Effect of red plum on quality characteristics of banana milk smoothies

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Abstract : The present study was carried out to enhance the functional quality of milk smoothies. Experiments were conducted on various formulations of smoothies using banana (T1 without plum) and red plum in different proportions (75:25 (T2), 50:50 (T3), and 25:75 (T4)) along with Sahiwal cows milk. Results revealed that physico-chemical quality characteristics of control (T1 banana-based smoothie) and smoothie replaced with red plum differ significantly ($P < 0.05$) for moisture, protein, fat, fiber, sugar, total solid, solid-not fat, pH, and vitamin-C. Smoothie prepared with 50 % banana and 50 % red plum (T3) rated higher sensory scores for all sensory attributes than other groups. Among all milk smoothies, T3 group was selected best on the basis of nutritional, physicochemical, and sensory qualities.

Keywords: Banana, Milk smoothie, Physico-chemical quality, Red plum, Sensory profile

Introduction

Appearance of the smoothie is like milk sake, semi solid in consistency. Smoothie is dairy products commonly prepared with fruit and milk and provides health promoted compounds (minerals, vitamins, fiber, polyphenolics) to the consumers. Milk and milk products are rich in good quality amino acids and fatty acids. However, in general milk is deficient in fiber and vitamin-C. India ranks first in milk production and produced 187.7 million metric tons (DAHD & F) in the 2018-19. The red plum is good source of vitamin-C, fibre and polyphenolic compounds etc. Consumers are very health conscious nowadays therefore; they demand healthy food products in terms of nutritive value and palatability. The nutritional quality of foods basically milk and fruit based products depends not only on the nutrient content of fruits but also on the processing conditions (Kumar et al. 2018). Addition of fresh fruits and/or vegetables in milk products improves its nutritional quality, sensorial attributes and also increased its functionality. Smoothie prepared with the mixing of fruits and milk also improves its minerals and vitamin content in milk products as well increases the absorption capacity of other nutrients.

Red Plum (*Prunus domestica*) is a fruit that belongs to the family of Rosaceae subgenus *Prunus* of the genus *Prunus*. Hassan et al. (2015) reported that phytoactive compounds present in plums have capacity to minimize the harmful effects caused by free radicals and protect against various life style diseases. Vitamin-C and various phytoactive compounds are an excellent antioxidant compounds present in plum can also prevent oxidative deterioration caused by free radicals in foods and inside human body. Plum is also a good source of fiber and antioxidants, which improves digestion and metabolism. Eating of plums boosts bone health, especially post-menopausal women Nourbakshi et al. (2013). So the present investigation was carried out to study the technology development and physico-chemical, nutritional and sensory assessment of fruits and milk based milk smoothies.

Materials and Methods

Sahiwal cow milk collected from the university dairy farm. Red plum, banana, sugar procured from the local market Mathura.

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Analytical reagents used in this study were purchased from the local supplier.

Method of preparation of banana and red plum milk smoothies

Clean and pasteurized milk of Sahiwal cow was used for preparation of milk smoothies. Smoothies were prepared in four separate groups i.e. control using banana T1 (without red plum) and treated groups added plum in different proportions T2, T3, and T4 using three different proportions of banana and red plum (75:25, 50:50 and 25:75) in each formulation. The two percent sugar was added in all variants of milk smoothies. At last sodium alginate @ 0.1 percent was added in formulation to make the desired consistency. The smoothies were developed following the procedure as described in flow diagram Fig. 1.

Analytical procedure

Proximate and physico-chemical quality characteristics of milk smoothies

Moisture, protein, fat, fiber, ash, total solid and solid not fat in milk smoothies were determined as per method described by AOAC (2000).

Fig. 1 Flow diagram for preparation of milk smoothies

Sugar

The sugar content in milk smoothies was estimated using the procedure of Pandya et al. (2013). In this procedure milk products were first made protein and fat free by adding 23 ml of HCl to 70 ml of milk sample. HCl deproteinizes the milk and all the proteins coagulated and settled in the bottom of the flask. The supernatant was separated. Its quantity was found out to be 23ml. It was further diluted with 77 ml milk to make the volume up to 100 ml. Then samples were heated with alkaline copper solution by using a special type of Folin-Wu tubes. Glucose and other reducing substances reduce copper from the cupric ions to the cuprous ions. When phosphomolybdic acid was added it was reduced from cuprous form to blue coloured molybdenum blue. Intensity of molybdenum blue is directly proportional to sugar. Its concentration was measured calorimetrically with a known standard at 420 nm.

pH

pH was determined by using digital pH meter (WTW, Germany, model pH 330i) by immersing the spear type combination electrode (Sentix®, Germany) directly into milk sample. The pH meter was calibrated prior to measurement every time as per the manufacturer's instructions using known buffers of pH 7.0 and 4.01.

Titrateable Acidity

The measurement of titrateable acidity in milk smoothies was according to the method described by Caric et al. (2000). Erlenmeyer flask used with a transfer pipette 20 ml smoothie and 1 ml of 2% w/v solution of phenolphthalein. Content was titrated with 0.1 M NaOH solution for appearance of faint pink color that will not get lost for over 2 minutes. Acidification of smoothie is calculated by the formula: $K = V \cdot 2$, where V- volume is consumed base neutralization.

Specific gravity

The specific gravity was determined according to the method of AOAC (2000) with some modifications. The density of milk smoothie was measured against the density of standard (water). Firstly, pre-weighed vessel was filled with standard reference fluid (water) to some predetermined level at 20°C and weight was taken. Secondly, milk smoothie was filled in similar vessel at similar level and temperature and weighed. Specific gravity of milk smoothie was calculated by the following formula:

$$\text{Specific gravity} = \frac{\text{Weight of milk sample}}{\text{Weight of distilled water}}$$

Vitamin-C

Vitamin-C in milk smoothies were estimated using the procedure of Hassan et al. (2016). In which 10 gm of milk smoothie was transferred into 100 ml volumetric flask homogenized by using 50 ml acetic acid solution with shaken, 4-5 drops of bromine water has been added until the solution became colored. Then a few drops of thiourea solution were added to it to remove the excess bromine and thus the clear solution was obtained. Then 2, 4-Dinitrophenyl hydrazine solution was added thoroughly with all standards and also with the oxidized ascorbic acid. Then complete the solution up to the mark with acetic acid. The absorbance for all samples was measured using spectrophotometer to determine the concentration of ascorbic acid in the smoothies.

Sensory evaluation

The sensory quality of milk smoothies were evaluated using 8 point descriptive scale (Keeton et al. 1983) where 8 denoted extremely desirable and 1 denoted extremely poor. A sensory panel (semi trained) of seven judges selected from post-graduate students and faculty of Veterinary College, DUVASU, Mathura were examined the various sensory attributes viz., color and appearance, flavour, body and texture, sweetness, acidity, consistency, mouthfeel and overall acceptability.

Statistical analysis

Data were analyzed using the software, Statistical Package for Social Sciences (SPSS) at the 0.05 level following the procedure of Snedecor and Cochran (1994). Duplicate samples were drawn for each parameter and the experiment was replicated thrice ($n=6$). Sensory evaluation was performed by a panel of seven member judges three times, so total observations of recorded for each sensory attribute were 21 ($n=21$). Data were subjected to one way analysis of variance, homogeneity test and Duncan's Multiple Range Test (DMRT) for comparing the means to find the effects between treatments.

Results and Discussion

Proximate composition of milk smoothies

The percent means of moisture content in T1, T2, T3, and T4 were 82.27 ± 0.04 , 82.39 ± 0.05 , 83.47 ± 0.04 , and 83.99 ± 0.05

respectively Table 1. The highest mean value of moisture was in T4 while the lowest was in T1. The analysis of variance indicated significant ($P < 0.05$) difference in mean moisture content among different treatments. Moisture content in treatment groups has a positive correlation with the replacement of banana with red plum. The variation in moisture content in the smoothie might be due to the variation in content of banana and red plum. It could be due to higher moisture in plum as suggested by (Munmun, 2005) during the preparation of jellies like products. Saranyambiga et al. (2017) also reported that increased moisture percent on the addition of Jamun fruit in milk smoothie than control. The percent mean values of fat in T1, T2, T3, and T4 were 2.27 ± 0.04 , 2.49 ± 0.05 , 2.53 ± 0.01 , and 2.79 ± 0.05 respectively Table 1. The highest mean value of fat was in T4 while the lowest was in control. The analysis of variance indicated no significant ($P > 0.05$) difference in the mean fat content of T2 and T3 while these values were significantly ($P < 0.05$) different with the mean fat values of T1 and T4. Banana added milk smoothie has lower fat content than red plum added smoothie. The reason might be higher fat in red plum (2 percent) as compared to banana (0.33 percent). The same findings were given by Akther et al. (2012) during the preparation of plum based leather or jelly-like products. The percent mean contents of protein was comparatively higher in banana milk (2.83 ± 0.02) smoothie than red plum added smoothie T2 (2.74 ± 0.02), T3 (2.71 ± 0.02), and T4 (2.69 ± 0.05) respectively Table 1. Protein content in smoothies prepared with a higher amount of red plum showed a decreasing pattern with an increase in red plum which could be due to the lower amount of protein in plum than a banana. These findings are very well justified with the report of Balaswamy et al. (2013) on the development of smoothies from selected fruit pulps/juices and Akther et al. (2012) for plum based jelly products. The percent mean contents of ash in T1 (0.97 ± 0.04), T2 (0.95 ± 0.02), T3 (0.94 ± 0.02), and T4 (0.91 ± 0.01) respectively. The highest mean value of ash was in T1 while the lowest was in T4 Table 1. The analysis of variance indicated no significant ($P > 0.05$) difference in mean ash content among different treatments. The ash content in all groups of milk smoothies remains the same which might be due to all most comparable mineral content in banana and red plum. The percent mean contents of fiber in T1, T2, T3, and T4 were 0.98 ± 0.04 , 1.05 ± 0.02 , 1.18 ± 0.05 , and 1.29 ± 0.05 respectively Table 1. The highest mean value of fiber was in T4 while the lowest was in T1. The analysis of variance indicated a significant ($P < 0.05$) increase in mean fiber values from T1 to T3 and T4. The higher fiber in higher plum based smoothies could be attributed to higher fiber

Table 1 Ingredients used in the preparation of milk smoothie

Ingredients	T1	T2	T3	T4
Milk (g)	125	125	125	125
Banana (g)	75	56.25	37.50	18.75
Red plum (g)	-	18.75	17.50	56.25
Sugar (%)	2/4/6	4	4	4
Sodium alginate (%)	0.1	0.1	0.1	0.1

Fig. 2 pH and Titratable acidity (% LA) of banana and red plum based milk smoothies

Means bearing different superscripts (a, b, c, d) within row differ significantly ($P < 0.05$)

Where: T1= Banana based milk smoothie

T2= 75% Banana and 25% red plum based milk smoothie

T3=50% Banana and 50% red plum based milk smoothie

T4=25% Banana and 75% red plum based milk smoothie

Table 2 Treatment wise physico-chemical characteristics of banana and red plum based milk smoothies (Means $\pm$ SE)

Parameters	Banana and red plum based milk smoothies			
	T1	T2	T3	T4
Moisture (%)	82.27 $\pm$ 0.04	82.39 $\pm$ 0.05	83.47 $\pm$ 0.04	83.99 $\pm$ 0.05
Fat (%)	2.27 $\pm$ 0.04	2.49 $\pm$ 0.05	2.53 $\pm$ 0.01	2.79 $\pm$ 0.05
Protein (%)	2.83 $\pm$ 0.02	2.74 $\pm$ 0.02	2.71 $\pm$ 0.02	2.69 $\pm$ 0.05
Ash (%)	0.97 $\pm$ 0.04	0.95 $\pm$ 0.02	0.94 $\pm$ 0.02	0.91 $\pm$ 0.01
Fibre (%)	0.98 $\pm$ 0.04	1.05 $\pm$ 0.02	1.18 $\pm$ 0.05	1.29 $\pm$ 0.05
Sugar (%)	10.68 $\pm$ 0.03	10.38 $\pm$ 0.02	9.17 $\pm$ 0.03	8.33 $\pm$ 0.17

• Means bearing different superscripts (a, b, c, d) within row differ significantly ($P < 0.05$)

• Where: T1= Banana based milk smoothie

T2= 75% Banana and 25% red plum based milk smoothie

T3=50% Banana and 50% red plum based milk smoothie

T4=25% Banana and 75% red plum based milk smoothie

contents in plum (4 percent) than a banana (2.6 percent) as suggested by Walkling-Ribeiro et al. (2010) during shelf life assessment of fruit-based smoothies. The percent mean contents of sugar in T1, T2, T3, and T4 were 10.68 $\pm$ 0.03, 10.38 $\pm$ 0.02, 9.17 $\pm$ 0.03, and 8.33 $\pm$ 0.17 respectively Table 1. The highest mean value of sugar was in the milk smoothie T1 while the lowest was in T4. The analysis of variance indicated a significant ($P < 0.05$) decrease in mean sugar content of different treatments with increased levels of red plum in the formulation. Contrary to these findings, contents of sugar, total solids, and solid-not-fat showed a decreasing pattern due to lower amounts of minerals and other substances in plum than banana as suggested by Keenan et al. (2011) during the quality assessment of fruit-based smoothies.

Physico-chemical quality of milk smoothie

The percent mean contents of total solids were in T1 (17.73 $\pm$ 0.02), T2 (17.61 $\pm$ 0.01), T3 (16.53 $\pm$ 0.01), and T4 (16.01 $\pm$ 0.01) respectively Table 2. The highest mean value of total solids was in T1 while the lowest was in T4. The analysis of variance indicated a significant ($P < 0.05$) difference in mean total solids content among T1, T3, and T4. The percent mean contents of Solids-not-fat in T1, T2, T3, and T4 were 15.46 $\pm$ 0.03, 15.12 $\pm$ 0.01, 14.00 $\pm$ 0.11, and 13.22 $\pm$ 0.01 respectively Table 2. The highest mean value of SNF was in T2 while the lowest was in T4. The analysis of variance indicated a significant ($P < 0.05$) difference in mean SNF content among T1, T3, and T4. However, some contrary reports were also noticed on values of sugar and Solid-not-fat which might be due to the overall effect of banana and red plum on the composition of smoothies as reported by Rao et al. (2002) in milk products prepared with blending of orange juice in skim milk powder. The

Table 3 Physico-chemical quality of red plum based milk smoothies (Means $\pm$ SE)

Physico-chemical quality	Banana and red plum based milk smoothies			
	T1	T2	T3	T4
Total Solids (%)	17.73 ^a $\pm$ 0.02	17.61 ^{ab} $\pm$ 0.01	16.53 ^c $\pm$ 0.01	16.01 ^d $\pm$ 0.01
Solids-not-fat (%)	15.46 ^a $\pm$ 0.03	15.12 ^{ab} $\pm$ 0.01	14.00 ^c $\pm$ 0.11	13.22 ^d $\pm$ 0.01
Specific gravity	1.061 $\pm$ 0.01	1.066 $\pm$ 0.02	1.069 $\pm$ 0.01	1.071 $\pm$ 0.01
Vitamin-C (mg/100g)	3.55 ^d $\pm$ 0.03	4.98 ^c $\pm$ 0.05	6.29 ^b $\pm$ 0.05	7.61 ^a $\pm$ 0.01

- Means bearing different superscripts (a, b, c, d) within row differ significantly (P<0.05)
- Where: T1= Banana based milk smoothie
T2= 75% Banana and 25% red plum based milk smoothie
T3=50% Banana and 50% red plum based milk smoothie
T4=25% Banana and 75% red plum based milk smoothie

Table 4 Sensory profile of banana and red plum based milk smoothies (Means $\pm$ SE)

Sensory attributes	Banana and red plum based milk smoothies			
	T1	T2	T3	T4
Colour & Appearance	7.08 ^a $\pm$ 0.13	5.85 ^b $\pm$ 0.35	7.20 ^a $\pm$ 0.17	5.58 ^b $\pm$ 0.34
Flavour	7.20 ^{ab} $\pm$ 0.17	6.04 ^b $\pm$ 0.35	7.29 ^a $\pm$ 0.17	5.66 ^b $\pm$ 0.37
Body & Texture	7.08 ^{ab} $\pm$ 0.17	4.55 ^c $\pm$ 0.86	7.20 ^a $\pm$ 0.20	6.78 ^{abc} $\pm$ 0.20
Sweetness	6.33 ^a $\pm$ 0.38	5.12 ^b $\pm$ 0.28	6.58 ^a $\pm$ 0.32	5.16 ^b $\pm$ 0.27
Acidity	6.87 ^a $\pm$ 0.20	5.08 ^c $\pm$ 0.26	6.95 ^a $\pm$ 0.22	6.04 ^b $\pm$ 0.35
Consistency	6.33 ^a $\pm$ 0.20	5.41 ^b $\pm$ 0.26	6.41 ^a $\pm$ 0.19	5.14 ^b $\pm$ 0.21
Mouthfeel	6.70 ^a $\pm$ 0.23	6.16 ^b $\pm$ 0.23	6.70 ^a $\pm$ 0.23	6.45 ^b $\pm$ 0.35
Overall acceptability	6.79 ^{ab} $\pm$ 0.19	5.29 ^d $\pm$ 0.26	6.87 ^a $\pm$ 0.23	6.20 ^{bc} $\pm$ 0.18

- Means bearing different superscripts (a, b, c, d) within row differ significantly (P<0.05)
- Where: T1= Banana based milk smoothie
T2= 75% Banana and 25% red plum based milk smoothie
T3=50% Banana and 50% red plum based milk smoothie
T4=25% Banana and 75% red plum based milk smoothie

mean values of pH in milk smoothies varied significantly between control and treatments Fig. 2a. The highest mean value of pH was in control while the lowest was in T4 groups. Milk smoothie prepared with the addition of red plum exhibited a significantly lower pH value than control which might be due to the lower pH of the red plum fruit (2.72-3.84) reported by Costa (2013) as compared to the banana fruit (4.68) by de Jesus et al. (2004). The titratable acidity value did not differ significantly (P>0.05) among all milk smoothie samples Fig. 2b. The highest mean value of titratable acidity was observed in T1 and lowest in T4. The variation in titratable acidity value in milk smoothie is due to the variation in the titratable acidity value of fruits. The mean values of specific gravity were in T1 (1.061 $\pm$ 0.01), T2 (1.066 $\pm$ 0.02), T3 (1.069 $\pm$ 0.01), and T4 (1.071 $\pm$ 0.01) respectively (Table 2) and did not differ significant (P>0.05). This might be due to the comparable specific gravity of added fruit in the milk smoothie.

Vitamin-C

The mean contents of Vitamin-C (mg/100 g) in T1, T2, T3, and T4 were 3.55 $\pm$ 0.03, 4.98 $\pm$ 0.05, 6.29 $\pm$ 0.05, and 7.61 $\pm$ 0.01 respectively Table 2. The highest mean value of Vitamin-C was in T4 while the lowest was in T1. The analysis of variance indicated a significant

(P<0.05) increase in mean Vitamin-C content with increased levels of red plum in the formulation. The increasing trend of vitamin-C with an increase in red plum in the smoothies could be attributed to the higher (25 percent) vitamin-C in red plum as compared to lower (10 percent) in banana. These findings are very well agreed with the reports of Shukla et al. (2017) on quality characterization of pasteurized mango based milk beverages.

Sensory profile of red plum milk smoothies

The mean scores of colour and appearance in T1, T2, T3 and T4 were 7.08 $\pm$ 0.13, 5.85 $\pm$ 0.35, 7.20 $\pm$ 0.17 and 5.58 $\pm$ 0.34 respectively Table 4. The highest mean score of colour and appearance was observed in T3 while lowest was in T4. The analysis of variance indicated no significant (P>0.05) difference between control (T1) and T3 but these scores were significantly (P<0.05) higher than T2 and T4. The mean scores of flavour in T1, T2, T3 and T4 were 7.20 $\pm$ 0.17, 6.04 $\pm$ 0.35, 7.29 $\pm$ 0.17 and 5.66 $\pm$ 0.37 respectively Table 4. The highest mean score of flavour was observed in T3 while lowest was in T4. The analysis of variance indicated significantly (P>0.05) higher mean flavour score of T3 than T2 and T4. The mean scores of body and texture were for T1 (7.08 $\pm$ 0.17), T2

(4.55 ± 0.86), T3 (7.20 ± 0.20) and T4 (6.78 ± 0.20) respectively Table 4. There was no significant ($P > 0.05$) difference between control and T3 but these scores were significantly ($P < 0.05$) higher than T2. The mean scores of sweetness in T1, T2, T3 and T4 were 6.33 ± 0.38 , 5.12 ± 0.28 , 6.58 ± 0.32 and 5.16 ± 0.27 respectively Table 4. The highest mean score of sweetness was observed in T3 while lowest was in T1. The highest mean score of acidity was observed in T3 while lowest was in T2. The analysis of variance indicated no significant ($P > 0.05$) difference in mean acidity score between T1 and T3 but these scores were significantly ($P < 0.05$) higher than T1 and T4. The mean scores of consistency in T1 (6.33 ± 0.20), T2 (5.41 ± 0.26), T3 (6.41 ± 0.19) and T4 (5.14 ± 0.21) were respectively Table 4. The mean scores of mouth feel in T1, T2, T3 and T4 were 6.70 ± 0.23 , 6.16 ± 0.23 , 6.70 ± 0.23 and 6.45 ± 0.35 respectively. Smoothie prepared with 50% banana and 50% red plum (T3) rated highest score for mouth feel and rated lowest score for T2. The mean scores for overall acceptability smoothie prepared with banana and red plum was rated for T1 (6.79 ± 0.19), T2 (5.29 ± 0.26), T3 (6.87 ± 0.23) and T4 (6.20 ± 0.18) respectively Table 4. Smoothie prepared with addition of 50% banana and 50% red plum showed significantly ($P < 0.05$) higher OA scores than T1 and T4; however C had comparable scores with T3 and T4. The sensory scores on most of the sensory attributes of best variant in all breeds overall showed comparable scores to the control. It showed that panelists were highly satisfied with the product of 50:50 percent banana and red plum. However, panelists recorded the significantly ($P < 0.05$) higher scores on acidity in products than control. The similar pattern of acceptance was observed by (Bhardwaj, 2011) during utilization of fruits and vegetable in preparation of milk based beverage. Balaswamy et al. (2013) also advocated that the selection of fruit is not a single criterion for acceptance of smoothies but its acceptance on sensory basis is also dependant on the proportion of its use in smoothie recipe.

Conclusions

Red plum is highly rich in fibres, vitamin-C and phyto-active compounds. Results can be concluded that milk smoothie prepared with incorporation of red plum significantly increased the fiber and fat content in the milk products. Milk and milk products are deficient in vitamin-C however in this study on addition of red plum in milk smoothie considerably increased the vitamin-C. Milk smoothie prepared with the addition of 50: 50 proportions of banana and red plum rated best on the basis of sensory evaluation by sensory panelist. This study further recommended for the storage study of selected products with control.

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