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Processing of Yogurts enriched with Mango, Papaya and Banana

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Abstract

Fruit enriched yogurts prepared with fresh fruits have the potential to increase consumption rates of yogurts, therefore, yogurts enriched with fruit minces of banana, mango, papaya and a combination of all three were prepared individually by using 3% (v/v) of *Lactobacillus bulgaricus* and *Streptococcus thermophillus* at the ratio of 1:1. An expert panel of sensory evaluation assessed all the yogurt samples and determined the suitable formulations in terms of type and percentage of fruits used in the preparation of the yogurts. The yogurt samples were also evaluated by chemical and microbial load assessments. The quality of the yogurts was improved due to the addition of 12% single fruit minces of mango, papaya and banana, however, the yogurts enriched with mango minces were the most acceptableto the panelists. But the higher content of fruit minces (15-21%) in yogurts decreased the overall acceptability gradually to the panelists. The impacts of different preservatives of 0.01% sorbic acid, 0.01% benzoic acid and a combination of two(0.005% each) for extending the shelf life of fruit enriched yogurts at room (25-30°C) and refrigeration (< 5°C) storage were also investigated. Sorbic acid and benzoic acid were effective to lengthen the shelf life of fruit enriched yogurts during room temperature and refrigerated storage of the yogurts, whereas, sorbic acid and refrigeration temperature dominated prolonging the shelf life of the yogurts.

Keywords: fruit enriched yogurt, mango, papaya, banana

Introduction

Enriching yogurt with fruit such as banana, mango and papaya, increases the food value of yogurt, and brings exceptional yogurt flavor which is attractive to the consumers at a greater extend. Fruit enriched yogurt is prepared with fruit minces to enhance nutritional value and flavor. Incorporating mango pulp and soymilk can enhance yogurtís flavor and nutritional value, and these additions of mango pulp and soymilk to milk influence the physicochemical characteristics of sensory and texture profile and reduce syneresis (Kumar & Mishra, 2004). The addition of freeze or air dried apple cubes in yogurt increased the concentration of unconcentrated milk and sensory evaluation by an expert panel showed that yogurt had an acceptable taste (Mastrocola *et al.*, 1996). In Bangladesh, yogurts produced in sweetmeat shops in a small scale are mainly being consumed by the consumers, but in many cases, plain yogurts are being prepared traditionally without considering the improvement of nutritional value of yogurts. In this aspect, the worth of the feasibility of enriching yogurt with indigenous fruits can be examined in order to improve the quality as well as nutritional value of yogurts.

Yogurt making starter culture is a mixture of *Streptococcus thermophilus* and *Lactobacillus delbrueckii spp. bulgaricus*, with a cocci-rods ratio of usually 1:1. The reasons for selecting the combinations of starter cultures used during the manufacture of yogurt are to achieve the desired flavor characteristics of the product, mainly lactate, aroma compounds and to provide the consumers with a wide choice of therapeutics products

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(Tamime & Robinson, 1999).

Yogurt is considered as a healthy food, due to the beneficial properties of its high level of protein content, minerals especially calcium and phosphorous and also fat soluble vitamins of A and D. Many scientists conducted experiments to evaluate the beneficial effects of yogurts, for example, Zemelís *et al.* (2004) showed that obese people who consumed 3-4 daily servings of yogurt while on a balanced, reduced-calorie diet, lost significantly more weight and fat than those who consumed similar amounts of calcium through supplements. They subsequently demonstrated that calcium in yogurt was an important component contributing to the anti-obesity.

For some individuals, yogurt has a definite therapeutic value, especially who usually suffer from stomach and intestinal disorders. It is an assumption that the acid fermenting bacteria and lactose of milk are able to create conditions in the intestinal tract, which are unfavorable for the growth of putrefactive bacteria and thereby prevents the formation of gas in the intestine, and this condition is known as "autointoxication" (Patel & renz-Schauen, 1997). Yogurt is also effective in lowering the blood cholesterol level (Mann & Spoerry, 1974). It is valued for controlling the growth of bacteria and incurring intestinal diseases, for instance, constipation, diarrhea and dysentery (Shahani & Chandan, 1979). Butriss (1997) showed that yogurt had anticancer activities. Thus, of all cultured milk products, yogurt is the most well known and most popular worldwide.

Preservation by retaining stable shelf life of yogurt is a concerning matter for its preparation because increasing shelf life of it in storage is essential for commercial marketing as well as home consumption further. The standard rules and regulations of the addition of preservatives in yogurt have worth importance, and hence, in UK, for example, the SI (1995) provides general information regarding preservatives which are permitted in fruit yogurt, but not in natural yogurt. A similar approach has also been adopted by FAO/WHO (1990) and the permitted preservatives in yogurt, which come exclusively from the fruit preparations, are sorbic acid (including its Na-, K- and Ca-salts), sulphur dioxide and benzoic acid. The maximum permitted level in the final product is 50 mg/kg (singly or in combination) (FAO/WHO, 1990). Cooling the yogurt to <10°C, and maintaining the low temperature until product reaches the consumer, helps to slow down the biological and biochemical reactions that are taking place in the yogurt. Possible biochemical reactions are fat oxidation in the presence of oxygen, hydration of the protein constituent in yogurt, changing in color of the fruit additive, changing in exposed surface physical appearance (Tamime & Robinson, 1999). Refrigeration of yogurt is essential in order to minimize some of these reactions.

The objectives of the work were preparation and sensory evaluation of fruit enriched yogurt and, investigation of the effects of preservatives for extending shelf life of yogurt in terms of physicochemical and microbial load.

Materials and Methods

Materials

Fresh cowís milk, good quality ripe fruits (bananas, mangoes and papayas) and sugars were obtained from a local market, and fresh milk was stored in a refrigerator for preventing spoilage and fruits were kept at 14±1°C with a relative humidity of 90-95% after packing in low density polyethylene bags. Preservatives of sorbic acid, benzoic acid (Sigma, USA) and packaging materials were also used.

Starter culture

Yogurt starter culture (*Streptococcus thermophilus* and *Lactobacillus bulgaricus*) was obtained from Laboratorium Wisby Tonder ApS (Denmark). The freeze-dried culture was propagated by inoculation into fresh milk with 3% fat, which had been heated at 137°C for 2 s (Shaker *et al.*, 2000). Inoculated milk was incubated at 45°C until pH of 4.6 was reached, then stored overnight at 4°C.

Preparation of the fruit enriched yogurt

In order to pasteurize and increase the concentration of the milk 20-25% of the volume of milkwas reduced by heating at boiling temperature. At a rate of 5% (w/v) market sugar was added to the heated milk at the end of

the boiling. The concentrated milk was then allowed to cool to inoculation temperature of 42°C and was inoculated with 3% (v/v) purified culture of *Lactobacillus bulgaricus* and *Streptococcus thermophillus*at the ratio of 1:1. According to the Table 1, the desired level of fruit minces were added to the inoculated milk, and mixed uniformly. Inoculated fruit mixed milk was then poured into clean plastic cups; these plastic cups were placed into an incubator at 43°C for incubation until complete coagulation. After (about 6 hr) complete coagulation, the yogurt samples were cooled to room temperature and stored in a refrigerator for analysis.

Chemical analysis of composition of different yogurt samples

The yogurt samples were analyzed for moisture content, total solid, ash, protein, fat, pH and acidity. The moisture content of yogurt was determined by heating 10 g of yogurt samples at 105°C for 24 hr in an oven (AOAC, 1995), and the total solid (TS) percentage was determined according to the AOAC. Ash content was measured by heating the residue from moisture determination at 550°C for 24 hr as described by the AOAC. Protein content was determined using the Kjeldahl method (AOAC, 1995). Fat content was determined by the method of Soxhlet (AOAC, 1995).pH was measured bya pH meter (Orion, model 230A, USA). Acidity was determined by the titration method expressing in terms of % lactic acid (AOAC, 1995).

Total bacterial counts

For total viable count of yogurt samples, standard plate count was performed according to the method described in "Standard Methods for the Examination of Dairy Products", American Public Health Association (1967).

Sensory evaluation of different fruit enriched yogurts

Sensory evaluation was done according to the 100-point scale described by Nelson and Trout (1981) with some modifications by allocating 50 points for smell and taste, 30 points for body and consistency and 20 points for color and texture, and overall acceptability was calculated by the accumulation of three individual point obtained for each sample. Yogurt samples were tested by a panel of 10 judges, 5 men and 5 women. Their ages ranged from 22 to 35 years. All the judges were conversant with the factors governing the quality of the product. The fruit enriched yogurts prepared for each test sample, were coded with a random two digit number. The panelists were asked to evaluate the smell and taste, body and consistency and color and texture of the yogurts by giving a score ranging from the above mentioned point system.

Preservation Phase

Mango fruit enriched yogurt (yogurt enriched with 12% mango fruit minces) was chosen to observe the impacts of preservatives for long term storage in refrigeration and room temperatures. Four different preservative treatments were considered to observe their impacts in extension of shelf life of mango enriched yogurt during storage. The treatments tested were: T_1 (control,12% mango enriched yogurt without using any preservative), T_2 (0.01% benzoic acid was added to12% mango enriched yogurt), T_3 (0.01% sorbic acid was added to 12% mango enriched yogurt) and T_4 (0.005% each of benzoic acid and sorbic acid was added to 12% mango enriched yogurt). The yogurts with preservative were divided into two groups, thereafter, one group of yogurt samples was stored at room temperature (25-30°C), and another group of yogurt samples was stored in a refrigerator (< 5°C) in the laboratory. Yogurt samples stored in room temperature were drawn everyday and the shelf life of yogurt was determined by physical tests (evaluation of sensorial viewpoints of smell and taste, body and consistency, color and texture by a test panel), chemical tests (acidity and pH) and a microbiological test (total bacterial count in cfu/ml). Similarly, yogurt samples stored in a refrigerator were drawn 2-day intervals and the shelf life of yogurt was determined.

Statistical analysis

The experimental data were analyzed (ANOVA) with the computer program SAS version 8.2 to determine any significant difference among the different fruit enriched

yogurts. Differences between means were determined by Duncanís multiple range test (DMRT) at $P<0.05$.

Results and Discussions

Sensory evaluation of different fruit enriched yogurts

Yogurt was enriched with different fruits of banana, mango, papaya or a combination of all three. In order to formulate a suitable fruit contents in yogurt the added fruit was at a rate of 12%, 15%, 18% or 21%. In general, these content rates are favorable for people. The yogurts were examined with the sensorial view points of smell and taste, body and consistency and color and texture by an expert panel of 10 judges. The panelists determined the best formulation in terms of the fruit type and percentage of different fruit used in the preparation of yogurts. The best formulation was 12% (by weight) of different fruits of banana, mango, papaya or a combination of all three. Hekmat and Reid (2006) reported that 11% strawberry flavoring in yogurt gave the best acceptability to the panelists.

The panelists ranked the yogurts enriched with banana, mango, papaya or a combination of all three for different percent of fruit contents in yogurts by giving scores individually. The yogurts from higher to lower acceptability to the panelists were as followed: $B_1 > B_2 > B_3 > B_4$ (Fig. 1, banana yogurt), $M_1 > M_2 > M_3 > M_4$ (Fig. 2, mango yogurt), $P_1 > P_2 > P_3 > P_4$ (Fig. 3, papaya yogurt), or $C_1 > C_2 > C_3 > C_4$ (Fig. 4, a combination of all three fruits). The analysis of variance (ANOVA) of the data indicate that the effects of fruit contents in yogurts were significant at $P<0.05$. The lower fruit contents of 12% of banana, mango, papaya or a combination of all three played a dominating role holding the quality of the yogurts in terms of smell, taste, consistency, color and texture. But increasing the fruit contents from 15% to 21 % decreased the quality of the yogurts, subsequently, scores of sensory evaluation given by the panelists for yogurts with the higher fruit contents (15% to 21%) dropped down gradually. From the manufacturerís point of view, the physical properties of yogurt, for example, viscosity /consistency of the coagulum are of great importance and, in general, the higher the level of solids in the yogurt mix and the greater the viscosity/ consistency of the end product (Tamime & Robinson,

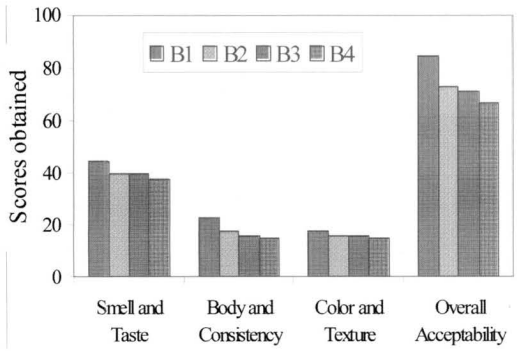

Fig. 1. Sensory evaluation of banana fruit enriched yogurt.

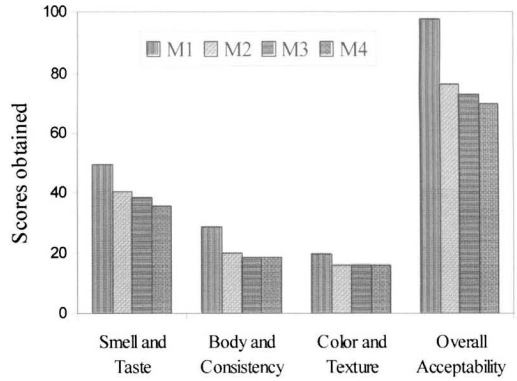

Fig. 2. Sensory evaluation of mango fruit enriched yogurt.

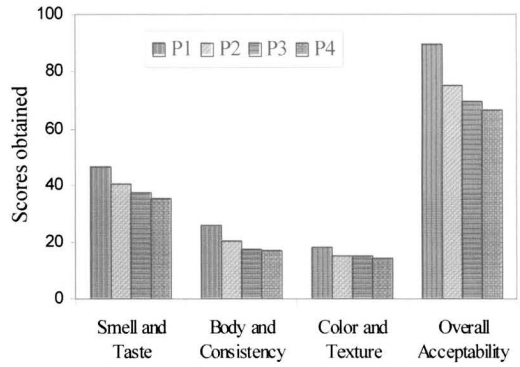

Fig. 3. Sensory evaluation of papaya fruit enriched yogurt.

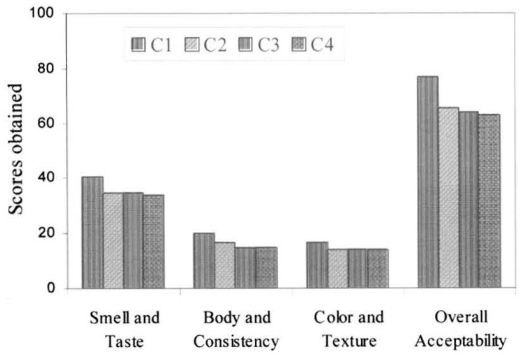

Fig. 4. Sensory evaluation of a combination of banana, mango and papaya fruit enriched yogurt.

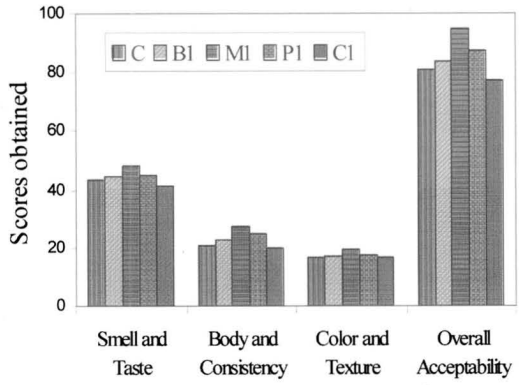

Fig. 5. Sensory evaluation of 12% different fruit enriched yogurts.

1999). The higher amounts of fruit contents of 15%-21 % in yogurts had effects on viscosity/consistency, created syneresis and influenced texture and color, which caused decreasing the scores given by the panelists.

The panelists also determined the best fruit type and ranked the different fruit enriched yogurts as M_1 (12% mango)> P_1 (12% papaya) > B_1 (12% banana)> C (Control, without fruit) > C_1 (a combination of all three fruits of 12%), which was shown in Fig. 5. The yogurt enriched with a combination of all three fruits of 12% was the least acceptableto the panelists. On the other hand, the yogurt enriched with 12% mango obtained the highest score due toits unique flavor to the panelists and it provided attractive color and texture to the yogurt. This showed that the quality of yogurt can be improved with 12% single fruit of mango, papaya or banana. Desai *et al.* (1994) showed thatthe yogurts prepared with mango or pineapple, were more acceptable than those of normal quality yogurts.

Chemical assessment of different fruit enriched yogurts

The chemical compositions of acidity, pH, protein, fat, total solids, ash and moisture contents for different fruit enriched yogurts including control (without fruit) are shown in Table 2. The range of acidity of the yogurts from 0.83 to 0.91 was in the normal range (0.73 to 1.16%) reported by Ghosh and Rajorhia (1987). The acidity of yogurts increased but the pH decreased in the yogurts compared to C (control, without fruit) due to the addition of fruit minces (Table 2) there difference are significant difference. Banana fruit enriched yogurts (B_1) contained the highest amounts (4.42%) of proteins

Table 1. The rate of the addition of fruit minces to the yogurts

Sample	Fruit contents	Sample	Fruit contents
C	Control, without fruit	P_1	12% papaya minces
B_1	12% banana minces	P_2	15% papaya minces
B_2	15% banana minces	P_3	18% papaya minces
B_3	18% banana minces	P_4	21% papaya minces
B_4	21% banana minces	C_1	12% of all three fruit (each 33% of 12%) minces
M_1	12% mango minces	C_2	15% of all three fruit (each 33% of 15%) minces
M_2	15% mango minces	C_3	18% of all three fruit each 33% of 18%) minces
M_3	18% mango minces	C_4	12% of all three fruit (each 33% of 21%) minces
M_4	21% mango minces		

Table 2. Comparison of the average chemical parameters of different types of yogurt samples

Chemical parameters	Different yogurt samples				
	C	B_1	M_1	P_1	C_1
% Acidity	0.83 ± 0.02	0.87 ± 0.04	0.91 ± 0.03	0.88 ± 0.03	0.86 ± 0.03
pH	4.5 ± 0.10	4.31 ± 0.04	4.26 ± 0.05	4.29 ± 0.06	4.27 ± 0.06
% Protein	4.31 ± 0.05	4.42 ± 0.07	4.39 ± 0.06	4.32 ± 0.04	4.33 ± 0.03
% Fat	3.9 ± 0.07	4.2 ± 0.03	4.1 ± 0.04	4.3 ± 0.04	4.4 ± 0.03
% Total solids (TS)	20.67 ± 0.62	26.13 ± 0.11	24.67 ± 0.11	25.67 ± 0.16	24.13± 0.17
% Ash	1.26 ± 0.05	1.39 ± 0.04	1.35 ± 0.09	1.27 ± 0.06	1.41 ± 0.08
% Moisture	77.33 ± 0.32	73.87 ± 0.17	75.33 ± 0.34	74.33 0.22	75.87 ± 0.11

C (control, without fruit), B_1 (12% banana), M_1 (12% mango), P_1 (12% papaya), C_1 (12% of all three fruits)

and was followed by M_1 (12% mango), C_1 (a combination of all three fruits of 12%) and P_1 (12% papaya), respectively. The lowest protein content was in C (control). It showed that protein content increased in yogurt in order to the addition of fruits. Desai *et al.* (1994) found the similar out puts preparing mango and pineapple yogurts. The range of fat contents of the different yogurt samples was from 3.9 % to 4.4% (Table 2), which was slightly lower than that of finding (4.3% to 8.8%) found by Ghosh and Rajorhia (1987).But the fat contents in the yogurts enriched with different fruits were higher than "control" (C, without fruit).It showed that the solid contents increased in the yogurts with the addition of fruit minces (Table 2) and the range of the solid contents in the different yogurt samples was from 20.67% to 26.13%. Ghosh and Rajorhia (1987) found a wide variation (26.9 to 43.0%) of total solid contents in 20 different market yogurt samples, but Desai *et al.* (1994) found 21.99% total solid content in plain yogurts. The ash contents (minerals) increased in fruit enriched yogurts compared to control (C, without fruit) yogurt due to the fruit minces in the yogurt samples (Table 2). Desai *et al.* (1994) showed that mineral contents increased in yogurts due to mango or pineapple contents in the yogurts. It showed that the moisture contents in different fruit enriched yogurts were less than that of control yogurt (C, without fruit).

Physical tests (sensory evaluation)

The yogurt samples stored at both of room and

Table 3. Comparison of organoleptic parameters of different preservative treatments of the yogurts at room temperature

Storage period (days)	Smell and taste (50)				Body and consistency (30)				Color and texture (20)			
	Treatment				Treatment				Treatment			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
0	49.0±1.05^a	48.0±1.29^a	49.0±1.05^a	48.0±1.49^a	29.1±0.99^a	28.1±0.99^a	28.0±0.94^a	29.0±1.05^a	19.0±0.94^a	18.2±1.03^a	19.0±1.05^a	18.2±1.14^a
1	46.0±0.94^b	47.0±1.03^a	48.0±1.33^a	47.0±1.05^a	28.0±1.15^a	28.0±0.82^a	27.9±0.99^a	27.2±1.03^a	17.1±0.88^a	18.0±1.25^a	18.1±1.10^a	17.1±0.99^a
2	38.8±1.40^b	47.0±1.05^a	47.0±1.10^a	38.0±2.00^b	17.1±1.29^b	25.2±1.34^a	24.2±2.04^a	18.1±0.99^b	15.0±0.67^b	16.1±0.99^{ab}	17.0±0.94^a	16.0±1.05^{ab}
3	32.2±1.40^c	43.0±1.37^a	41.0±1.22^b	33.0±1.70^c	15.0±0.67^c	19.0±0.82^b	21.1±1.29^a	14.3±0.67^c	13.3±1.06^b	15.0±0.67^a	16.1±1.20^a	13.1±0.99^b
4	NC	34.0±0.94^b	38.0±1.93^a	NC	NC	17.2±1.23^b	19.0±1.56^a	NC	NC	13.4±1.17^b	16.0±0.94^a	NC
5	-	NC	35.0±1.15^a	-	-	NC	18.1±0.99^a	-	-	NC	13.4±1.26^a	-
6	-	-	NC	-	-	-	NC	-	-	-	NC	-

Means with same superscript within a row are not significantly different at $P<0.05$.
NC= Not consumable, T_1 (control, without preservative), T_2 (0.01% benzoic acid), T_3 (0.01% sorbic acid) and T_4 (a combination of 0.005% each of benzoic acid and sorbic acid)

refrigeration temperatures were examined by an expert panel of 10 judges in order to determine the shelf life of them. The panelists determined the shelf life of yogurts giving scores for smell and taste, body and consistency and color and texture of the yogurts. The panelists also evaluated the yogurts by accepting or rejecting the yogurt samples whether they were consumable or not. The yogurt samples of T_1 (control, without preservative), T_2 (0.01% benzoic acid), T_3 (0.01% sorbic acid) and T_4 (a combination of 0.005% each of benzoic acid and sorbic acid) were consumable for 2, 6 and 8 days (Table 3) in room temperature storage and for 12, 14, 16 and 18 days (Table 4) in refrigeration temperature storage, respectively. The panelists then rejected all the yogurt samples for consumption as all of them were spoiled. In both of room and refrigeration temperatures, the scores given by the panelists for smell and taste, body and consistency and color and texture, decreased gradually (Table 3 and Table 4) with the storage time being passed. Significant differences were observed between the yogurt samples at $P<0.05$ during storage time.

The results also showed that the mixture of benzoic acid and sorbic acid had no effect in room temperature to extend the shelf life of the yogurt, but the mixture of them prolonged the shelf life of the yogurt in refrigeration storage. Both of benzoic acid and sorbic acid were effective to extend the shelf life of the yogurt in room and refrigeration temperatures. But sorbic acid was more effective than benzoic acid lengthening the shelf life of the yogurts during storage. Refrigeration temperature was also more potential than room temperature prolonging the shelf life of the yogurts. Souad *et al.* (1994) reported that 0.075% sodium benzoate, 0.15% potassium sorbate or their mixture extended the self-life of yogurts and potassium sorbate was the most preferred preservative during refrigeration storage to lengthen the shelf life of yogurts. Sorbic acid is a mycostatic agent in that it does not reduce the actual number of yeasts and moulds in the product, but merely inhibits their activity, perhaps by interfering with their dehydrogenase systems (Tamime & Robinson, 1999). Benzoic acid is the predominant phenolic acid in freshly squeezed cranberry juice and the potent antifungal properties of benzoic acid may have eliminated benzoic

Table 4. Comparison of organoleptic parameters of different preservative treatments of the yogurts at refrigeration temperature

Storage period (days)	Smell and taste (50)				Body and consistency (30)				Color andtexture (20)			
	Treatment				Treatment				Treatment			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
0	49.0±1.05^{a}	48.0±1.29^{a}	49.0±1.05^{a}	48.0±1.49^{a}	29.1±0.99^{a}	28.1±0.99^{a}	28.1±0.94^{a}	29.0±1.05^{a}	19.0±0.94^{a}	18.2±1.03^{a}	19.0±1.05^{a}	18.2±1.14^{a}
2	47.9±099^{ab}	48.0±0.94^{ab}	48.7±1.25^{a}	47.3±0.95^{b}	28.0±1.05^{a}	27.9±0.99^{a}	27.0±1.33^{ab}	26.2±0.92^{b}	19.0±0.94^{a}	18.1±1.03^{a}	19.0±0.94^{a}	18.0±0.82^{a}
4	45.1±0.74^{b}	47.0±1.05^{a}	46.1±0.88^{ab}	44.2±1.03^{ab}	25.1±1.37^{b}	27.0±1.05^{a}	26.2±0.92^{ab}	26.0±0.67^{ab}	17.2±1.14^{a}	18.0±1.05^{a}	17.1±0.99^{a}	16.1±0.88^{b}
6	43.2±1.34^{b}	45.1±1.29^{a}	45.2±1.32^{a}	41.3±1.25^{c}	23.2±1.40^{b}	23.2±0.92^{b}	26.0±1.15^{a}	25.0±0.87^{a}	16.1±0.99^{a}	17.1±0.99^{a}	17.1±0.74^{a}	16.0±0.82^{a}
8	41.0±1.05^{b}	42.0±1.15^{b}	45.0±0.82^{a}	39.0±1.15^{c}	21.0±0.94^{b}	23.0±1.49^{a}	24.1±0.99^{a}	23.3±1.16^{a}	16.0±0.82^{ab}	16.2±0.79^{ab}	17.0±0.94^{a}	15.2±0.63^{b}
10	39.2±1.35^{c}	41.2±1.12^{b}	43.0±1.33^{a}	37.1±1.52^{d}	20.8±1.23^{b}	22.3±1.42^{a}	23.1±0.94^{a}	23.1±0.99^{a}	14.0±0.94^{b}	16.2±0.63^{a}	16.2±1.14^{a}	15.0±0.82^{b}
12	32.3±1.49^{c}	41.0±1.15^{a}	40.1±1.29^{a}	37.0±1.70^{b}	18.1±0.99^{b}	22.1±1.45^{ab}	21.2±1.14^{a}	21.0±1.05^{a}	12.1±1.20^{c}	16.1±0.88^{a}	16.0±1.43^{a}	14.1±0.88^{b}
14	NC	40.0±1.05^{a}	40.0±1.15^{a}	33.5±1.18^{b}	NC	21.2±1.14^{a}	21.1±1.05^{a}	19.1±0.88^{b}	NC	15.1±0.99^{a}	15.2±0.79^{a}	13.1±0.74^{b}
16	-	39.0±1.41^{a}	39.1±1.45^{a}	NC	-	20.0±0.82^{a}	19.1±0.74^{b}	NC	-	14.1±0.99^{b}	15.0±0.77^{a}	NC
18	-	35.0±1.05^{b}	37.2±1.22^{a}	-	-	19.0±1.05^{a}	19.0±0.94^{a}	-	-	13.4±1.07^{a}	15.0±0.82^{a}	-
20	-	NC	34.1±0.99^{a}	-	-	NC	18.1±1.37^{a}	-	-	NC	13.3±0.67^{a}	-
22	-	-	NC	-	-	-	NC	-	-	-	NC	-

Means with same superscript within a row are not significantly different at $P<0.05$.
NC= Not consumable, T_1 (control, without preservative), T_2 (0.01% benzoic acid), T_3 (0.01% sorbic acid) and T_4 (a combination of 0.005% each of benzoic acid and sorbic acid)

acid sensitive fungi (Chen *et al.*, 2001).

Chemical tests (acidity and pH)

The yogurt samples stored in room and refrigeration temperatures and the relation between storage time of the yogurts and acidity or pH was investigated. The results obtained during the storage are shown in Table 5 and Table 6. The results showed that acidity of the yogurt samples increased; whereas, pH of the yogurt samples decreased gradually in both phases of room and refrigeration with the storage time being passed at $P< 0.05$.The results also showed that preservative and temperature had significant impacts ($P<0.05$) in changing acidity and pH during storage. Acidity and pH changes of the yogurt samples were more rapid in room temperature than refrigeration temperature. Lactic acid bacteria multiplied rapidly having favorable growth temperature of 25-30°C during room temperature

Table 5. Variation of acidity and pH of different preservative treatments of the yogurts at room temperature

Storage period (days)	% Acidity				pH			
	Treatment				Treatment			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
0	0.61±0.03	0.61±0.04	0.63±0.03	0.62±0.02	4.10±0.13	4.12±0.03	4.20±0.03	4.16±0.05
1	0.96±0.03	0.80±0.04	0.78±0.03	0.95±0.05	2.99±0.10	3.11±0.03	4.00±0.04	3.00±0.05
2	1.14±0.4	0.99±0.05	0.89±0.06	1.16±0.03	2.80±0.04	2.86±0.03	3.96±0.03	2.79±0.04
3	1.34±0.03	1.12±0.04	0.99±0.07	1.32±0.03	2.62±0.05	2.82±0.04	3.10±0.10	2.65±0.05
4	NC	1.28±0.03	1.15±0.06	NC	NC	2.67±0.02	2.85±0.04	NC
5	-	NC	1.34±0.03	-	-	NC	2.61±0.03	-
6	-	-	NC	-	-	-	NC	-

NC= Not consumable, T_1 (control, without preservative), T_2 (0.01% benzoic acid), T_3 (0.01% sorbic acid) and T_4 (a combination of 0.005% each of benzoic acid and sorbic acid)

Table 6. Variation of acidity and pH of different preservative treatments of the yogurts at refrigeration temperature

Storage period (days)	% Acidity				pH			
	Treatment				Treatment			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
0	0.61±0.03	0.61±0.04	0.63±0.03	0.62±0.02	4.10±0.13	4.12±0.03	4.20±0.03	4.16±0.05
2	0.86±0.05	0.78±0.03	0.74±0.04	0.80±0.03	3.66±0.04	3.86±0.03	3.95±0.04	3.65±0.04
4	0.96±0.03	0.83±0.04	0.77±0.04	0.87±0.05	3.40±0.02	3.64±0.03	3.76±0.05	3.52±0.06
6	1.04±0.05	0.87±0.05	0.81±0.04	0.97±0.03	3.19±0.03	3.39±0.03	3.63±0.02	3.38±0.09
8	1.17±0.05	0.96±0.04	0.91±0.04	1.05±1.06	3.01±0.04	3.18±0.04	3.49±0.05	3.27±0.06
10	1.29±0.05	1.01±0.03	0.99±0.03	1.19±0.05	2.91±0.05	3.01±0.04	3.33±0.04	3.12±0.06
12	1.35±0.04	1.17±0.07	1.08±0.82	1.27±0.05	2.80±0.04	2.96±0.04	3.00±0.05	2.93±0.04
14	NC	1.35±0.05	1.22±0.10	1.41±0.04	NC	2.85±0.04	2.95±0.02	2.70±0.04
16	-	1.47±0.06	1.36±0.04	NC	-	2.71±0.05	2.82±0.04	NC
18	-	1.61±0.05	1.45±0.67	-	-	2.62±0.04	2.70±0.04	-
20	-	NC	1.59±0.05	-	-	NC	2.63±0.04	-
22	-	-	NC	-	-	-	NC	-

NC= Not consumable, T_1 (control, without preservative), T_2 (0.01% benzoic acid), T_3 (0.01% sorbic acid) and T_4 (a combination of 0.005% each of benzoic acid and sorbic acid)

storage and they produced lactic acids by lactose fermentation in a large scale, which caused rapid increasing of acidity and decreasing of pH in the yogurt samples. On the other hand, refrigeration temperature of < 5°C retarded the rapid multiplication of lactic acid bacteria and thereby extended the shelf life of the yogurts for further consumption (Tamime & Robinson, 1999).

Microbiological tests

The total bacteria (cfu/ml) in the yogurts during storage were estimated everyday for room storage and 2-day intervals for refrigeration storage. The relations between bacterial growth and storage period at refrigeration and room temperatures are shown in Fig. 6 and Fig. 7. The results showed that the growth of bacteria in the yogurts increased with the increasing of storage period up to 7 to 9 days in refrigeration storage. Then the growth of bacteria was little from 8 to 12 days. After 12days the growth of bacteria recessed gradually. These growth curves of bacteria followed more or less original trend of bacterial growth curve (Tamime & Robinson, 1999). El-Kenaay (1996) examined yogurt samples at 7-day intervals of storage at 5°C temperature and reported that total lactic acid bacterial counts increased during 0-7 days of storage in all yogurts but decreased after >7 days of storage. On the other hand, at

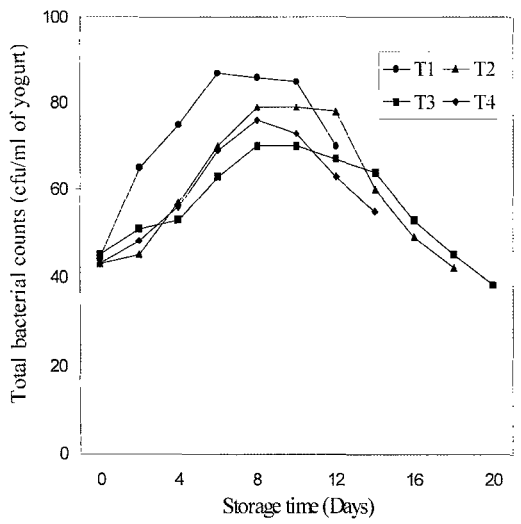

Fig. 6. Relationship between total bacterial count and storage time at refrigeration temperature.

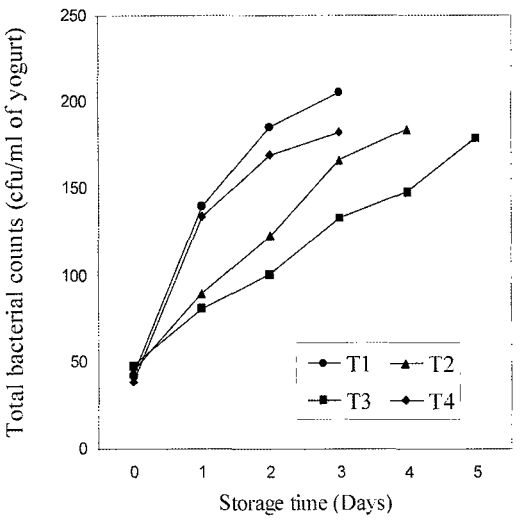

Fig. 7. Relationship between total bacterial count and storage time at room temperature.

room storage the growth curves increased gradually and these growth curves of bacteria followed the growth phase only due to rapid growth of bacteria and spoilage of all the yogurt samples rapidly.

Conclusion

The fruit contents in the yogurts have increased acceptability to the panelists but the amounts of fruit in the yogurts should be optimized. 12% fruit of mango, papaya or banana in the yogurts improved the nutritional value and the quality of the yogurts. The higher amounts of fruit of 15%-21 % in the yogurts decreased the quality of them. The yogurt enriched with 12% mango was the most acceptable to the panelists. The smell, taste, consistency, color and texture of the yogurts inclined to decrease during both of room and refrigeration storage. Sorbic acid and benzoic acid can maintain the chemical quality, and lengthen the shelf life of the mango fruit enriched yogurts during storage; therefore, sorbic acid and benzoic acid can be used as safe preservatives for fruit enriched yogurts under refrigerated and room storage.

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