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Quality Evaluation of Yogurt Supplemented with Fruit Pulp (Banana, Papaya, and Water Melon)

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Abstract: Fruit yogurts with three different fruit pulps (banana, papaya and watermelon) at a ratio of 5%, 10% and 15% were prepared and stored at refrigeration condition for 15 days to study the physico-chemical and organoleptic changes over storage period. Addition of fruit pulp significantly ($p<0.05$) affected the physico-chemical and sensorial properties of fresh yogurt samples. Low synersis value with better textural quality were found in fruit yogurt samples compared with the control sample at refrigerated storage condition. Addition of 15% banana pulp resulted in lowest synersis in yogurt among all treatments. Papaya yogurt with all ratios were found most accepted, whereas watermelon yogurt samples were found least preferred to panelists at the end of storage period. Yogurt with maximum 15% fruit pulp, and especially papaya fruit could be recommended for large scale production of fruit yogurt.

Keywords: Fruit Yogurt, Fruit Pulp, Synersis, Quality Evaluation, Physico-chemical

1. Introduction

Yogurt is acidified, custard like semisolid dairy product produced by fermenting pasteurized milk with starter culture containing lactic acid producing bacteria [1]. Yogurt is also known as dhai and one of delicious cultured dairy products in Bangladesh and most of the Asian countries. Yogurt is easily digestible because of its low amount of lactose compared to pasteurized milk. It is most healthy dairy product because of its high amount of nutrients like polyunsaturated fatty acid, protein, calcium, phosphorous. Yogurt is also very effective in curing diarrhea, dysentery, constipation, lowing blood cholesterol and carcinogenesis [2]. Color, flavor, aroma and texture of yogurt depend upon the raw milk, strains involved and manufacturing process [3]. Smooth, glossy and clean surface without any cracking, no syneresis, and no off-flavor indicate the best quality of yogurt.

Yogurt has been proved to be suitable product to make almost complete food by incorporating inexpensive nutrient source [4]. Fruits (strawberry, apple, watermelon, papaya, mango, banana and grape) and vegetables are rich sources of vitamins, mineral, fibers and anti-oxidants can be used in making value-added yogurt [5, 6 and 7]. Fruit dahi is widely popular due to its partially masked acetaldehyde flavor compared to plain dahi [8]. Papaya and pineapple fruits have been selected as best flavor enhancer fruits used in dahi compared to kiwi and kaki fruits [9].

FAO and WHO recommend 5-15% of fruit concentration to use in making value-added yogurt [9]. Pectin and fructose of fruits improve consistency and viscosity of yogurt by getting mixed with, and mouth fell is improved. Pectin is reversely absorbed on casein and increases steric repulsion, and thus aggregation is decreased [10 and 11]. Banana, papaya and water-melon are easily available and mostly consumed fruits in Bangladesh for high amount of β-carotene, lycopene, phenol, anti-oxidant and minerals. Banana is an important source of antioxidants (vitamin C, A and E) and calcium, magnesium and potassium [12]. Papaya is characterized by high amount of proteolytic enzyme like papain and chmyopapain, which help in digestion [13]. Watermelon pulp is rich source of lycopene, vitamin C, B1, B6, potassium, magnesium, zinc, and iodine but low in

calories [14]. Thus blending of banana, papaya and watermelon would produce balanced food. However, banana, papaya and watermelon could be used in the production of fruit yogurts that would reduce the postharvest loss also.

Research works on developing fruit yogurt incorporating banana, papaya and watermelon have not yet done in Bangladesh. This research work was carried out with a view to developing and evaluating fruit yogurts supplemented with pulp of banana, papaya and watermelon.

2. Materials and Methods

2.1. Collection of Raw Materials

Fresh milk was collected from dairy farm of the university. Starter culture, fruits for pulp preparation and sugar were purchased from the local market.

2.2. Preparation of Fruit Pulp

At first, fresh and fully ripe fruits namely, papaya, banana and watermelon were washed properly. Peels were removed with the help of a sharp knife, and seeds were removed from papaya and watermelon manually. Fruit pulp was extracted by a pulper separately. Then, each fruit pulp was filtered with clean cloth and homogenized with a homogenizer. Homogenized fruit pulps were then blanched at 80±1°C for 5 minutes. After cooling, pulps were kept at refrigeration temperature (4°C) in sterile PET bottle separately until the preparation of yogurt.

2.3. Yogurt Preparation

Fresh whole milk was filtered to remove dirt if any in it and then boiled to reduce 15% of its initial volume. During boiling of milk 10% sugar was added and stirred continuously by a stirrer to prevent the formation of cream layer. Heated milk was allowed to cool and when milk temperature was 42-43°C, same amount of milk was poured into different ten cups from which different type of fruit yogurt was prepared. Previously treated fruit pulp (papaya, banana and watermelon) was then added to each cup separately at a rate of 5%, 10% and 15% (v/v) except control. Starter culture (1.5%) was added at 41°C temperature to each cup and then incubated at 37°C for 8-12 hours until complete card formation. Finally, yogurt samples were cooled and stored at refrigerated condition for 15 days of storage study.

2.4. Chemical Analysis

Moisture, ash, protein, acidity, total soluble solids (TSS) and pH of yogurt samples were determined by following methods described by [15]; Moisture content by drying oven method at 105°C for 24 hours; Ash content by muffle furnace ignition method at 550°C; Protein content by Kjeldahl method; acidity by titration against 0.1N sodium hydroxide using phenolphthalein indicator; TSS by Refractometer as degree brix (°B) and pH by pH meter. Fat content was determined by Garber method [16]; solid not fat and carbohydrate were determined by standard mathematical procedure.

2.5. Synersis

An amount of 10 g of the yogurt was spread in a thin layer to cover the surface of the Whatman No. 1 filter paper. The yogurt was filtered under vacuum for 10 min. The liquid that passed through the filter paper was collected and recorded. The percentage of syneresis was calculated as the weight of the liquid divided by the weight of the initial sample multiplied by 100 [17].

2.6. Sensory Evaluation

Sensory evaluation of yogurt were carried out by 30 panelists on a nine-point hedonic scale for different sensory parameters such as color, flavor, taste, body consistency and overall acceptability.

2.7. Statistical Analysis

All the data obtained from three replications were analyzed as a completely randomized design procedure using the general linear model procedure of the SPSS statistical package program (SPSS, Inc., Chicago, IL). The model included fruit pulp ratio and storage time as main effects, and fruit pulp x storage time interaction. Duncan's multiple range test was used to measure the significant difference between means ($P<0.05$).

3. Results and Discussion

3.1. Chemical Analysis of Raw Milk

The chemical compositions of milk namely, moisture, ash, protein, fat, pH, acidity, total solid (TS), Solid Non-Fat (SNF) and lactose were analyzed to know the quality of milk before yogurt production. Results of chemical analyses of milk are shown in Table 1. Protein content of raw milk was 4.33%, which was within the range of 2.3% to 4.4%. [18]. Fat content (3.8%) of raw milk was lower than the fat content (4.16%) reported by [19]. Acidity of raw milk was 0.15, which was within the normal range.

Table 1. *Chemical composition of raw milk.*

Sample	Composition								
Raw milk	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	pH	Acidity (%)	TS (%)	SNF (%)	Lactose (%)
	87.7	0.67	4.33	3.80	6.53	0.15	12.30	8.50	3.41

TS- Total solids; SNF- Solids not Fat.

3.2. Physico-Chemical Properties of Fresh Yogurts

Physico-chemical properties of control and fruit yogurts are shown in Table 2. Significant variation ($p<0.05$) in moisture content was observed in fruit yogurts compare to control yogurt. Moisture content in fruit yogurts increased with the increase of fruit pulp except the addition of banana pulp. The highest (75.35%) and the lowest (74.55%) moisture content were observed in W_3 and B_3 sample respectively whereas, moisture content (74.60%) was observed in control sample. The moisture content in banana yogurt decreased with the increase of pulp because of its low moisture than other pulps. It should be noted that moisture content of fruit yogurt could be increased due to high moisture content of fruit pulp. This result was agreement with the finding observed by [20].

The addition of fruit pulp exhibited more prominent effects on ash content of fruit yogurts. A range of ash content (0.52-0.84%) was resulted in yogurt samples in this study (Table 2). Ash content in papaya and watermelon yogurts decreased with the increase of pulp concentration, but it was contradictory to banana yogurt because of high ash content (1.10%) in banana pulp [21]. The highest (0.84%) and the lowest (0.52%) ash content were observed in B_3 and W_3 sample respectively whereas, ash content (0.72%) was observed in control sample. A similar observation was reported by [21] who resulted higher ash content (0.80%) in banana yogurt (10%) among yogurts developed with apple (10%) and strawberry (10%). In a previous study, [22] observed lower ash content (0.55%) in watermelon pulp (15%) yogurt.

Significant difference ($p<0.05$) in protein content in different yogurt samples was found (Table 2). It was observed that change in protein content in yogurt samples was greatly influenced by incorporation of fruit pulps. Protein content in yogurt samples decreased with the increase of pulp content. The highest (3.80%) and lowest (3.53%) protein were found in control and W_3 sample respectively. B_1 sample was found with highest protein content (3.76) among fruit yogurts, whereas P_1 and W_1 were found with 3.71% and 3.72% protein respectively. Low protein content in fruit pulp than raw milk might be major cause of low protein content in high fruit pulp incorporated yogurt. This result was in line with the finding of [23 and 21].

The variation in pH and acidity of yogurts were highly significant ($p<0.05$) due to the effects of different fruit pulps (Table 2). The addition of fruit pulps decreased the pH in yogurt, and pH range was 0.67-0.79%. Lowest pH (4.27) and highest pH (4.60) were recorded belongs to yogurt sample W_3 and control respectively. W_3 sample was found to be more acidic (0.79%) among fruit yogurts because of its lowest pH (4.27). Fruit pulps were acidic than raw milk that increased acidity in yogurts. These findings were in agreement with the findings of [21, 24 and 19].

Fat content is one of the most important quality factors of yogurt or fruit yogurt. It depends on milk quality, amount of fruit pulp, fruit variety and other treatments. Addition of fruit pulps had significant ($p<0.05$) effect on fat content of fruit yogurt (Table 2). Result showed that, maximum (3.75%) and minimum (3.37%) fat content were found in control and W_3 yogurt sample respectively. Highest fat (3.69%) was found in B_1 sample among fruit yogurt samples. Fat content in fruit yogurt decreased gradually with the increase of pulp content because of very low amount of fat content in pulps compared to milk. A similar observation was also reported by [19 and 9].

The significant ($p<0.05$) variation in total solids (TS) and carbohydrate (CHO) content were observed in all yogurt samples in this research (Table 2). The highest (25.45%) and lowest (24.65) were found in B_3 and W_3 sample respectively, whereas 25.40% of TS was recorded in control sample. In fruit yogurt samples, TS and CHO content were not found to be increased with the increase of fruit pulp except banana yogurt. B_3 sample was recorded with the highest carbohydrate (CHO) content (17.37%), whereas 17.13% of CHO was found in control sample. The finding of TS and CHO content in B_3 sample was appreciated because [21] reported glucose (5%), fructose (6.5%) and sucrose (12%) in banana pulp.

Table 2. *Physico-chemical properties of fresh yogurts.*

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	pH	Acidity (%)	TS (%)	CHO (%)
C	74.60±0.0^{c}	0.72±0.1^{ab}	3.80±0.0^{a}	3.75±0.0^{a}	4.60±0.0^{a}	0.67±0.0^{b}	25.40±0.0^{a}	17.13±0.0^{ab}
B_1	74.60±0.0^{c}	0.76±0.01^{a}	3.76±0.0^{a}	3.69±0.0^{a}	4.56±0.0^{a}	0.69±0.0^{b}	25.40±0.0^{a}	17.19±0.0^{ab}
B_2	74.58±0.0^{c}	0.80±0.02^{a}	3.73±0.0^{a}	3.63±0.0^{ab}	4.50±0.0^{ab}	0.72±0.0^{ab}	25.42±0.0^{a}	17.26±0.0^{a}
B_3	74.55±0.0^{c}	0.84±0.01^{a}	3.68±0.0^{b}	3.56±0.0^{b}	4.46±0.0^{b}	0.75±0.0^{a}	25.45±0.0^{a}	17.37±0.0^{a}
P_1	74.80±0.0^{b}	0.70±0.01^{ab}	3.71±0.0^{ab}	3.68±0.0^{a}	4.51±0.0^{ab}	0.70±0.0^{b}	25.20±0.0^{b}	17.11±0.0^{ab}
P_2	74.98±0.0^{ab}	0.68±0.02^{ab}	3.60±0.0^{bc}	3.57±0.0^{b}	4.42±0.0^{b}	0.73±0.0^{ab}	25.02±0.0^{bc}	17.17±0.0^{a}
P_3	75.13±0.0^{ab}	0.65±0.02^{ab}	3.52±0.0^{c}	3.44±0.0^{c}	4.39±0.0^{bc}	0.77±0.0^{a}	24.87±0.0^{c}	17.26±0.0^{a}
W_1	74.85±0.0^{b}	0.67±0.01^{ab}	3.72±0.0^{ab}	3.63±0.0^{ab}	4.49±0.0^{ab}	0.72±0.0^{ab}	25.15±0.0^{ab}	17.13±0.0^{ab}
W_2	75.13±0.0^{ab}	0.60±0.02^{bc}	3.61±0.0^{bc}	3.49±0.0^{c}	4.38±0.0^{bc}	0.75±0.0^{a}	24.87±0.0^{c}	17.17±0.0^{a}
W_3	75.35±0.2^{a}	0.52±0.02^{c}	3.53±0.0^{c}	3.37±0.0^{c}	4.27±0.0^{c}	0.79±0.0^{a}	24.65±0.0^{c}	17.23±0.0^{a}

TS- Total solids; CHO- Carbohydrate; C- Control; B_1- Yogurt with 5% banana pulp; B_2- Yogurt with 10% banana pulp; B_3- Yogurt with 15% banana pulp; P_1- Yogurt with 5% papaya pulp; P_2- Yogurt with 10% papaya pulp; P_3- Yogurt with 15% papaya pulp; W_1- Yogurt with 5% watermelon pulp; W_2- Yogurt with 10% watermelon pulp; W_3- Yogurt with 15% watermelon pulp; means with different superscripts in same column are significantly different.

3.3. Synersis of Yogurts During Storage

Table 3 shows the results of synersis of yogurts upon storage. Data revealed that addition of fruit pulp significantly ($p<0.05$) affected the synersis of yogurts. Synersis decreased with the addition of fruit pulp and remarkably decreased with the addition of 15% fruit pulp in fresh sample (Table 3). Fruit yogurt samples except banana yogurt were found to be decreased in synersis value up to 5 days of storage and then increased quickly. The synersis value in banana yogurt samples decreased up to 10 days and increased at 15 days of storage. However, lowest value of synersis (42.12%) was found in B_3 sample after 15 days of storage. These results were in accordance with the results of [25]. Again, [26] reported that low solid content, high temperature of incubation and inadequate storage condition could be possible reasons of increased synersis value in yogurt.

Table 3. *Synersis of stored yogurts.*

Parameter	Storage period	C	B_1	B_2	B_3	P_1	P_2	P_3	W_1	W_2	W_3
Synersis (%)	Fresh	48.50^{a}	47.67^{ab}	46.89^{b}	44.78^{c}	48.34^{a}	47.67^{ab}	47.23^{ab}	48.45^{a}	47.14^{b}	47.03^{b}
	5	40.98^{a}	39.92^{b}	39.12^{ab}	38.56^{c}	41.06^{a}	40.98^{a}	41.00^{a}	41.12^{a}	41.02^{a}	41.00^{a}
	10	44.00^{ab}	39.85^{bc}	39.08^{d}	37.23^{e}	41.10^{ab}	40.98^{b}	41.80^{b}	44.35^{a}	44.89^{a}	44.56^{a}
	15	48.45^{a}	46.34^{b}	46.03^{b}	43.12^{c}	48.23^{a}	47.56^{ab}	46.79^{b}	48.46^{a}	47.23^{sb}	47.10^{sb}

C, B_1, B_2, B_3, P_1, P_2, P_3, W_1, W_2 and W_3: see ligand to Table 2 for details; means with different superscripts in same raw are significantly different.

3.4. Sensory Evaluation

As shown in Table 4, data indicated that there was significant ($p<0.05$) difference in sensory attributes during storage period. Fruit yogurts were found most preferred to panelists than control yogurt. Storage study revealed that papaya yogurt was most accepted followed by banana yogurt and watermelon yogurt was found worst based on overall acceptability among the fruit yogurts. Usually, fruit pulp helped to maintain textural properties of finished products. Higher solid and fiber content in fruit pulp may be associated with increasing viscosity and consequently improve the textural properties of fruit yogurts. This finding was similar to [24] who reported better textural quality of stirred fruit yogurts than control.

Table 4. *Sensory evaluation of yogurts during storage.*

Physical criteria	Storage period	C	B_1	B_2	B_3	P_1	P_2	P_3	W_1	W_2	W_3
Color	Fresh	8.50^{a}	8.50^{a}	8.42^{ab}	8.14^{b}	8.51^{a}	8.59^{a}	8.65^{a}	8.44^{ab}	8.50^{a}	8.58^{a}
	5	8.41^{ab}	8.22^{b}	8.13^{bc}	7.85	8.48^{a}	8.51^{a}	8.57^{a}	8.35^{ab}	8.41^{ab}	8.52^{a}
	10	8.35^{ab}	8.06^{bc}	7.71^{c}	7.49^{d}	8.35^{ab}	8.39^{a}	8.41^{a}	8.20^{b}	8.21^{b}	8.31^{ab}
	15	8.21^{a}	7.83^{b}	7.30^{c}	7.19^{d}	8.10^{a}	8.13^{a}	8.14^{a}	7.85^{b}	7.69^{ab}	7.69^{ab}
Flavor	Fresh	8.70^{a}	8.89^{a}	8.97^{a}	9.00^{a}	8.90^{a}	8.94^{a}	8.96^{a}	8.00^{ab}	8.40^{ab}	8.63^{ab}
	5	8.41^{bc}	8.62^{b}	8.73^{ab}	8.85^{a}	8.58^{b}	8.61^{b}	8.84^{a}	7.85^{d}	7.99^{c}	8.20^{e}
	10	8.25^{b}	8.42^{ab}	8.48^{ab}	8.59^{a}	8.35^{ab}	8.39^{ab}	8.51^{a}	7.70^{c}	7.79^{c}	7.81^{c}
	15	8.20^{ab}	8.30^{a}	8.31^{a}	8.33^{a}	8.21^{ab}	8.31^{a}	8.29^{a}	7.55^{c}	7.59^{c}	7.62^{b}
Taste	Fresh	8.68^{b}	8.68^{b}	8.78^{ab}	9.00^{a}	8.68^{b}	8.70^{b}	8.90^{a}	8.10^{c}	8.11^{c}	8.12^{c}
	5	8.59^{b}	8.60^{b}	8.65^{ab}	8.89^{a}	8.60^{b}	8.62^{ab}	8.85^{a}	8.00^{c}	8.01^{c}	8.02^{c}
	10	8.40^{b}	8.45^{b}	8.50^{b}	8.69^{a}	8.42^{b}	8.46^{b}	8.59^{ab}	7.78^{c}	7.79^{c}	7.79^{c}
	15	8.10^{c}	8.26^{b}	8.34^{b}	8.58^{a}	8.29^{b}	8.29^{b}	8.49^{a}	7.45^{d}	7.46^{d}	7.48^{d}
Firmness	Fresh	8.88^{a}	8.88^{a}	8.89^{a}	8.90^{a}	8.78^{b}	8.71^{b}	8.69^{b}	8.39^{c}	8.21^{d}	8.10^{d}
	5	8.79^{a}	8.75^{ab}	8.80^{a}	8.83^{a}	8.52^{b}	8.46^{b}	8.35^{bc}	8.07^{c}	7.89^{d}	7.72^{de}
	10	8.56^{ab}	8.55^{ab}	8.59^{ab}	8.74^{a}	8.41^{b}	8.35^{b}	8.29^{bc}	7.77^{c}	7.69^{c}	7.60^{c}
	15	8.20^{b}	8.26^{ab}	8.29^{ab}	8.48^{a}	8.19^{b}	8.09^{bc}	8.00^{c}	7.35^{c}	7.26^{c}	7.18^{d}
Overall acceptability	Fresh	8.80^{a}	8.79^{a}	8.69^{ab}	8.65^{ab}	8.79^{a}	8.72^{a}	8.73^{a}	8.10^{b}	7.79^{c}	7.60^{cd}
	5	8.69^{a}	8.70^{a}	8.59^{ab}	8.57^{ab}	8.71^{a}	8.65^{a}	8.64^{a}	7.78^{b}	7.56^{c}	7.51^{cd}
	10	8.45^{b}	8.61^{a}	8.60^{a}	8.37^{b}	8.63^{a}	8.60^{a}	8.51^{ab}	7.35^{bc}	7.29^{c}	7.20^{d}
	15	8.19^{b}	8.45^{a}	8.42^{ab}	8.14^{b}	8.50^{a}	8.51^{a}	8.46^{a}	7.20^{c}	7.16^{c}	7.06^{d}

C, B_1, B_2, B_3, P_1, P_2, P_3, W_1, W_2 and W_3: see ligand to Table 2 for details; means with different superscripts in same raw are significantly different.

4. Summary and Conclusion

Fruit yogurt is a new concept regarding dairy products in Bangladesh. Various indigenous fruits could be added to yogurt in form of pulp to increase the nutritional quality and improve the textural properties of yogurts. In this research, three different fruit pulps were added in yogurt and all fruit yogurts were found nutritionally and organoleptically superior than control. In addition, low amount of synersis was observed in fruit yogurt samples than control sample. Papaya yogurt was most preferred over other banana and watermelon yogurts. Therefore, fruit yogurt namely papaya yogurt could be processed in Bangladesh and recommended to the people of all ages.

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