International Journal of Innovation and Scientific Research
ISSN 2351-8014 Vol. 10 No. 1 Oct. 2014, pp. 77-82

http://www.ijisr.issr-journals.org/

Development and Shelf-Life Prediction of Pineapple (*Ananas comosus*) Preserve and Candy

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ABSTRACT: The present study was conducted to develop and investigate pineapple (*Ananas comosus)* preserve and candy to assess its prospect in marketability and study their storage life. Pineapple slices were treated with 2% solution of common salt to prevent browning, then cut into cube shape and treated with 1% calcium chloride and 0.25% potassium metabisulphide solution and finally processed. The preserves were processed with 60° Brix, 65° Brix and 70° Brix sugar syrup. The candies were processed with 65° Brix, 70° Brix and 75° Brix sugar syrup. Initially the composition of pineapple preserves processed with different level of sugar ware found in the range as moisture content 33.09-35.65%, ash 1.36-1.42%, protein 1.01-1.07%, fat 0.61-0.66%, total sugar 61.37-63.73% and reducing sugar 30.52-31.46% and pineapple candies were found in the range as moisture content 19.05-20.88%, ash 1.52-1.58%, protein 1.15-1.21%, fat 0.72-0.77%, total sugar 75.70-77.35% and reducing sugar 45.16-46.39%. The sensory results showed that color, flavor, texture, taste and overall acceptability scores differed significantly ($p<0.05$). The preserve (P_2) processed from 65° Brix sugar syrup and the candy (C_2) processed from 70° Brix sugar syrup was the favorite sample of the sensory evaluation with the highest overall acceptability among others of the similar product. The shelf-life of candy (6 month) packed in high-density polyethylene bag is higher than preserve (4 month) packed in glass bottle when stored at ambient temperature (27° C to 30°C).

KEYWORDS: Pineapple, preserve, candy, nutritional evaluation, organoleptic properties and storage life.

1 INTRODUCTION

The pineapple (*Ananas comosus*) is a compound fruit and matures within 18-22 months after plantation. It has exceptional juiciness and a vibrant tropical flavor that balances the tastes of sweet and tart. It is the leading edible member of the family Bromeliaceae which embraces about 2,000 species, mostly epiphytic and many strikingly ornamental [1].

Pineapple is a major fruit of Bangladesh. According to cultivated area and yield of production, it occupies 5th position (4.6 M. tons/ acre). The major growing area of our country are: Sylhet, Tangail, Chittagong Hill Tracts, Dhaka (mainly Joydebpur) and Chittagong [2].

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The pineapple fruit must be a good source of vitamin A and B and rich in vitamin C. It contained enzymes, bromelin and pineapple leaf was a good source of chlorophyll [3]. The quality of pineapple largely depends on the amount of sugar and acid present, while the amount of sugar depends on the ripeness of the fruit, also on the variety, soil condition and climatic condition [4]. Pineapple does not increase in sweetness after it is harvested because of absence of starch stored in the fruit that will change to sugar. The sugars are formed in leaves of the pineapple plant and transferred to the fruit. It is usually sweeter in summer months when days are longer with abundant sunshine [5].

Candy is a sweet food prepared from fruits or vegetables by impregnating them with sugar syrup followed by draining of excessive syrup and then drying the product to a shelf stable state. Fruits and vegetables like apples, ginger, mangoes, guava, carrots and citrus peels have been used to prepare candies [6, 7 and 8]. A mature fruit with heavy sugar syrup till it becomes tender and transparent is known as preserves. Fruits, impregnetated with sugar on glucose syrup and subsequently drained free of syrup and dried, is known as candy. The most suitable fruits and vegetables for preserves and candy are pineapple, cherry, papaya, amla etc. [3].

Further, attributable to least commercial involvement, the pineapple is still to be used in processed industries. And also there are huge requirement for this type product from the stand point of health and nutrition. Considering the above facts the present investigation was undertaken with the following objectives: (i) to develop preserve and candy from pineapple, (ii) to predict the shelf-life of pineapple preserve and candy.

2 MATERIALS AND METHODS

The experiment was conducted in the laboratory of the Department of Food Processing and Engineering, Chittagong Veterinary and Animal Sciences University, Bangladesh. The fresh and fully mature pineapple (Honey Queen Variety), sugar and salt collected from the local market were used in the study. Other ingredients were used from laboratory stocks. All of them were at analytical grade (purity ≥ 98%).

2.1 PREPARATION OF PINEAPPLE

Fully mature pineapples (Honey Queen Variety) were collected from local market and washed thoroughly under running water. The pineapples were peeled with a stainless steel knife and kept them in a 2% solution of common salt to prevent browning. The fruits were cut into cube shape with knife and after that the cubes were treated with 1% calcium chloride and 0.25% potassium metabisulphide solution. Then the pineapples were washed with water. Finally these pieces of pineapple were ready to make preserve and candy.

2.2 PROCESSING OF PINEAPPLE PRESERVE

The cubes were dipped in sugar syrup of 50° Brix containing 0.2 per cent citric acid for a day. Then the cubes were removed from the syrup and increased consistency of syrup to 60° Brix by boiling. The cubes were dipped in sugar syrup of 60° Brix containing 0.2 per cent citric acid for a day. Then the process was repeated to raise the strength of syrup from 60° Brix to 65° Brix and finally to 70° Brix. The cubes were steeped in 70° Brix TSS for a week. At each level of TSS (60° Brix, 65° Brix and 70° Brix coded as P_1, P_2 and P_3 respectively) the syrup was drained and filled the container with fresh sugar syrup corresponding with the level of TSS from whom that was collected. The sugar was used as similarly described by Ponting *et al.* (1966) [9]. The preserves thus prepared were packed in glass bottle and stored in room temperature (27±3^{o}C).

2.3 PROCESSING OF PINEAPPLE CANDY

The cubes were dipped in sugar syrup of 50° Brix containing 0.2 per cent citric acid for a day. Then the cubes were removed from the syrup and increased consistency of syrup to 65° Brix by boiling. The cubes were steeped in 65° Brix syrup for a day. Then the process was repeated to raise the strength of syrup from 65° Brix to 70° Brix and finally to 75° Brix. The cubes were steeped in 75° Brix for a week. At each level of TSS (65° Brix, 70° Brix and 75° Brix coded as C_1, C_2 and C_3 respectively) the syrup was drained before bottling. The preserves were spread on tray and then dried in a Cabinet dryer at 70°C for 2 hr. The products were finally brought to room temperature (27°C ± 3^{0}C) [9].The candies thus prepared were packed in high-density polyethylene bag and stored in room temperature (27±3^{o}C).

2.4 CHEMICAL ANALYSIS

The fresh pineapple, processed preserves and candies were analyzed for moisture, ash, vitamin-C, protein, fat, total sugar, reducing sugar and dietary fiberas per the methods of AOAC [10]. Ranganna (2011) states the methods of reducing sugar and non-reducing sugar determination [11].

2.5 ORGANOLEPTIC PROPERTIES

Sensory characteristics of all types of candies and preserves were evaluated for different sensory attributes by a panel of trained and semi trained 20 panelists each. All the panelists were briefed before evaluation. Sensory attributes like appearance and color, flavor, taste, texture and overall acceptability for all samples were assessed using nine point hedonic scales. Hedonic scale was in the following sequence: 9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like nor dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2= Dislike very much and 1= Dislike extremely [12]. The samples were coded with letters and served to the panelists at random to guard against any bias.

2.6 SHELF-LIFE OF PRESERVE AND CANDY

The prepared preserve was packed in glass bottle and the candy was packed in high-density polyethylene bag (HDP). Both the preserve and candy was stored in room temperature (27±3^{o}C). The packed preserve and candy was unwrapped at a regular interval to asses through organoleptic test for color, flavor and overall acceptability. The spoilage was determined by organoleptic rejection and visual microbial growth.

2.7 STATISTICAL ANALYSIS

The data obtained from the experiments were statistically analyzed for analysis of variance (ANOVA) and consequently Duncan's Multiple Range Test (DMRT) was used to determine significant difference among the various samples in triplicate. Data were analyzed using the software, IBM SPSS Statistics, version 20 at the 0.05 level [13].

3 RESULT AND DISCUSSION

3.1 COMPOSITIONS OF FRESH PINEAPPLE

Initially the moisture content 88.25%, ash 0.87%, protein 0.58%, fat 0.46%, total sugar 5.04%, reducing sugar 3.96%, dietary fiber 1.44% and vitamin-C 48.66 mg/100 g was obtained in fresh pineapple (Honey Queen). These findings are more or less similar to those reported by Kader *et al*. (2010) [2].

3.2 CHEMICAL CHARACTERISTICS OF PINEAPPLE PRESERVES

In the present study three types of pineapple preserves, containing syrup with 60˚ Brix, 65˚ Brix and 70˚ Brix respectively, were prepared and analyzed for their composition. The results are presented in Table 1.

The analysis showed the higher moisture content of pineapple preserves was obtained from sample P_1 (35.65%) and the lower moisture content was obtained from sample P_3 (3.09%). There was significant variation of moisture content among the sample P_1, P_2 and P_3. This variation might be due to various levels of syrup concentration used in preserve and processing time of preserve. The higher sugar concentration and processing time increases the osmotic dehydration, that's why decrease moisture contents. On the other hand, ash, protein, fat, total sugar and reducing sugar significantly increased. The P_3 pineapple preserve had higher ash (1.42%), protein (1.07%), fat (0.66%), total sugar (63.63%) and reducing sugar (31.46%) followed by P_2 and P_1.

The composition of pineapple preserve processed with different level of sugar was found in the range as moisture content 33.09-35.65%, ash 1.36-1.42%, protein 1.01-1.07%, fat 0.61-0.66%, total sugar 61.37-63.73% and reducing sugar 30.52-31.46%.

3.3 CHEMICAL CHARACTERISTICS OF PINEAPPLE CANDIES

In the present study three types of pineapple candy, processed with 65˚ Brix, 70˚ Brix and 75˚ Brix syrup respectively, were prepared and analyzed for their composition. The compositions of pineapple cadies have been shown in Table 1.

Table 1. Composition of Pineapple Preserves and Candies[1,2]

Component (%)	Preserve			Candy		
	P_1	P_2	P_3	C_1	C_2	C_3
Moisture	35.65±0.02[a]	34.38±0.03[b]	33.09±0.03[c]	20.88±0.03[a]	20.01±0.02[b]	19.05±0.03[c]
Total ash	1.36±0.006[c]	1.39±0.003[b]	1.42±0.006[a]	1.52±0.006[c]	1.55±0.003[b]	1.58±0.006[a]
Protein	1.01±0.006[c]	1.03± 0.003[b]	1.07±0.003[a]	1.15±0.003[c]	1.17±0.003 [b]	1.21±0.006 [a]
Fat	0.61±0.003[c]	0.63±0.003[b]	0.66±0.003[a]	0.72±0.003[c]	0.75±0.003[b]	0.77±0.003[a]
Total sugar	61.37±0.03[c]	62.54±0.05[b]	63.73±0.10[a]	75.70±0.04[c]	76.50±0.07[b]	77.35±0.14[a]
Reducing sugar	30.52±0.03[c]	30.97±0.01[b]	31.46±0.06[a]	45.16±0.02[c]	45.64±0.06[b]	46.39±0.11[a]

[1]*Values are mean ± standard error of triplet determinations.*
[2]*Means with different superscript within the same row differ significantly ($p < 0.05$) using Duncan multiple range test.*

The analysis showed the higher moisture content (20.88%) was obtained in C_1 followed by C_2 (20.01%) and C_3 (19.05%).There was significant variation of moisture content among the sample C_1, C_2 and C_3.The C_3 had higher ash (1.58%), protein (1.21%), fat (0.77%),total sugar (77.35%) and reducing sugar (46.39%) and C_1 had lower ash (1.52%), protein (1.15%), fat (0.72%), total sugar (75.70%) and reducing sugar (45.16%).This variation might be due to various levels of syrup concentration used in pineapple candy and processing time of candy. The higher sugar concentration and processing time decrease moisture contents. On the other hand, ash, protein, fat, total sugar and reducing sugar significantly increased.

The composition of pineapple candies processed with different level of sugar was found in the range as moisture content 19.05-20.88%, ash 1.52-1.58%, protein 1.15-1.21%, fat 0.72-0.77%, total sugar 75.70-77.35% and reducing sugar 45.16-46.39%.

3.4 ORGANOLEPTIC PROPERTIES OF PINEAPPLE PRESERVE

The pineapple preserves, containing syrup with 60˚ Brix, 65˚ Brix and 70˚ Brix respectively, were subjected to sensory evaluation by a panel of 40 tasters. The mean score for color, flavor, texture, taste and overall acceptability of the pineapple preserves are presented in Table 2. The two-way analysis of variance (ANOVA) indicated that all these sensory attributes of different preserves were significantly ($p<0.05$) different and thus the preserves showed varied degree of acceptability in terms of color, flavor ,texture, taste and overall acceptability .

Table 2. Mean Scores for Color, Flavor, Texture, Taste and Overall Acceptability of Pineapple Preserves

Sample code	*Mean scores on sensory attributes				
	Color	Flavor	Texture	Taste	Overall acceptability
P_1	6.463±0.411[c]	6.271±0.532[c]	6.332±0.601[c]	6.577±0.329[c]	6.371±0.432[c]
P_2	8.134±0.244[a]	8.125±0.311[a]	8.079±0.049[a]	8.307±0.069[a]	8.189±0.093[a]
P_3	7.425±0.391[b]	7.374±0.201[b]	7.401±0.431[b]	7.527±0.211[b]	7.394±0.321[b]
LSD ($p<0.05$)	0.465	0.465	0.465	0.465	0.465

Means ± Standard Error with different superscripts within a column are significantly different and the same superscripts do not significantly different (NSD) at **p<0.05.*

As shown in Table 2, the color, flavor, texture, taste and overall acceptability of the preserves were not equally acceptable. The Duncan's Multiple Test (DMRT) revealed that the mean sensory score for color (8.134), flavor (8.125), texture (8.079), taste (8.307) and overall acceptability (8.189) of $P_2$was higher followed by P_3 and P_1. P_1 was inferior due to low concentration of sugar and P_3contained very high concentration of sugar. Among the experimental preserves, the P_2 was the favorite sample of the sensory evaluation with the highest overall acceptability.

3.5 ORGANOLEPTIC PROPERTIES OF PINEAPPLE CANDY

The pineapple candies were subjected to sensory evaluation by a panel of 40 tasters. The mean score for color, flavor, texture, taste and overall acceptability of the pineapple candies are presented in Table 3. The two-way analysis of variance (ANOVA) indicated that all these sensory attributes of different pineapple candies were significantly ($p<0.05$) different and

the extent of difference among the samples for their quality attributes were calculated by DMRT methods. Thus degree of acceptability in terms of color, flavor, texture, taste and overall acceptability of the pineapple candies were observed.

Table 3. Mean Scores for Color, Flavor, Texture, Taste and Overall Acceptability of Pineapple Candies

Sample code	*Mean scores on sensory attributes				
	Color	Flavor	Texture	Taste	Overall acceptability
C_1	6.941 ± 0.264^{c}	6.887 ± 0.211^{c}	6.924 ± 0.129^{c}	6.945 ± 0.152^{c}	6.938 ± 0.153^{c}
C_2	8.534 ± 0.322^{a}	8.481 ± 0.401^{a}	8.187 ± 0.321^{a}	8.431 ± 0.318^{a}	8.389 ± 0.217^{a}
C_3	7.772 ± 0.341^{b}	7.604 ± 0.337^{b}	7.318 ± 0.107^{b}	7.432 ± 0.283^{b}	7.509 ± 0.284^{b}
LSD ($p<0.05$)	0.465	0.465	0.465	0.465	0.465

**Means with different superscripts within a column are significantly different at p<0.05*

The colors, flavors, textures, tastes and overall acceptability of the pineapple candies were not equally acceptable. In the case of color, the DMRT test revealed that C_2 was most preferred and securing higher mean score (8.534) and C_1 was securing lower mean score (6.941). The flavor of C_2 was more preferred and significantly different than other samples. The texture of C_2 (8.187) was significant better than C_1 (6.924) and C_3 (7.318). In the case of taste, the DMRT test revealed that C_2 was most preferred and securing higher mean score (8.431) and $C_1$was securing lower mean score (6.945). The DMRT test of the overall acceptability revealed that $C_2$was more preferred due to its highest secured mean score (8.389) and significantly better than other samples.

3.6 Shelf-Life Of Pineapple Preserves And Candies

The shelf-life of pineapple preserves(packed in glass bottle) and candies(packed in high-density polyethylene bag) was studies for the period of 135 days and 195 days respectively at ambient temperature (27 ± 3^{o}C).Observation of color, flavor, overall acceptability and fungal growth of pineapple preserve and candy has been shown in Table-4. No remarkable change of preserve was observed up to 4 months (120 days) of storage. The remarkable change in color, flavor, overall acceptability and fungal growth were observed at 135 days of storage and the pineapple preserve (containing 65˚ Brix syrup) remarked as unacceptable to consume. The changes occurred possibly due to fermentation in presence of fungus (mold and yeast). Fraziar and Westheff (1978) described that main spoilage organism for fruit products are mold and yeast [14]. From table 3, the pineapple preserves containing 65˚ Brix syrup were shelf stable up to 4 months of storage at ambient temperature.

The color, flavor and fungal growth of pineapple candies processed with 70˚ Brix syrup were acceptable as there were no changes up to 6 month of storage time. The remarkable change was detected and the candy processed with 70˚ Brix syrup remarked as unacceptable to consumer at 195 days of storage. The changes occurred possibly due to fermentation in presence of fungus (Table 4). From table 4, the pineapple candy processed with 70˚ Brix syrup were shelf stable up to 6 months of storage at ambient temperature.

Table 4. Effect of Storage Time on the Quality of Pineapple Preserves and Candies

Storage period (day)	Preserve (P_2)				Candy(C_2)			
	Color	Flavor	Overall acceptability	Fungal Growth	Color	Flavor	Overall acceptability	Fungal Growth
0	Good	Pleasant	Acceptable	Not Visible	Good	Pleasant	Acceptable	Not Visible
30	Good	Pleasant	Acceptable	Not Visible	Good	Pleasant	Acceptable	Not Visible
60	Good	Pleasant	Acceptable	Not Visible	Good	Pleasant	Acceptable	Not Visible
90	Good	Pleasant	Acceptable	Not Visible	Good	Pleasant	Acceptable	Not Visible
120	Good	Pleasant	Acceptable	Not Visible	Good	Pleasant	Acceptable	Not Visible
135	Not Good	Off Flavor	Not Accepted	Visible	Good	Pleasant	Acceptable	Not Visible
150	-	-	-	-	Good	Pleasant	Acceptable	Not Visible
180	-	-	-	-	Good	Pleasant	Acceptable	Not Visible
195	-	-	-	-	Not Good	Off Flavor	Not Accepted	Visible

Comparing pineapple preserve and candy, it was clear that the storage stability of candy (6 month) is higher than preserve (4 month) as the moisture content was lower in candy (20.01%) than preserve (34.38%). Both the preserve and candy provide necessary plastic mouth feel to enable the food to be ready to eat (RTE) and product can kept for long time without refrigeration or thermal processing in any hermetically sealed container.

4 CONCLUSION

The study indicated a good prospect of pineapple processing for commercial products. From the investigation it may be concluded, the best pineapple preserves containing 65˚ Brix syrup and candies processed with 70˚ Brix syrup were identified based on sensory attributes. Both the pineapple preserve and candy contains reduced amount of moisture than the fresh fruit. The shelf-life of candy (6 month) is higher than preserve (4 month) where moisture content was the most important factor. So the pineapple can be used for preparing preserve and candy both at home scale and could be made available throughout the year. By processing pineapples value may be increased and production can be maximized which will have effect on the national economy. Further investigation is necessary to study economic and safety aspects of the pineapple products before commercial exploitation.

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