluble solids was analyzed. 3g of sample was dissolved in 10ml of distilled water in a flask and was titrated against 0.1N NaOH using 1% phenolphthalein as indicator. Pink color was the end point. Final readings were noted by method prescribed by Soukoulis *et al.*, [18]. pH values were analyzed by direct measurement with digital pH meter as given in AOAC (2016) [19]. Total soluble solids were determined by using refractometer that was expressed in degree brix as described by Larriguadiere *et al.*, [20]. Syneresis and water holding capacity was determined by centrifugal acceleration test as described by Ares *et al.*, [21]. Sensory parameters (color, texture, taste, aroma and overall acceptability) were analyzed for sensory evaluation

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by using methods described by Wichchukit and O' Mahonye [22]. The obtained data were subjected to statistical analysis by following the guidelines explained by ANOVA Montgomery.

RESULTS

After preparation of soy, oats and coconut yogurt, it was analyzed for different tests like protein, fat, fiber, moisture, ash, carbohydrates. Mean values of protein, fat, fiber, moisture, ash and carbs content for different yogurt samples are given in Table 1. The mean value of protein contents of control sample was 8.83±0.152 while protein contents of other different treatments was 6.0±0.1(T_1), 3.2±0.1 (T_2) and 1.06±0.66 (T_3). Mean results of fat contents of different treatments T_o, T_1, T_2 and T_3 were 4.9±0.1, 3.1±0.1, 3.5±0.1 and 8.5±0.65 respectively. The maximum value 8.5±0.65% was noticed in the treatment T_3 (coconut yogurt) and lowest value 3.1±0.1 was observed in T_1 (soy yogurt). The mean value of fiber contents of control sample was 0.01±0.015 while fiber contents of other different treatments was 1.93±0.152(T_1), 1.1±0.1 (T_2) and 1.76±0.665 (T_3). ANOVA results of moisture contents of vegan yogurts showed that highly significant ($p<0.01$) difference was observed among the treatments of different yogurts. Mean results of moisture contents of different treatments T_o, T_1, T_2 and T_3 were 80±1, 84.43±4.007, 66.69±0.164% and 82.17±1.268 respectively. The maximum value 84.43±4.007 was noticed in the treatment T_1 (soy yogurt) and lowest value 66.69±0.164 was observed in T_2 (oat yogurt). ANOVA results of ash content of vegan yogurts also showed that highly significant ($p<0.01$) difference was observed among the treatments of different yogurts. Mean results of ash contents of different treatments T_o, T_1, T_2 and T_3 were 0.24±0.243, 0.52±0.08, 0.29±0.060 and 0.32±0.015 respectively. The maximum value 0.52±0.08 was noticed in the treatment T_1 (soy yogurt) and lowest value 0.24±0.243 was observed in T_o (dairy yogurt). The mean value of carbohydrates contents of control sample was 3.91±0.104 while carbohydrates contents of other different treatments was 9.28±0.01(T_1), 20.76±0.659 (T_2) and 16.16±1.258(T_3).

Table 1: Mean values of proximate composition of soy, oats and coconut yogurts

Treatments	Protein	Fat	Fiber	Moisture	Ash	Carbs
T0	8.83±0.152^e	4.9± 0.1^b	0.016±0.015^b	80 ± 1^a	0.24±0.243^b	3.91±0.104^d
T1	6.0± 0.1^b	3.1± 0.1^c	1.93 ± 0.152^e	84.43±4.007^a	0.523±0.087^a	9.28± 0.01^c
T2	3.2 ± 0.1^c	3.5 ± 0.1^c	1.1 ± 0.1^a	66.69±0.164^b	0.29 ± 0.060^b	20.76±0.659^a
T3	1.06±0.665^d	8.5±0.65^a	1.76± 0.665^a	82.17±1.268^a	0.32 ± 0.015^b	16.16±1.258^b

T_0=(Control dairy yogurt sample)
T_1=(Soy yogurt sample)
T_2=(Oat yogurt sample)
T_3=(Coconut yogurt sample)

After proximate analysis, physico-chemical analysis of yogurts was done. ANOVA results for TSS of vegan yogurts are given in Table 2, which showed that highly significant ($p<0.01$) difference was observed among treatments of different yogurts. Mean results of TSS of different treatments T_o, T_1, T_2 and T_3 were 12.26±1.330, 13.5±1, 34.04±3.214 and 17.5±1 respectively. The maximum value was of treatment T_2 (oat yogurt) which was 34.04±3.214 and lowest value was observed in T_o (dairy yogurt) which was 12.26±1.330. Mean squares of pH of different yogurt samples showed non-significant difference between different treatments of yogurt samples. The mean value of pH of control sample was 4.5±0.1 while pH of other different treatments was 4.6±0.1(T_1), 4.4±0.1 (T_2) and 4.73±0.493(T_3). ANOVA results of titratable acidity of vegan yogurts showed that highly significant ($p<0.01$) difference was observed among the treatments of different yogurts. Mean results of titratable acidity of different treatments T_o, T_1, T_2 and T_3 were 1±0.264, 0.68±0.1, 0.008±0.001 and 0.48±0.01 respectively. The maximum value was of treatment T_o (dairy yogurt) which was 1±0.264 and lowest value was observed in T_2 (oat yogurt) which was 0.008±0.001.

Table 2: Mean values of Physico-chemical analysis of soy, oats and coconut yogurts

	TSS	pH	TA
T0	12.26± 1.330^c	4.5 ± 0.1^a	1±0.264^a
T1	13.5 ± 1b^c	4.6 ± 0.1^a	0.68±0.1^{ab}
T2	34.04± 3.21^{a}a	4.4± 0.1^a	0.008±0.001^c
T3	17.5± 1^b	4.73±0.493^a	0.48±0.01^b

T_0=(Control dairy yogurt sample)
T_1=(Soy yogurt sample)
T_2=(Oat yogurt sample)
T_3=(Coconut yogurt sample)

Mean values for syneresis of T_o, T_1, T_2 and T_3 were found to be 33.9±1.25, 36.7±0.23, 12.0±0.5 and 23.1±0.01(Figure 1).

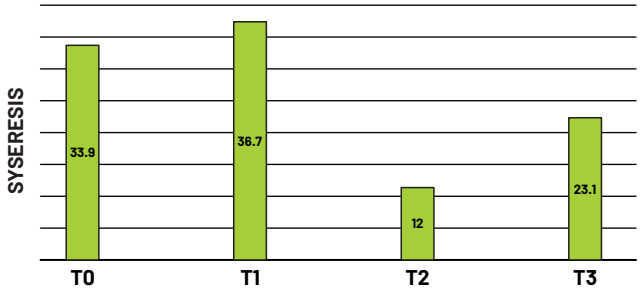

Figure 1: Graph representing syneresis of soy, oat and coconut yogurts

Figure 2 represents water holding capacity of different yogurts. Mean results for water holding capacity were 86.1±1.20(T_o), 85.0±1.40(T_1), 89.0±0.02(T_2) and 76.6±0.01(T_3) respectively for soy, oat and coconut yogurts.

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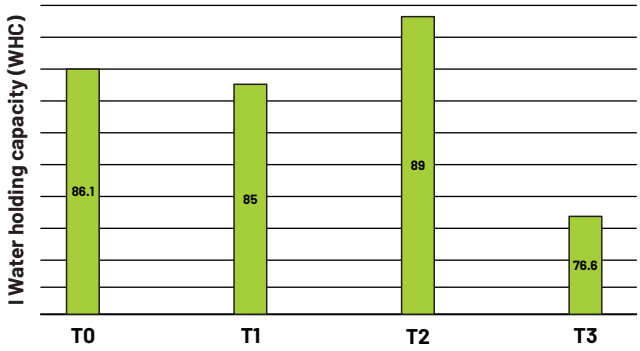

Figure 2: Graph representing water holding capacity of soy, oat and coconut yogurts

Eight participants were asked to taste and answer questions on each of the three yoghurt samples. The hedonic ratings of qualities such as color/appearance, taste, aroma/odour, texture and overall acceptability of yoghurts were included in the questions. The samples were completely random. ANOVA results of color of dairy, soy, oat and coconut yogurts showed that there was non-significant ($p>0.05$) difference among the treatments of these yogurt samples. Regarding color/appearance of yogurt samples, the mean values for dairy, soy, oat and coconut yogurts were found as 6.75±0.33, 6.87±0.34, 6.87±0.34 and 6.5±0.325 respectively according to 9-point hedonic scale (Table 2).

Table 2: Mean values of sensory evaluation of soy, oats and coconut yogurts

Treatment	Color	Taste	Texture	Aroma	Overall acceptability
T0	6.75±0.33^{a}	8± 0.4^{a}	7.5±0.37^{a}	6.62±0.33^{ab}	8.12±0.40^{a}
T1	6.87±0.34^{a}	6.87±0.34^{a}	6.87±0.34^{a}	5.87±0.29^{b}	7±0.35^{a}
T2	6.87±0.34^{a}	7.12±0.35^{a}	6.5±0.32^{a}	6.37±0.31^{ab}	7.25±0.36^{a}
T3	6.5±0.325^{a}	8±0.4^{a}	7.37±0.36^{a}	7.37±0.36^{a}	8±0.4^{a}

T_0=(Control dairy yogurt sample)
T_1=(Soy yogurt sample)
T_2=(Oat yogurt sample)
T_3=(Coconut yogurt sample)

Mean squares for taste of dairy, soy, oat and coconut yogurt samples showed that there is significant difference between treatments of yogurt samples. The mean sensory score regarding taste of dairy, soy, oat and coconut yogurt samples were found to be 8±0.4, 6.87±0.34, 7.12±0.35 and 8±0.4 respectively according to 9-point hedonic scale (Figure 3).

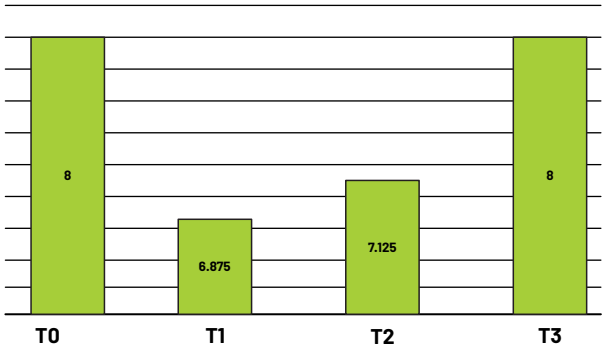

Figure 3: Graph representing taste of soy, oat and coconut yogurts

Mean squares of texture of dairy, soy, oat and coconut yogurt samples showed non-significant difference between treatments of yogurt samples. The mean sensory score regarding texture of dairy, soy, oat and coconut yogurt samples were found to be 7.5±0.37, 6.87±0.34, 6.5±0.32 and 7.37±0.36 respectively according to 9-point hedonic scale (Figure 4).

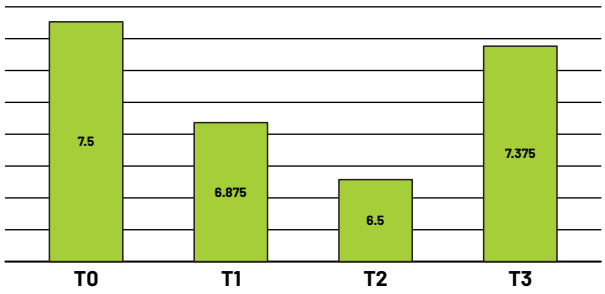

Figure 4: Graph representing texture of soy, oat and coconut yogurts

ANOVA results of aroma of dairy, soy, oat and coconut yogurt samples showed that there was significant ($p<0.05$) difference among treatments of different yogurts. Regarding aroma of samples of yogurt, the analysis shows the sensory score for soy, oat and coconut yogurts were found to be 5.87±0.29, 6.37±0.31 and 7.37±0.36 respectively according to 9-point hedonic scale while keeping dairy yogurt as control treatment which gained 6.62±0.33 mean score. It shows that coconut yogurts gained more score regarding its good color while soy and oat yogurts gained less scores than coconut yogurts (Figure 5).

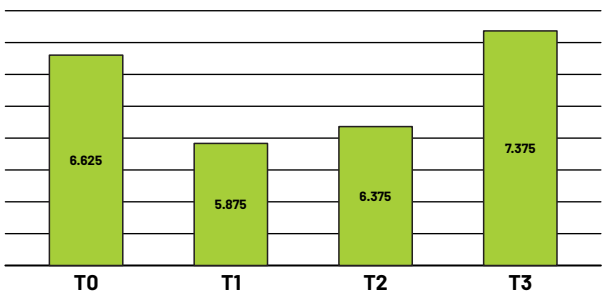

Figure 5: Graph representing aroma of soy, oat and coconut yogurts

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Eight participants were asked to taste and answer questions on each of the three yoghurt samples. The hedonic ratings of qualities such as color/appearance, taste, aroma/odour, texture and overall acceptability of yoghurts were included in the questions. The samples were completely random. ANOVA results of color of dairy, soy, oat and coconut yogurts showed that there was non-significant ($p>0.05$) difference among the treatments of these yogurt samples. Regarding color/appearance of yogurt samples, the mean values for dairy, soy, oat and coconut yogurts were found as 6.75±0.33, 6.87±0.34, 6.87±0.34 and 6.5±0.325 respectively according to 9-point hedonic scale (Table 2).

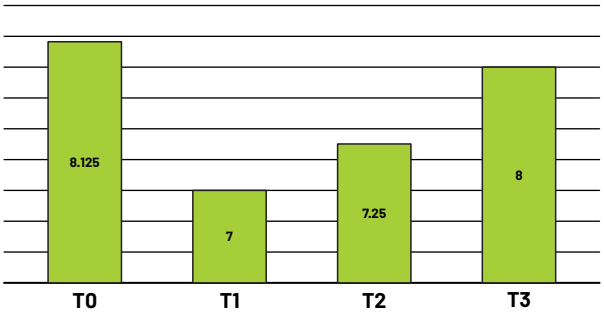

Figure 6: Graph representing overall acceptability of soy, oat and coconut yogurts

DISCUSSION

Plant-based milk substitutes are becoming increasingly popular. In general, they can serve as low-cost alternatives for cow's milk for individuals who cannot afford it due to its high price and restricted availability, or for those who are allergic to cow's milk. The current study was aimed to develop healthy plant-based yoghurts with high overall acceptability as an alternative to bovine milk that is both tasty and nutritionally appropriate to suit current consumer demands. For this purpose, soy, oat and coconut yogurts were prepared first and then analyzed for crude fat, crude fiber, crude protein, carbohydrates, ash, moisture contents, titratable acidity, total soluble solids, pH, syneresis and water holding capacity analysis. After proximate and physico-chemical analysis, yogurts were analyzed for sensory evaluation to check its quality and acceptability for color, aroma, taste, texture and overall acceptability. After that, all obtained data were subjected to statistical analysis. The results of protein content of different yogurts found in the current study are similar to the results of Craig and Brothers, who reported 6g protein contents in soy yogurt, 3g protein contents in oat yogurt and 0-1.5g protein contents in coconut yogurts. The results of fat contents of different yogurts found in the current study are also similar to the results of Craig and Brothers, who reported 2.5-3.5g fat contents in soy yogurt, 3-4.8g fat contents in oat yogurt and 5.5-12.5g fat contents in coconut yogurts. The results of fiber contents of different yogurts found in the current study are similar to the results of above study, who reported 1-2g fiber contents in soy yogurt, 1-2g fiber contents in oat yogurt and 0.6-2g fiber contents in coconut yogurts [23]. The results of moisture contents of different yogurts found in the current study are similar to the results of Osundahunsi *et al.*, who reported 87.8±0.01 moisture contents in soy yogurt, while moisture contents reported by Malki *et al.*, in oat yogurt was 65.79±1.0 and moisture contents in coconut yogurt was 83.52±0.00 as reported by Ezeonu *et al.*, [3, 24, 25]. The results of ash contents of different yogurts found in the current study are similar to the results of Osundahunsi *et al.*, who reported 0.52±0.23 ash contents in soy yogurt, while ash contents reported by Malki *et al.*, in oat yogurt was 0.37±0.3 and ash contents in coconut yogurt was 0.36±0.01 as reported by Ezeonu *et al.*, [3, 24, 25]. The results of carbohydrates content of different yogurts found in the current study are similar to the results of another study, who reported 18.5-23.5g carbohydrates contents in soy yogurt, 19-20g carbohydrates contents in oat yogurt and 10-22g carbohydrates contents in coconut yogurt [23]. The results of total soluble solids of different yogurts found in the current study are similar to the results of Osundahunsi *et al.*, who reported total soluble solids in soy yogurt are 14.5±0.21 while total soluble solids reported by Malki *et al.*, in oat yogurt was 36.38±0.3 and total soluble solids in coconut yogurt was 10.47**±**1.93 as reported by Nidife *et al.*, [3, 16, 24]. The results of pH of different yogurts found in the current study are similar to the results of Grasso *et al.*, who reported 4.38-4.56 pH of soy yogurt and 4 pH of coconut yogurts while pH of oat yogurt was 4.5 that was reported by Rani *et al*. The results of titratable acidity of different yogurts found in the current study are similar to the results of Grasso *et al.*, who reported 0.78% of titratable acidity of soy yogurt and 0.49% of titratable acidity of coconut yogurt while titratable acidity of oat yogurt was 0.009% as reported by Rani *et al*. The results of appearance of different yogurts found in the current study are also similar to the results of Grasso *et al.*, who reported 6.82±0.01 appearance value for soy yogurt and 6.93±0.30 appearance value for coconut yogurt while appearance value for oat yogurt was 6±0.00 that was reported by Rani *et al.* The results of taste of different yogurts found in the current study are similar to the results of Grasso *et al.*, who reported 5.75±0.21 taste value for soy yogurt and 4.79±0.16 taste value for coconut yogurt while taste value for oat yogurt was 7 that was reported by Rani *et al.* The results of texture of different yogurts found in the current study are similar to the results of Grasso *et al.*, who reported 6.49±0.31 texture value for soy yogurt and 6.37±0.23 texture value for coconut yogurt while texture value for oat yogurt

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was 6±0.00 that was reported by Rani *et al.* The results of aroma/odour of different yogurts found in the current study are similar to the results of Grasso *et al.*, who reported 6.29±0.05 aroma value for soy yogurt and 6.43±0.35 aroma value for coconut yogurt while aroma value for oat yogurt was 6±0.00 that was reported by Rani *et al.* The results of overall acceptability of different yogurts found in the current study are similar to the results of Grasso *et al.*, who reported 5.95±0.21 overall acceptability value for soy yogurt and 5.19±0.27 overall acceptability value for coconut yogurts while overall acceptability value for oat yogurt was 6.2±0.00 that was reported by Rani *et al*, [26, 27].

CONCLUSIONS

The study's findings demonstrated that it is possible to make plant-based yoghurt to meet the organoleptic needs of consumers, particularly those who are lactose intolerant or follow a vegan diet. Development of vegan yogurts will be important to fulfill functional nutritional values for children, adults as well as old ages as there is a gap in market of products made from non-dairy sources. Soy bean and oats are good and inexpensive source of protein especially for many vegetarians or vegan and for those who cannot buy meat and milk. Fat and cholesterol contents are present in low amount in vegan milk than animal milk. Non-dairy yogurt contains unsaturated fatty acid that help to reduce incidences of cardiovascular diseases. In case of lactose intolerance, consumption of vegan milk is beneficial. Non-dairy yogurts have high nutrients and minerals level and it will work as a synbiotic food which is important for human gut, intestine and increase antibodies in human body so it boosts immunity.

Authors Contribution

Conceptualization: HN, NR
Methodology: SM, NR
Formal Analysis: AN, SM
Writing-review and editing: UF, HN

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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