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Development and Quality Evaluation of Yoghurt Fortified with Pineapple, Apple and Sweet Lemon Juice (Fruit Yoghurt)

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Abstract **- Yoghurt or dahi is consumed worldwide for its nutritional and health benefits. The research was conducted to prepare yoghurt incorporating different fruit juices and also to evaluate their quality characteristics. For this purpose, plain yoghurt and fruit yoghurts were prepared from whole milk of buffalo by adding different levels of fruit juice (5%, 10% and 15%) of different fruits (pineapple, apple and sweet lemon) except plain one in which fruit juice was not added and inoculating with strain of lactic acid bacteria (LAB). Quality of yoghurt samples were analyzed with the help of physical (smell and taste, body and consistency, color and texture) and chemical (moisture, total solids, ash, protein, fat and carbohydrate content and pH) characteristics. Yoghurts fortified with 5% and 10% pineapple juice and apple juice were good in smell and taste; 10% apple juice yoghurt being the best among all fruit yoghurts. Yoghurts with 5% pineapple juice and 5% and 10% apple juice were good in body and consistency; 5% apple juice yoghurt being the best among all fruit yoghurts. Yoghurts with 5% and 10% pineapple juice, 5% apple juice and 5% and 10% sweet lemon juice were good in color and texture; 10% pineapple juice yoghurt being the best among all fruit yoghurts. Thus, yoghurts fortified with 5% and 10% pineapple juice and apple juice were good in overall physical characteristics; 5% apple juice yoghurt being the best among all fruit yoghurts.**

Moisture content was increased in 10% pineapple juice and at all concentrations of apple juice and sweet lemon juice yoghurts than 0% fruit juice or plain yoghurt, while decreased in 5% and 15% pineapple juice yoghurts. Total solids content was increased in 5% and 15% pineapple juice yoghurts than plain yoghurt, while decreased in 10% pineapple juice and at all concentrations of apple juice and sweet lemon juice yoghurts. Ash content was decreased at all concentrations of all fruit (pineapple, apple and sweet lemon) juice yoghurts than plain yoghurt. Protein content was decreased at all concentrations of all fruit juice yoghurts than plain yoghurt. Fat content was decreased at all concentrations of all fruit juice yoghurts than plain yoghurt. Carbohydrate content was increased in 5% and 15% pineapple juice and at all concentrations of sweet lemon juice yoghurts than plain yoghurt, while decreased in 10% pineapple juice and at all concentrations of apple juice yoghurts. pH was decreased at all concentrations of all fruit juice yoghurts than plain yoghurt. This formulation and quality findings will be helpful to set up fruit yoghurt industry.

Keywords: Yoghurt, Dahi, Pineapple, Apple, Sweet lemon, Fruit juices, LAB, Quality

INTRODUCTION

The milk and milk products are important food items for people of all ages. Together with milk, fermented milk products are occupying a greater portion of daily food menu of a modern civilized nation, certainly due to their great food value and palatability. Fermentation has been an ideal technology to preserve milk from time immemorial. Of all, cultured milk products, the yoghurts are well known and most popular worldwide (Mansour et al., 1994). It is a nutritiously balanced food containing almost all the nutrients present in milk but in a more assimilable form. Worldwide, cow's milk is most commonly used to make yogurt, but milk from buffalo, goats, ewes, mares, camels, and yaks is also used in various parts of the world. In India, it is most often made from cow or buffalo milk with the buffalo milk version being the fattier of the two. It can be made from different types of milk, including skimmed, semi-skimmed, whole, evaporated or powdered forms.

Fermentation of milk by specific microflora accompying a technological modification and using some additives induces change in taste, texture, visual appearance, color, flavor and the nutritive properties of milk and produces a wide variety of foods (Oberman & Libudzisz, 1998). Yoghurt is generally considered as a safer product and its unique flavor appeals to so many that consideration is being given by nutritionists to incorporate inexpensive source of nutrients to make it an almost complete food (Boghra & Mathur, 2000). Human consumption of yoghurt has been associated with tremendous health benefits due to improvement of gastrointestinal functions and disease risk reduction (Heyman, 2000). Like milk, yoghurt is a healthy and delicious food due to its high nutritive and therapeutic value (Perdigon et al., 2002). Due to low lactose content it is easily digestible and palatable than milk. It is valued for controlling the growth of bacteria and in curing of

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intestinal diseases like constipation, diarrhea and dysentery, anti-carcinogenic effect and lowering blood cholesterol (Kamruzzaman et al., 2002).

Dahi or yoghurt is a custard like semi solid, acidified dairy product made by fermenting partially evaporated milk with a special culture containing lactic acid producing bacteria (Munzur et al., 2004). The bacteria used to make yogurt are known as "yogurt cultures". It is obtained by lactic acid fermentation of milk through the action of a starter culture containing *Streptococcus thermophilus* and *Lactobacillus bulgaricus* (Adolfsson *et al*., 2004). Fermentation of lactose by these bacteria produces lactic acid, which acts on milk protein that coagulate and set to give yogurt its texture and its characteristic tang. A colourless liquid called acetaldehyde is also produced during fermentation and gives yogurt its distinct flavour. Flavor, texture, and aroma of yoghurt or dahi depend upon the country origin as well as other factors including raw materials quality, manufacturing processes and the strains involved (Kumar & Mishra, 2004).

Preparation of fruit yoghurt has been investigated by a number of researchers in different parts of world. But, in India no research work has yet been done on the manufacture of yoghurt incorporating pineapple, apple and sweet lemon juices. Hence in the present study, an attempt was made to develop a suitable technology for the production of fruit juice made yoghurt from whole milk fortified with different levels of pineapple, apple and sweet lemon juices and to compare their qualities on the basis of physical, chemical and microbiological parameters.

MATERIALS AND METHODS

1. Collection of materials

Fresh whole milk of buffalo was collected from the dairy farm at Indira nagar, Lucknow. Fruit juices of pineapple, apple & sweet lemon, sugar and starter culture were collected from the local market of Lucknow.

2. Preparation of plain yoghurt (control) and fruit (pineapple, apple and sweet lemon juice) yoghurt

Whole milk was heated in a pre-washed pan on the heater to reduce about one-third of its original volume. Sugar was added to the milk at the rate of 12% after boiling. During heating milk was stirred continuously with the help of a stirrer to avoid formation of cream layer. After desired heating, milk pan was taken out from the heater and allowed to cool. When the temperature was about 40°C, then milk was divided into four equal portions in the plastic cups and a different type of yoghurt was prepared from each portion. The plastic cups were pre-washed with boiled water before use. The fruit (pineapple, apple and sweet lemon) juice was incorporated into yoghurt at 10, 20 and 30% level in different cups except control (Nahar *et al*., 2007). Juice was added before incubation with starter culture (Guven and Karaca, 2002). Milk was inoculated with desirable proportion of starter culture (2%). The samples were incubated at 37°C until the complete curd formation/coagulation of yoghurt (8-12 h). The yoghurt samples were stored at about 4°C at refrigeration until used.

3. Physical tests of fruit yoghurt

After complete curd formation, the yoghurt samples were judged separately by a team of 15 experienced judges for organoleptic parameters including smell and taste, body and consistency, color and texture and data were analysed statistically (Hossain *et al*., 2011). A score card of total 20 points was used having maximum 10 points for smell and taste, 6 points for body and consistency and 4 points for color and texture. Plain yoghurt (no fruit juice added) was compared with yoghurts incorporating different concentrations (10, 20 and 30%) of pineapple, apple and sweet lemon juices for average smell and taste, body and consistency and color and flavor by a team of judges.

4. Chemical analysis of fresh milk and fruit yoghurt

Chemical characteristics of yoghurt samples were also analyzed as these are important indicators of quality measures of prepared fruit yoghurt. Moisture, total solids and ash content were determined (AOAC, 1999). Protein content was measured by Formol titration method (Pearson, 1976). Fat content was measured by Gerber's method (Pearson, 1976). Total carbohydrate content was determined by subtracting the measured protein, fat, ash and moisture from 100 (Lopez *et al*., 1998; Begum *et al*., 2011). Acidity was determined by titration with 0.1 N sodium hydroxide solution (Aggarwal and Sharma, 1961). PH was measured with the help of a pH strip.

RESULTS AND DISCUSSION

1. Qualitative analysis of the physical characteristics

Plain yoghurt (PL) in which no fruit juice was added and yoghurts incorporating different concentrations (5, 10 and 15%) of pineapple juice (P_1, P_2 and P_3), apple juice (A_1, A_2 and A_3), and sweet lemon juice (S_1, S_2 and S_3) were evaluated for organoleptic characteristics (average smell and taste, body and consistency, and color and flavor) by a team of 15 judges. A score card of total 20 points for physical characteristics was used having maximum 10 points for smell and taste, 6 points for body and consistency and 4 points for color and texture.

1.1. Comparison of physical characteristics of plain yoghurt and fruit yoghurts

All yoghurt samples were given total points out of 20 for overall physical characteristics by adding their average points out of 10, 6, and 4 for smell and taste, body and consistency, and color and flavor respectively. Results obtained are shown in table 1.1.

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TABLE 1.1: Total scores (out of 20) for physical characteristics of plain yoghurt and different fruit yoghurts.

Physical characteristics	PL	P_1	P_2	P_3	A_1	A_2	A_3	S_1	S_2	S_3
Smell and taste	8.6	8.3	8.9	7.5	8.5	9.4	7.8	7.7	6.9	6.1
Body and consistency	5.2	4.9	4.1	3.4	5.4	4.6	3.9	4.0	3.5	2.9
Color and texture	3.5	3.2	3.7	2.8	3.1	2.3	1.5	3.0	3.4	2.5
Total score	**17.3**	**16.4**	**16.7**	**13.7**	**17.0**	**16.3**	**13.2**	**14.7**	**13.8**	**11.5**

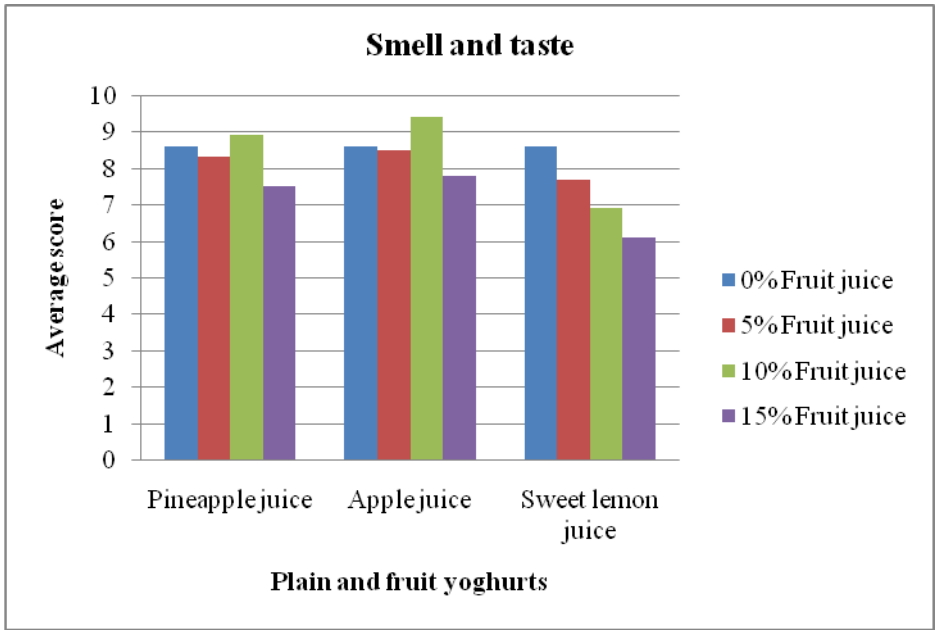
PL= Plain yoghurt with 0% fruit juice.
P_1, P_2 and P_3= Pineapple juice yoghurt with 5, 10 and 15% concentrations respectively.
A_1, A_2 and A_3= Apple juice yoghurt with 5, 10 and 15% concentrations respectively.
S_1, S_2 and S_3= Sweet lemon juice yoghurt with 5, 10 and 15% concentrations respectively.

Highest total score (17.3) for overall physical characteristics was seen in case of yoghurt with 0% fruit juice or plain yoghurt (PL), on the other hand, lowest total score (11.5) was recorded in case of yoghurt with 15% sweet lemon juice (S_3), as shown in figure 4.4. However yoghurts with 5% pineapple juice (P_1) having total score of 16.4, 10% pineapple juice (P_2) having total score of 16.7, 5% apple juice (A_1) having total score of 17.0 and 10% apple juice (A_2) having total score of 16.3 were also equally acceptable.

1.2. Smell and taste analysis

All yoghurt samples were analysed by a team of 15 judges and points were given out of 10 for smell and taste. Highest average score (9.4) for smell and taste was seen in case of yoghurt with 10% apple juice (A_2), on the other hand, lowest average score (6.1) was recorded in case of yoghurt with 15% sweet lemon juice (S_3), as shown in figure 1.2. However, yoghurt with 0% fruit juice or plain yoghurt (PL) having average score of 8.6 and yoghurts with 5% pineapple juice (P_1) having average score of 8.3, 10% pineapple juice (P_2) having average score of 8.9 and 5% apple juice (A_1) having average score of 8.5 were also equally acceptable.

FIGURE 1.2: Average scores (out of 10) for smell and taste of plain yoghurt and different fruit yoghurts.



1.3. Body and consistency analysis

All yoghurt samples were analyzed by a team of 15 judges and points were given out of 6 for body and consistency. Highest average score (5.4) for body and consistency was seen in case of yoghurt with 5% apple juice (A_1), on the other hand, lowest average score (2.9) was recorded in case

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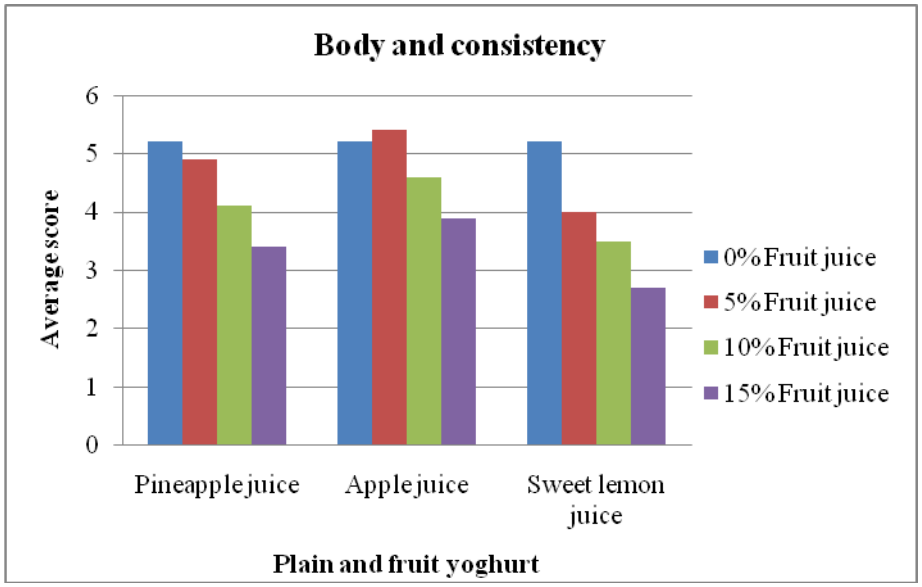
of yoghurt with 15% sweet lemon juice (S_3), as shown in figure 1.3. However, yoghurt with 0% fruit juice or plain yoghurt (PL) having average score of 5.2, yoghurts with 5% pineapple juice (P_1) having average score of 4.9 and 10% apple juice (A_2) having average score of 4.6 were also equally acceptable.

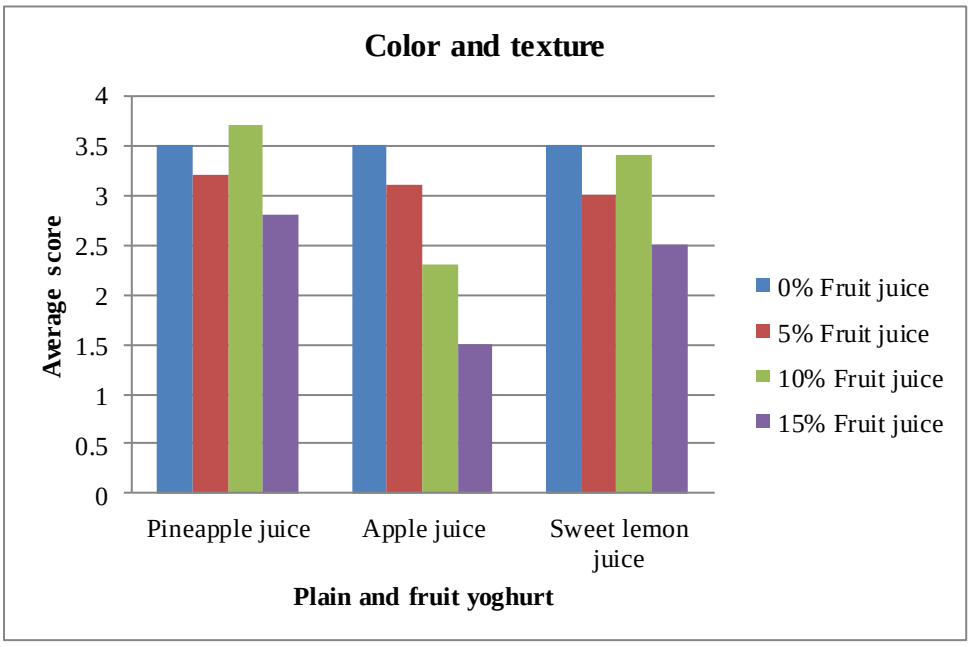
FIGURE 1.3: Average scores (out of 6) for body and consistency of plain yoghurt and different fruit yoghurts.



1.4. Color and texture analysis

All yoghurt samples were analysed by a team of 15 judges and points were given out of 4 for color and texture. Highest average score (3.7) for color and texture was seen in case of yoghurt with 10% pineapple juice (P_2), on the other hand, lowest average score (1.5) was recorded in case of yoghurt with 15% apple juice (A_3), as shown in figure 1.4. However, yoghurt with 0% fruit juice or plain yoghurt (PL) having average score of 3.5 and yoghurts with 5% pineapple juice (P_1) having average score of 3.2, 5% apple juice (A_1) having average score of 3.1, 5% sweet lemon juice (S_1) having average score of 3.0 and 10% sweet lemon juice (S_2) having average score of 3.4 were also equally acceptable.

FIGURE 1.4: Average scores (out of 4) for color and texture of plain yoghurt and different fruit yoghurts.



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2. Qualitative analysis of the chemical characteristics

Chemical characteristics (moisture content, total solids content, ash content, protein content, fat content, carbohydrate content and pH) of the plain yoghurt and fruit yoghurts were determined and analysed.

2.1. Comparison of chemical characteristics of plain yoghurt and fruit yoghurts

All the chemical characteristics (moisture content, total solids content, ash content, protein content, fat content, carbohydrate content and pH) were evaluated and compared. Results obtained for all yoghurt samples are shown in table 4.12.

TABLE 2.1: Chemical characteristics of plain yoghurt and different fruit yoghurts.

Chemical characteristics	PL	P_1	P_2	P_3	A_1	A_2	A_3	S_1	S_2	S_3
M.C.(%)	74.30	73.43	75.20	72.57	74.87	76.03	78.40	74.60	75.17	76.07
T.S.(%)	25.70	26.57	24.80	27.43	25.13	23.97	21.60	25.40	24.83	23.93
A.C.(%)	0.73	0.71	0.69	0.67	0.68	0.65	0.63	0.70	0.67	0.66
P.C.(%)	3.52	2.94	3.28	3.01	3.45	3.18	3.11	3.01	2.84	2.77
F.C.(%)	4.61	4.06	4.21	3.95	4.36	4.29	4.13	4.02	3.88	3.64
C.C.(%)	16.84	18.56	16.62	19.80	16.64	14.87	13.73	17.67	17.44	16.86
pH	6.2	5.8	5.5	5.3	5.9	5.7	5.4	5.6	4.9	4.1

PL= Plain yoghurt with 0% fruit juice.
P_1, P_2 and P_3= Pineapple juice yoghurt with 5, 10 and 15% concentrations respectively.
A_1, A_2 and A_3= Apple juice yoghurt with 5, 10 and 15% concentrations respectively.
S_1, S_2 and S_3= Sweet lemon juice yoghurt with 5, 10 and 15% concentrations respectively.
M.C.= Moisture content.
T.S.= Total solids content.
A.C.= Ash content.
P.C.= Protein content.
F.C.= Fat content.
C.C.= Carbohydrate content.

2.2. Moisture content determination

Moisture content was measured using formula,

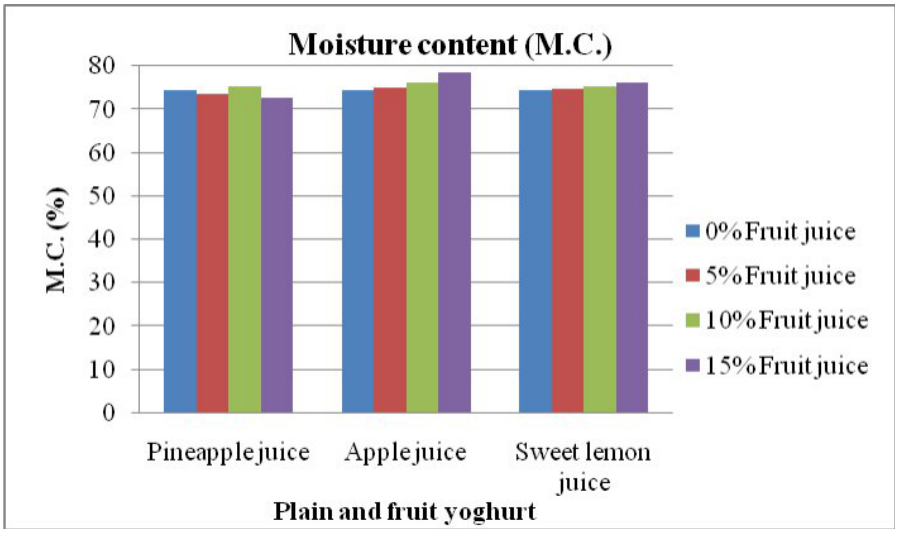
$$M.C.\ (\%) = \frac{(Y_1 - Y_2)}{Y_1} \times 100$$

where, Y_1 and Y_2 = Weight of yoghurt sample before drying and after drying respectively.

M.C. = Moisture content.

Highest moisture content (78.40%) was seen in case of yoghurt with 15% apple juice (A_3), on the other hand, lowest moisture ((72.57%) was recorded in case of yoghurt with 15% pineapple juice (P_3), as shown in figure 2.2. Moisture content was increased in 10% pineapple juice and at all concentrations (5%, 10% and 15%) of apple juice and sweet lemon juice yoghurts (P_2, A_1, A_2, A_3, S_1, S_2 and S_3) than 0% fruit juice or plain yoghurt (PL), while decreased in 5% and 15% pineapple juice yoghurts (P_1 and P_3).

FIGURE 2.2: Moisture content of plain yoghurt and different fruit yoghurts.



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2.3. Total solids content determination

Total solids content was measured using formula,

$$T.S.\ (\%) = \frac{(D + Y_2) - D}{Y_1} \times 100$$

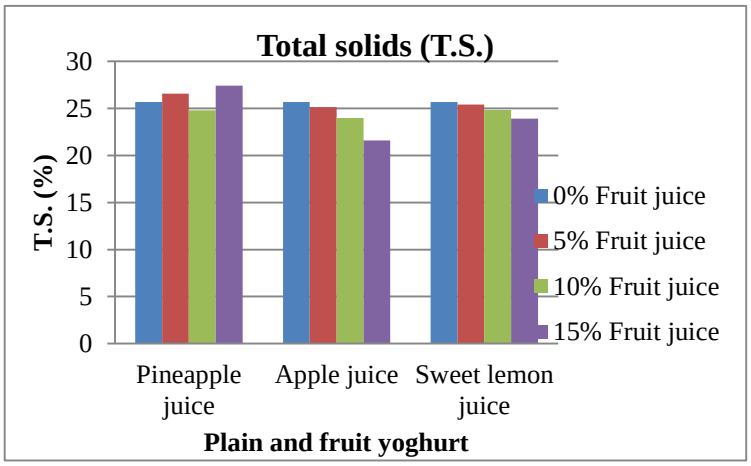
where, D = Weight of dish.

Y_1 and Y_2 = Weight of yoghurt sample before drying and after drying respectively.

T.S. = Total solids content.

Highest total solids content (27.43%) was seen in case of yoghurt with 15% pineapple juice (P_3), on the other hand, lowest total solids (21.60%) was recorded in case of yoghurt with 15% apple juice (A_3), as shown in figure 2.3. Total solids content was increased in 5% and 15% pineapple juice yoghurts (P_1 and P_3) than 0% fruit juice or plain yoghurt (PL), while decreased in 10% pineapple juice and at all concentrations (5%, 10% and 15%) of apple juice and sweet lemon juice yoghurts (P_2, A_1, A_2, A_3, S_1, S_2 and S_3).

FIGURE 2.3: Total solids content of plain yoghurt and different fruit yoghurts.



2.4. Ash content determination

Ash content was measured using formula,

$$A.C.\ (\%) = \frac{A}{Y} \times 100$$

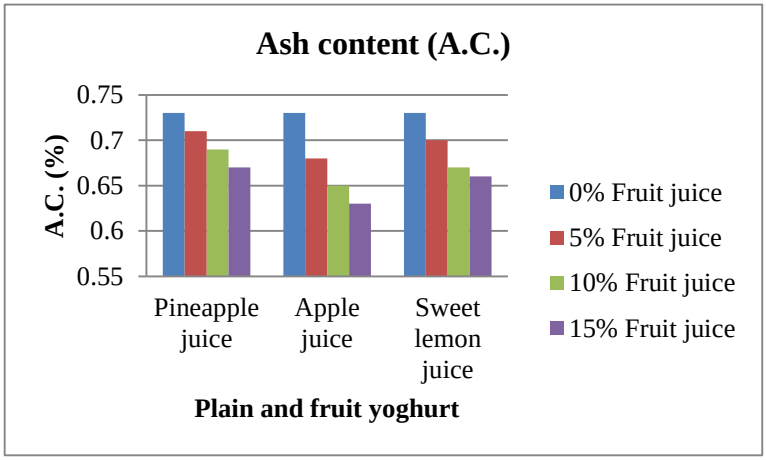
where, A = Weight of ash.

Y = Weight of yoghurt sample.

A.C. = Ash content.

Highest ash content (0.73%) was seen in case of yoghurt with 0% fruit juice or plain yoghurt (PL), on the other hand, lowest ash (0.63%) was recorded in case of yoghurt with 15% apple juice (A_3), as shown in figure 2.4. Ash content was decreased at all concentrations (5%, 10% and 15%) of all fruit (pineapple, apple and sweet lemon) juice yoghurts (P_1, P_2, P_3, A_1, A_2, A_3, S_1, S_2 and S_3) than 0% fruit juice or plain yoghurt (PL).

FIGURE 2.4: Ash content of plain yoghurt and different fruit yoghurts.



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2.5. Protein content determination

Protein content was measured using formula,

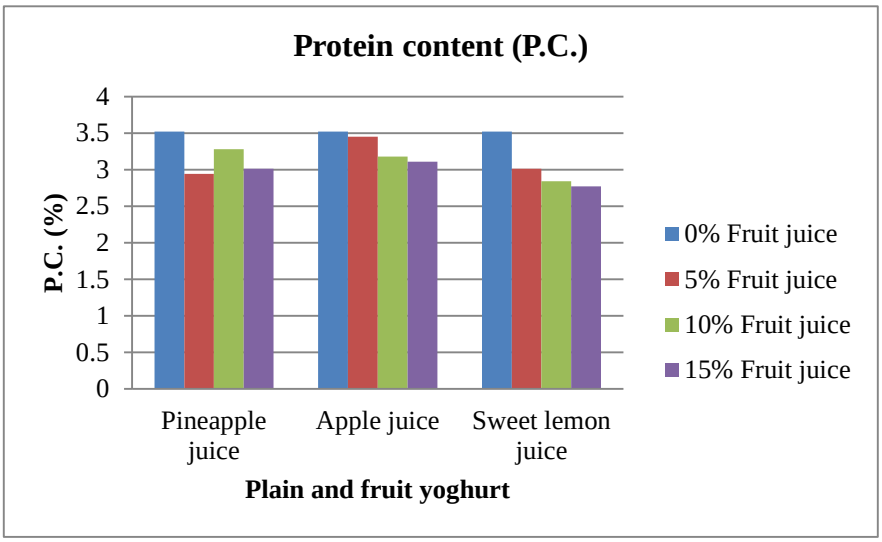
$$P.C.\ (\%) = V_{Avg.} \times 1.7$$

where, $V_{Avg.}$ = Average volume of NaOH in second titration.

P.C. = Protein content.

Highest protein content (3.52%) was seen in case of yoghurt with 0% fruit juice or plain yoghurt (PL), on the other hand, lowest protein (2.77%) was recorded in case of yoghurt with 15% sweet lemon juice (S_3), as shown in figure 2.5. Protein content was decreased at all concentrations (5%, 10% and 15%) of all fruit (pineapple, apple and sweet lemon) juice yoghurts (P_1, P_2, P_3, A_1, A_2, A_3, S_1, S_2 and S_3) than 0% fruit juice or plain yoghurt (PL).

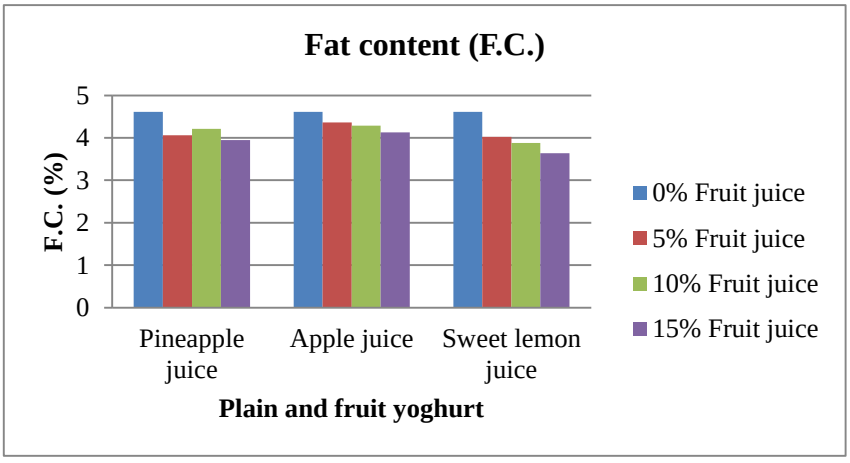
FIGURE 2.5: Protein content of plain yoghurt and different fruit yoghurts.



2.6. Fat content determination

Fat content was measured using butyrometer. Highest fat content (4.61%) was seen in case of yoghurt with 0% fruit juice or plain yoghurt (PL), on the other hand, lowest fat (3.64%) was recorded in case of yoghurt with 15% sweet lemon juice (S_3), as shown in figure 2.6. Fat content was decreased at all concentrations (5%, 10% and 15%) of all fruit (pineapple, apple and sweet lemon) juice yoghurts (P_1, P_2, P_3, A_1, A_2, A_3, S_1, S_2 and S_3) than 0% fruit juice or plain yoghurt (PL).

FIGURE 2.6: Fat content of plain yoghurt and different fruit yoghurts.



2.7. Carbohydrate content determination

Carbohydrate content was measured using formula,

$$C.C.\ (\%) = 100 - \{M.C.\ (\%) + A.C.\ (\%) + P.C.\ (\%) + F.C.\ (\%)\}$$

where, M.C. = Moisture content.

A.C. = Ash content.

P.C. = Protein content.

F.C. = Fat content.

C.C. = Carbohydrate content.

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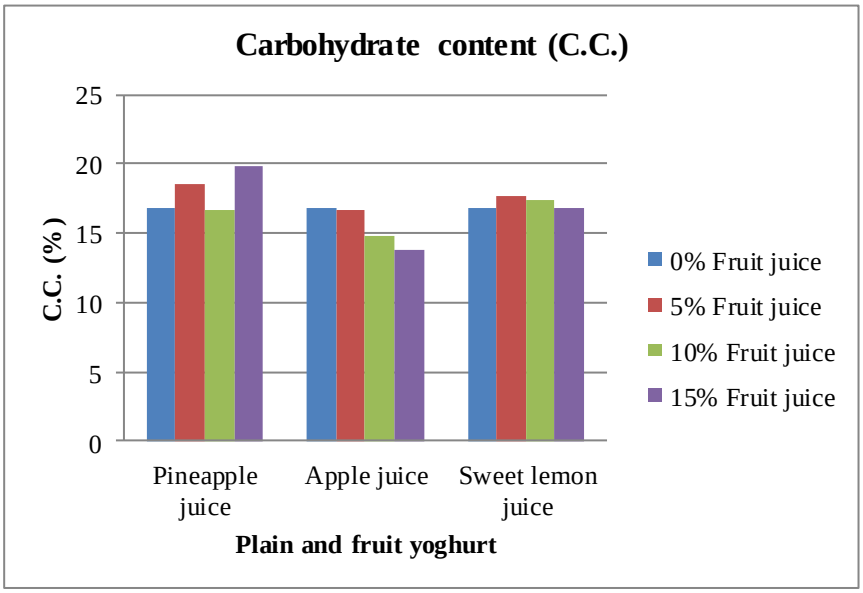
Highest carbohydrate content (19.80%) was seen in case of yoghurt with 15% pineapple juice (P_3), on the other hand, lowest carbohydrate (13.73%) was recorded in case of yoghurt with 15% apple juice (A_3), as shown in figure 2.7. Carbohydrate content was increased in 5% and 15% pineapple juice and at all concentrations (5%, 10% and 15%) of sweet lemon juice yoghurts (P_1, P_3, S_1, S_2 and S_3) than 0% fruit juice or plain yoghurt (PL), while decreased in 10% pineapple juice and at all concentrations (5%, 10% and 15%) of apple juice yoghurts (P_2, A_1, A_2 and A_3).

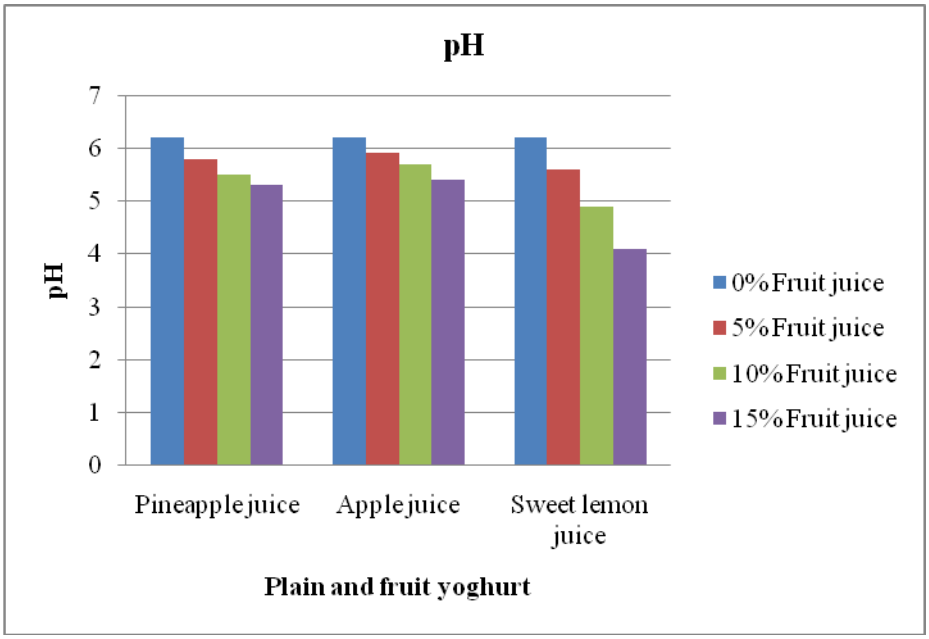
FIGURE 2.7: Carbohydrate content of plain yoghurt and different fruit yoghurts.



2.8. pH determination

Moisture content was measured using pH strips. Highest pH (6.2) was seen in case of yoghurt with 0% fruit juice or plain yoghurt (PL), on the other hand, lowest pH (4.1) was recorded in case of yoghurt with 15% sweet lemon juice (S_3), as shown in figure 2.8. pH was decreased at all concentrations (5%, 10% and 15%) of all fruit (pineapple, apple and sweet lemon) juice yoghurts (P_1, P_2, P_3, A_1, A_2, A_3, S_1, S_2 and S_3) than 0% fruit juice or plain yoghurt (PL).

FIGURE 2.8: pH of plain yoghurt and different fruit yoghurts.



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