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Effect of sugar and starch on chemical and organoleptic parameters of pineapple bar during storage

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Abstract

The aim of this study was to assess the effect of major ingredients on the changes of fundamental quality parameters of pineapple fruit bar during preparation and storage. Four samples were prepared by using Extreme Vertex mixture taking three major ingredients namely fruit pulp, sugar and starch content as factors and non-enzymatic browning data and overall acceptability as responses. The result revealed that compositional differences of different ingredients in formulation fitted to the quadratic linear model at $p<0.05$. Among the four formulations the liking intensity of formulation F_4 containing pineapple pulp 86%, starch 2% and sugar 12% showed the highest scores in all of the studied sensory parameters followed by F_2, F_3 and F_1. Among the components studied, sugars irrespective of sources are the main components responsible for non-enzymatic browning whereas starch contributes to retain color by forming a protecting film around the reducing groups.

Key words: pineapple, fruit bar, kinetics model, mixture design

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Introduction

The pineapple is a multiple fruit having juicy and fleshy pulp. The fruit is a good source of antioxidants, minerals, vitamins such as A and B and rich in vitamin C. It also contains enzymes, potassium, calcium, iron, bromelin etc. Pineapple fruits contain around 85-86.3% moisture, 13-19% total soluble solids (mainly as sucrose, glucose and fructose) (Hossain *et al.,* 2005). Pineapple has number of significant health benefits such as removing constipation, improving immune system, helping to reduce inflammation of joints and muscles, reducing risk of arthritis and it's a good remedy for curing coughs and colds (Jahan *et al.,* 2019). It is an important agricultural produce and is one of the major fruit in Bangladesh. The statistical data shows that about 395803 acreage land is under pineapple cultivation in Bangladesh with an annual production of 234493 metric tons (Hossaim and Islam, 2017). Pineapple is a seasonal fruit and perishable in nature, due to presence of high sugar and moisture (Hossain *et al.,* 2005). At peak season huge quantity of fruits are available in the market and postharvest losses during storage approaches as peak as 40%. Common practices to prevent post-harvest losses of the seasonal surplus pineapples are cold preservation for short time and the processing into shelf-stable value-added products for long time storage. Juice, squash, jam, jelly and canned pineapple slices are the examples of few value added products. Processing of pineapple into bar could be considered as one of the vital techniques to use the surplus pineapples. Fruit bar is a dehydrated fruit product which is made by drying a very thin layer of fruit pulp into a chewy product. Due to unique taste, texture, long shelf life, less processing cost and effort it is popular to the people. Basically, fruit pulps are mixed with appropriate quantities of sugar, acid, salt, starch and then dried into sheet-shaped products. Each ingredient have specific role in the product such as sugar gave the product a sweeter taste and increased the solids content, starch is used to increase the solid content of pineapple pulp and also to give desire consistency to form bar. Hence, it needs to assess the effect of the level of major ingredients in preparing pineapple fruit bar. One of the major problems of prepared fruit bars is the non-enzymatic browning. The product undergoes to color changes due to formation of deep pink color during storage. Thus the objectives of this study were to assess the levels of major ingredients affecting formulation of pineapple fruit bar, to investigate the level of major ingredients influencing the non-enzymatic browning and to assess the effect of storage period on the quality of pineapple fruit bar.

Materials and Methods

Ripe pineapple (*Giant kew*) collected from local market to pulp. Sugar, starch, citric acid, salt and sodium benzoate were purchased from local market, Mymensingh.

***Design of experiments to formulate pineapple fruit bars*:** The major ingredients for the preparation of pineapple fruit bar were pulp, starch and sugar. The above ingredients were mixed by vertex mixture. Initially, pineapple bar was developed varying the levels of those ingredients. The blending of three components like ratio of pulp, starch and sugar at their extreme ratio as selected by preliminary experiments produced only four runs when only linear constraints were considered.

***Preparation of fruit bar from pineapple pulp*:** At first, appropriate amount of ingredients were taken according to the formulation presented in Table 1. In all formulations, 1% salt, 0.25% citric acid and 500 ppm sodium benzoate were weighted and added. All the ingredients for each formulation were mixed thoroughly and heated at 80°C for 5 minutes for gelatinization of starch. After heating, the mixture was placed on a steel pan and smeared with very thin layer of polythene to prevent the fruit bar from sticking to plate after drying. The mixture was dried at 60°C constant temperature for 28 hours (Hossain and Amin, 2008). Then, the sheet was cut into bar at a size of (3" x 1" x 1/4"). The fruit bars was packed in single layer polyethylene bag and stored at room temperature and at elevated temperature (40^{o}C). For analyzing the storage quality, eight bars were packed in a packet and stored at room temperature. On the day of analyzing the storage quality, one bar from each packet was taken and analyzed for browning index and sugars.

Table 1. Formulation for preparation of pineapple fruit bar.

Ingredient	Formulation			
	F_1	F_2	F_3	F_4
Pineapple pulp (%)	88.5	88	86.5	86
Starch (%)	1.5	2	1.5	2
Sugar (%)	10	10	12	12
Citric acid	0.25	0.25	0.25	0.25
Salt	1	1	1	1
Sodium benzoate (ppm)	500	500	500	500

F_1=Pulp:Starch:Sugar=88.5%:1.5%:10%; **F_2**=Pulp: Starch: Sugar=88%:2%:10%; **F_3**=Pulp:Starch:Sugar=86.5%: 1.5%: 12%; **F_4** = Pulp:Starch:Sugar = 86%: 2%:12%.

***Analysis of storage quality of pineapple fruit bars*:** Non-enzymatic browning is in two forms caramelization and the Maillard reaction. Non-enzymatic browning was determined by measuring color developed by spectrophometric methods (Botrel *et al.,* 1993). In Brief, pineapple bar was homogenized into slurry with 10ml of ethyl alcohol by mortar pastel

(Rittichai and Athapol, 2010). The mixture was then centrifuged at 4000 rpm for 10min and the absorbance of the supernatant was measured at 420 nm for the non-enzymatic browning index (BI) using a spectrophotometer (Nuray *et al.,* 2003). During storage, browning index was determined on 0, 3, 7, 12, 15, 45 and 70 days interval at room temperature and at 40^{o}C. The amount of reducing sugar, non-reducing sugar and total sugar in the sample was analyzed according to Rangana (2002).

The prepared pineapple bars were subjected to sensory evaluation by a tasting panel with 10 panelists to evaluate color, flavor, taste and overall acceptability by a scoring rate on a 9 point hedonic scale. The scale was 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. The boundary frequency for each samples concerning to each attributes was then calculated and presented graphically. Qualitative parameter of color, taste and overall acceptability was evaluated by same panel.

Results and Discussion

Effects of major ingredients of the fruit bar on acceptability**:** Sensory evaluation, scores for overall acceptability, browning index is needed to find out the effects of major ingredients of the fruit bar on acceptability. It was done by the software of Statgraphics XVII.

Results presented graphically in Figure 1(a) and Figure 1(b). Analysis of data fitted to linear model for each of the components. The model is statistically significant at p<0*.05*. The fitted linear quadratic model is given below:

Overall Acceptability=$3.0X_1+8.0X_2+4.25X_3$ ………(1)

Browning Index=$0.439X_1-0.191X_2+0.37775X_3$ ……(2)

Where, X_1 is the percentage of pulp, X_2 is the percentage of starch and X_3 is the percentage of sugar.

The results revealed that overall acceptability was positively correlated with the sugar and starch content whereas negatively correlated with the pulp content (Figure 1a). In contrast the reverse is observed in browning index (Figure b) the painted contour region at the bottom of the graph depicts it clearly.

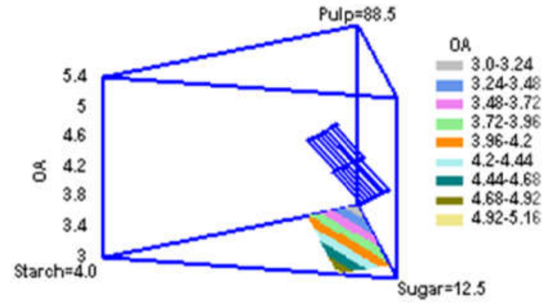

Figure 1(a). Effect of major ingredients of the bar formulation on the overall acceptability.

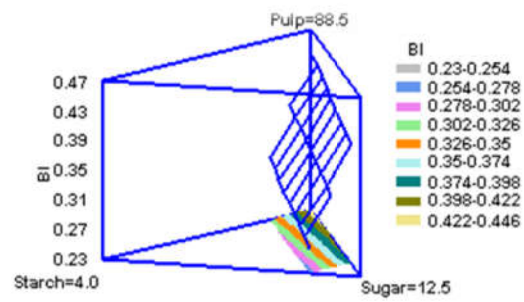

Figure 1(b). Effect of major ingredients of the bar formulation on the browning index.

Therefore, it seems that sugar and starch has independent roles in improving the quality of pineapple bars. Sugar might improve its taste by balancing acid-sugar ratio. Sugar also increased total soluble solids (TSS) (Gujral and Brar, 2003). Starch, might improve texture and color of the product and increase TSS. Gujral and Brar (2003), Compared to the different level of starch, the increased level of starch gave best color (2% starch F4). In addition to increasing solid content in bars, it also protects color of fruit bar to undergo Maillard reaction or caramellaization (Miller, 1993).

***Non-enzymatic browning in pineapple bar during storage*:** As shown in Figure 2, during storage, browning Index (BI) of formulation F_4 was the lowest and the highest was in Formulation F_1 and F_3 that supportive to the physical appearance of the fruit bars.

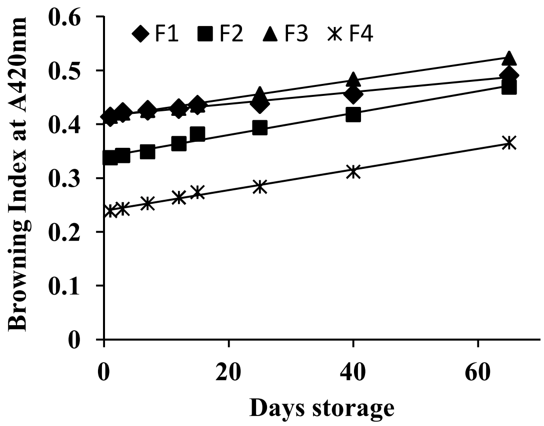

Figure 2. Zero-order kinetic plots of non-enzymatic browning index value (A420nm) change during storage of pineapple fruit bar. $\mathbf{F_1}$=Pulp:Starch:Sugar = 88.5%:1.5%:10%; $\mathbf{F_2}$= Pulp:Starch:Sugar = 88%:2%:10%; $\mathbf{F_3}$ = Pulp: Starch:Sugar = 86.5%: 1.5%: 12%; $\mathbf{F_4}$=Pulp: Starch: Sugar = 86%: 2%:12%.

Color of formulation F_2 is the lightest whereas the same was darkest in formulation 3 during the whole storage period. The physical appearance of sample F_2 remained in between and could easily be separated from other three samples. During storage there was a gradual increase of absorbance at a relatively slower rate in all.

As shown in Figure 3 and 4, after 7 days of storage at 40^{0}C, all the samples attained deep dark color except formulation F_4. Sample F_2 is rather less dark compared to formulation F_1 and F_3.

As shown in Table 2, data of individual samples fitted well to the zero-order kinetics model having R^2 value closed to unity. During storage at room temperature, rate constant was very small refers slower rate of non-enzymatic browning. Except sample F_2, rate constant of other three formulations were the same (0.042×10^{-3}/hr). However, rate constant of sample F_2 attained double (0.083×10^{-3}/hr) within the same storage duration indicating relatively faster browning reaction.

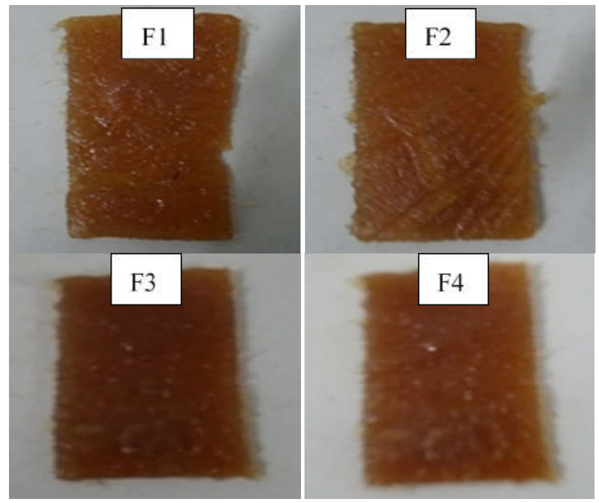

Figure 3. Physical appearance of pineapple fruit bars on the day of storage at room temperature. $\mathbf{F_1}$=Pulp:Starch:Sugar = 88.5%:1.5%:10%; $\mathbf{F_2}$= Pulp:Starch:Sugar = 88%:2%:10%; $\mathbf{F_3}$ = Pulp: Starch:Sugar = 86.5%: 1.5%: 12%; $\mathbf{F_4}$=Pulp: Starch: Sugar = 86%: 2%:12%.

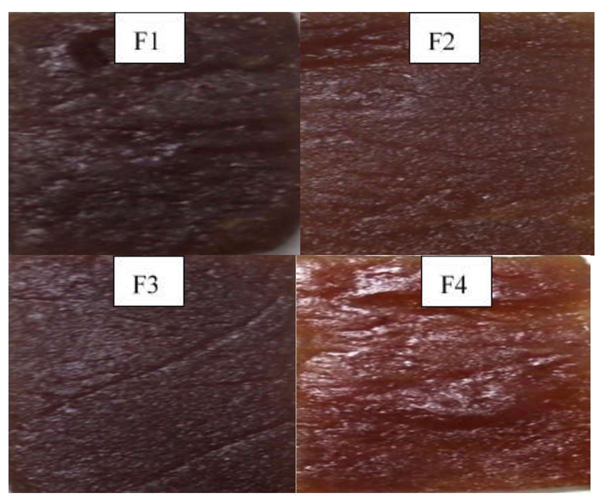

Figure 4. Physical appearance of pineapple fruit bars after 7 days of storage at 40^{0}C. $\mathbf{F_1}$=Pulp:Starch:Sugar = 88.5%:1.5%:10%; $\mathbf{F_2}$= Pulp:Starch:Sugar = 88%:2%:10%; $\mathbf{F_3}$ = Pulp: Starch:Sugar = 86.5%: 1.5%: 12%; $\mathbf{F_4}$=Pulp: Starch: Sugar = 86%: 2%:12%.

Non-enzymatic browning at elevated temperature (40^{0}C) was increased about 10 to 20 times compared to room temperature and highest value was observed in F_4 (0.958×10^{-3}/hr) which was 22 times higher than room temperature. The lowest rate constant given by the formulation F_3 was 0.458×10^{-3}/hr, which was 10 times higher compared to the same samples stored at room temperature.

Table 2. Result of model parameters.

Temperature (^{0}C)	Sample	Constant	Rate Constant (×10^{-3}/hr)	R^2
30±1	F1	0.413	0.042	*0.977*
	F2	0.339	0.083	*0.984*
	F3	0.415	0.042	*0.996*
	F4	0.238	0.042	*0.993*
40	F1	0.412 (0.55)	0.625	*0.976*
	F2	0.724 (0.48)	0.792	*0.981*
	F3	0.121 (0.59)	0.458	*0.997*
	F4	1.117 (0.35)	0.958	*0.999*

$\mathbf{F_1}$=Pulp:Starch:Sugar=88.5%:1.5%:10%; $\mathbf{F_2}$=Pulp:Starch:Sugar=88%:2%:10%; $\mathbf{F_3}$=Pulp:Starch:Sugar=86.5%:1.5%:12%; $\mathbf{F_4}$= Pulp: Starch:Sugar = 86%: 2%:12%.

In preparation of food products quality changes is the main factor to the consumers. The main cause of deterioration of fruit bar is non enzymatic browning, since enzymatic browning is eliminated by heat treatment during processing. Therefore, kinetic modeling of non enzymatic browning reactions is very important for fruit bar storage (Buedo *et al.,* 2001). From a practical standpoint, by measuring threat and temperature-dependence of non enzymatic browning reactions, it is possible to determine the period of storage at a given temperature without any quality deterioration (Burdurlu and Karadeniz, 2003). It has already been shown (Figure 2) that the absorbance of sample F_1 and F_3 are the highest whereas sample F_4 has the lowest and sample F_2 is in between of them. Changes in relative absorbance at 420 nm are related to brown pigment, which is mostly happened by non-enzymatic browning.

It is well-known that non-enzymatic browning is a chemical process that produces a brown color in foods without the activity of enzymes. Maillard reaction is one of non-enzymatic processes, where the chemical reaction occurs between an amino acid and a reducing sugar. Non- enzymatic browning could also be occurred due to caramelization of sugar present in foods (Miller, 1993). In this study during drying of formulated slurry to form dried bar at 60^{0}C, sugar present in sample might undergo caramelization and thus they might attain the brown color. The less brown color of Formulation F_2 and F_4 might due to addition of higher amount of starch. As shown in Table 1, these two formulations contained 2% starch whereas only 1.5% starch is in other two formulations. The higher amount of starch might create a protective surface around the amorphous materials like sugars and amino acids and prevent of occurring Maillard reaction as well as caramelization. At the same time, the content of higher amount of sugar in this formulation also facilitates to go for non-enzymatic browning, which can easily realized by observing sample F_2. The major differences in the formulation of sample F_2 and F_4 are in the content of sugar and hence it contributes to higher browning to sample F_2 compared to F_4. Isabel *et al.* (2011) found that the changes in amylase activity due to presence of starch and sugars contents in mango pulp.

Browning index data during storage fitted to zero order model, which is in agreement with other research works reported by Lozano (1991), Burdurlu and Karadeniz (2003) for apple juice, Ibarz *et al*. (1999) for pear puree. During storage at room temperature rate constant of all samples are quite similar except sample F_2. It means that non-enzymatic browning during storage at low temperature is very low. However, when storage temperature increased to 40^0C, non-enzymatic browning dramatically increased to 10 to 20 times. It reveals that at room temperature non-enzymatic browning is mostly occurred by Maillard reactions rather than carameliazetion. However, higher storage temperature increased non-enzymatic browning either by Maillard reaction or by caramelization. If it is occurred by Maillard reaction, it is highly possible that the reaction is accelerated at elevated temperature. Similar results for the order of reaction were found by other authors; such as Koca *et al*. (2007) developed zero order reaction kinetic model for carrots slices.; similarly Koca *et al*. (2003) showed that kinetics of non-enzymatic browning reaction in citrus juice followed the zero order reaction.

***Changes of sugar content of pineapple bars*:** Reducing sugar of pineapple bar during storage at room temperature was determined and presented graphically in Figure 5.

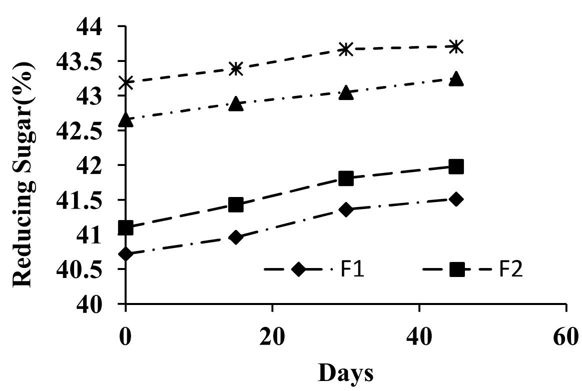

Figure 5. Changes of reducing sugar in pineapple fruit bar during storage. $\mathbf{F_1}$=Pulp:Starch:Sugar =88.5%:1.5%:10%; $\mathbf{F_2}$=Pulp:Starch:Sugar=88%: 2%:10%; $\mathbf{F_3}$ = Pulp: Starch:Sugar = 86.5%: 1.5%: 12%; $\mathbf{F_4}$=Pulp: Starch: Sugar = 86%: 2%:12%.

As shown in Figure 5, initially reducing sugar content of all the samples varied from 40.75% to 43.25%. Formulation F_4 contained relatively higher reducing sugar than other samples. However, reducing sugar content of formulation F_3 and F_4 remained quite closed. During storage, reducing sugar of all the formulations was increased during storage. However, the rate of change was relatively low and followed the same pattern. In case of formulation F_1, F_2 and F_4, changes of reducing sugar content of fruit bar were relatively higher up to 30 days of storage and then it came to almost stable.

Table 3. Percentage of changes of different sugars after 45 days of storage.

Formulation	Percent changes after 45 days of storage		
	Reducing sugar	Non-reducing sugar	Total Sugar
F1	0.79$^+$	1.53	0.74
F2	0.88$^+$	1.75	0.87
F3	0.59+	1.51	0.92
F4	0.52$^+$	1.06	0.54

'+' sign indicates reducing sugar content increased.

As shown in Table 3, the highest changes of reducing sugar after 45 days of storage was observed in case of formulation F_2 (0.88), followed by F_1(0.79) and the lowest was observed in formulation F_4 preceded by F_3. Pineapple fruit bars were also analyzed for non-reducing sugars during storage and data obtained were plotted and presented in Figure 6. Non-reducing sugar in fruit bar behaved opposite as it was observed for reducing sugar during storage meaning its content was decreased during storage. Unlike reducing sugar, initial non-reducing sugar content in fruit bar varied from 9% to 12.5%. Initial non-reducing sugar of formulation F_1 and F_2 were almost similar in one hand and Formulation F_3 and F_4 were much closer on the other hand. The former pair contained the highest reducing sugar compared to the latter one.

As shown in Figure 6, the highest non-reducing sugar loss was occurred for formulation F_2 (1.75%) and the lowest was for formulation F_4 (1%). Whereas the sugar loss of formulation F_1 and F_3 were almost the same and it is in between of F_2 and F_4 after 45 days of storage at room temperature (Table 3).

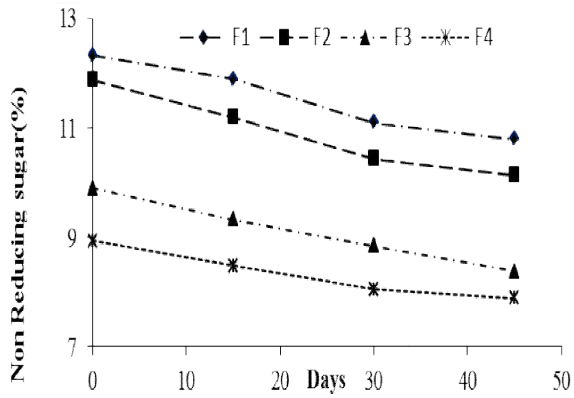

Figure 6. Changes of non-reducing sugar in pineapple fruit bar during storage. $\mathbf{F_1}$=Pulp:Starch:Sugar =88.5%:1.5%:10%; $\mathbf{F_2}$=Pulp:Starch:Sugar=88%: 2%:10%; $\mathbf{F_3}$ = Pulp: Starch:Sugar = 86.5%: 1.5%: 12%; $\mathbf{F_4}$=Pulp: Starch: Sugar = 86%: 2%:12%.

The kinetics of non-reducing sugar content in formulation F_4 was quite slow compared to other three formulations during storage. The stability of total sugar in fruit bars was observed and the collected data graphically presented in Figure 7.

As shown in Figure 7, total sugar content in pineapple fruit bar samples varies only 1% initially (52.1% to 53.1%). Initially, the highest total sugar content was for formulation F_1, followed by sample F_2 and then followed by sample F_3 and the lowest total sugar was found for Formulation F_4. However, total sugar content of formulation F_1 and F_2 were closed. During storage, unlike non-reducing sugar total sugar content of all the formulations was decreased for entire storage duration. However, the changing rate was quite slow and followed the similar pattern. In case of formulation F_4, changes of total sugar content in fruit bar was very slow compared to other formulation during 45 days of storage.

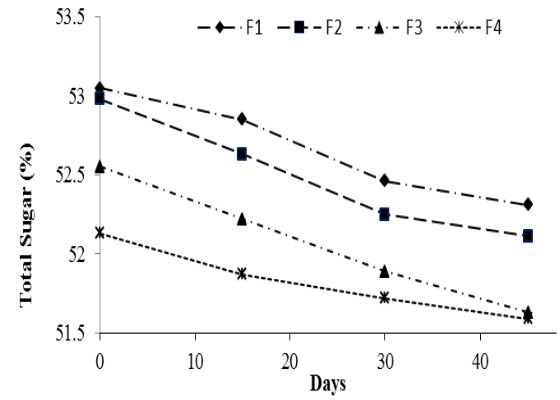

Figure 7. Changes of total sugar in pineapple fruit bar during storage. $\mathbf{F_1}$=Pulp:Starch:Sugar=88.5%: 1.5%:10%; $\mathbf{F_2}$=Pulp:Starch:Sugar=88%: 2%: 10%; $\mathbf{F_3}$=Pulp:Starch:Sugar=86.5%:1.5%:12%; $\mathbf{F_4}$=Pulp: Starch: Sugar = 86%: 2%:12%.

As shown in Table 3, the highest changes of total sugar in different formulation of pineapple bar after 45 days of storage was observed in case of formulation F_3 (0.92), followed by F_2 (0.87) and the lowest was observed for formulation F_4 preceded by F_1. After 45 days of storage, the total sugar content of formulation F_3 and F_4 came to the same.

It has already been stated that the variation of color of pineapple fruit bars was due to non-enzymatic browning, which occurred during preparation as well as storage. From compositional point of view, the most influencing factors for non-enzymatic browning of pineapple fruit bar is the concentration of sugars and amino acids. On the other hand, moisture content and storage temperature are the physical factors influencing the non-enzymatic browning.

During preparation of pineapple fruit bar, sugar present in fruit including added sugar gets to be concentrated as well as caramelized with progressive drying at the elevated temperature and thus pink pigment was formed. The compositions of pineapple fruit pulp as reducing sugar are 10.5 %, non-reducing sugar 7.4 % and total sugar 17.90 % (Hemalatha and Anbuselvi, 2013). After preparation of pineapple bar, the content of them obtained in different formulation changed as reducing sugar (40.72-43.19%), non-reducing sugar (8.94-12.33%) and total sugar (52.13- 53.05 %) including external addition of 10 to 12% sucrose.

As shown in Figure 5, initial non-reducing sugar content of sample F_1 and F_2 were low whereas F_3 and F_4 were high. According to Table 1, in spite of containing the higher amount of pulp, only due to addition of lower amount of sugar (10%), their reducing sugar content were lower than the latter two. Though sucrose is non-reducing sugar, due to prolong heat treatment during drying a partial hydrolysis or inversion of sucrose was resulted in to reducing sugar like glucose and fructose (Islam and Akter, 2012). During storage at room temperature, reducing sugar content of all samples was increased slowly up to the end of the storage period (45 days). However, at the end of storage period (45 days), the reducing sugar content in fruit bar just became reverse. It can be assumed that the Maillard reaction might be continued in all the samples at low temperature and this reaction was comparatively higher in sample F_3 and F_4, most probably due to low water activity. Between sample F_1 and F_2, the highest content of reducing sugar of sample F_2 than F_1 might due to the content of starch. Starch could be responsible to release additional reducing sugars.

In case of non-reducing and total sugar, the phenomenon was exactly the opposite, which was observed for all the samples during storage at room temperature. The reason could be the same as it has already been discussed for reducing sugar, i.e., the decreased in reducing sugars might be due to hydrolysis or inversion of non-reducing sugar to reducing sugar. It is noticeable that the non-reducing and total sugar content of sample F_4 is considerably low, which might due to simultaneous influence of increased amount of sugar (12%) and starch (2%). In comparison of sample F_2 and F_3, high amount of starch and low amount of sugar might more favorable in retaining non-reducing sugars than that of low amount of starch and high amount of sugar. However, in case of total sugar F_3 formulation looks better. The decrease in total sugars might be due to reaction of sugar with amino acid and co-polymerization sugars in the presence of acid which might slightly decrease the total sugar in bar.

Abdelazim *et al*. (2011) found an increasing trend of reducing sugars in making jam. According to Selvamuthakumaran *et al.* (2013) the change of total sugar in spiced squash was 32.09% to 30.41% after 6 months of storage and reducing sugar was changed in 18.05% to 20.24% after 6 months of storage.

***Effects of storage period on liking- intensity of pineapple fruit bar*:** The liking intensity scores for flavor, taste and overall acceptability of different types of bar formulations were evaluated by a panel of 10 judges.

The graphical presentation of liking intensity in terms of color as influenced by storage time is given in Figure 8.

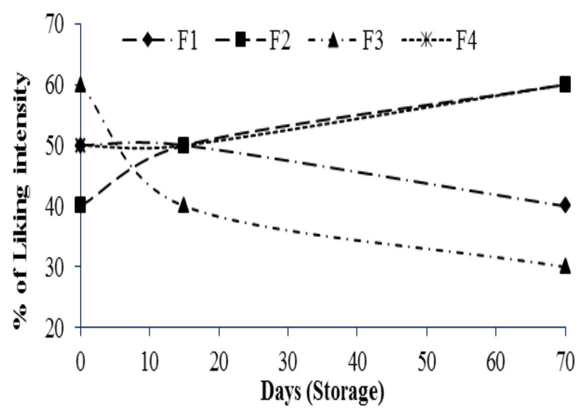

Figure 8. Representative curves of ‘Liking Intensity’ in terms of color of pineapple fruit bar changing during storage. $\mathbf{F_1}$=Pulp:Starch: Sugar=88.5%:1.5%:10%; $\mathbf{F_2}$=Pulp:Starch:Sugar =88%:2%:10%; $\mathbf{F_3}$=Pulp:Starch:Sugar=86.5%: 1.5%:12%; $\mathbf{F_4}$ = Pulp:Starch:Sugar = 86%: 2%: 12 %.

Initially liking intensity for color of different samples of pineapple bar varied from 40% to 60% (from Figure 8). Initially the sample F3 obtained the highest liking intensity regarding to color whereas sample F_3 attained the lowest intensity. Samples F_1 and F_4 have the almost similar intensity and remained in between of other two samples. During storage liking intensity of different samples relating to color was changed in a complex manner. The liking intensity of sample F_3 decreased sharply up to 15 days of storage and then went linearly up to end of the storage. Sample F_1 remained almost unchanged up to 15 days of storage and then decreased in a linear fashion like sample F_3. The liking intensity of sample F_2 for color increased gradually up to the end of the storage. Whereas liking intensity of sample F4 for color showed stable up to 15 days and then gradually increased for the entire storage duration. The graphical presentation of liking intensity in terms of taste as influenced by storage time is given in Figure 9.

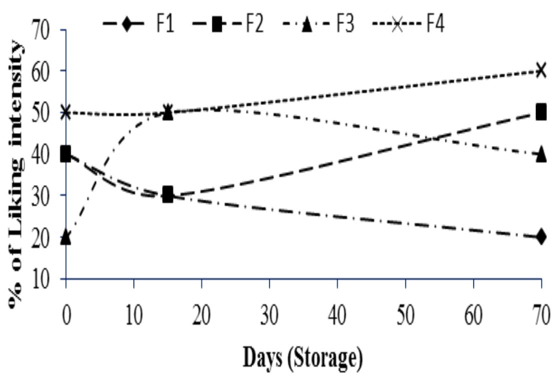

Figure 9. Representative curves of 'Liking Intensity' of taste of pineapple fruit bar during storage. **F_1**=Pulp:Starch:Sugar=88.5%:1.5%: 10%; **F_2**=Pulp:Starch:Sugar=88%:2%:10%; **F_3**= Pulp:Starch:Sugar=86.5%:1.5%:12%; **F_4**=Pulp: Starch:Sugar = 86%: 2%:12 %.

The liking intensity of samples for taste was varied from 20% to 50% on the day of on-set of storage study. During first evaluation, about 50% of panelists liked the sample F_4 whereas only 20% panelist liked the sample F_3. The liking intensity of sample F_1 and F_3 for taste were the same on the day of preparation. The liking intensity of sample F_2 concerning to taste was increased up to 15 days of storage and then decreased gradually up to the end of the storage time. The liking intensity of sample F_2 and F_3 for taste were slowly decreased up to 15 days of storage and then it was increased for sample F_2 and decreased for sample F_1. In case of sample F_4, the liking intensity for taste remained almost stable up to 15 days of storage and then it was increased gradually up to end of the storage period.

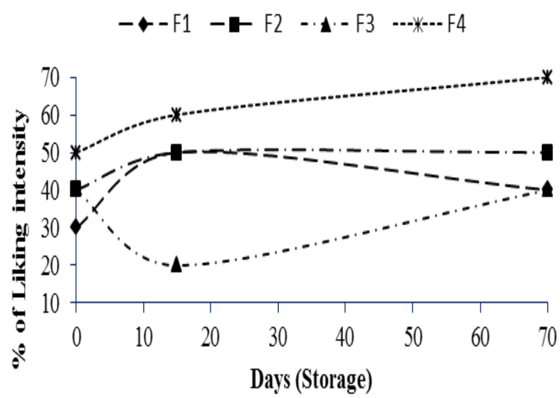

Figure 10. Representative curves of liking intensity for overall acceptability of pineapple fruit bar during storage. **F_1**=Pulp:Starch:Sugar=88.5% :1.5%:10%; **F_2**=Pulp:Starch:Sugar=88%:2%: 10%; **F_3**=Pulp:Starch:Sugar=86.5%:1.5%:12%; **F_4**=Pulp: Starch:Sugar = 86%: 2%:12 %.

As shown in Figure 10, the liking intensity of samples for overall acceptability was varied from 30% to 50% on the day of sample preparation. During first evaluation, about 50% of panelists liked the sample F_4 whereas only 30% of panelist liked F_1. The liking intensity of sample F_2 and F_3 for overall acceptability were the same on the first day of sensory evaluation. The liking intensity of sample F_1 concerning to overall acceptability was increasing up to 15 days of storage and then decreasing gradually up to the end of the storage. The liking intensity of sample F_1 and F_2 for overall acceptability were increased up to 15 days of storage and then it was remained almost unchanged for sample F_2 and decreased gradually for sample F_1. In case of sample F_4, the liking intensity for overall acceptability gradually increased for entire storage period studied in this work.

Storage-Liking methods are used to measure intensity of specific attribute like color, taste and overall acceptability of product. These modifications are often accompanied by textural changes or formulation change of the products. Consumer tests give a direct measure of liking that can be used more directly to estimate shelf-life. Since non-enzymatic browning has direct influence on color development and sugar content of dehydrated products like pineapple fruit bars, it is utmost important to assess the consumer responses towards stored products. Concerning to the liking intensity of samples for colors, the liking of majority of the respondents were continued for samples F_2 and F_4 up to the end of the storage which might due to insignificant changes of their color due to non-enzymatic browning. Results showed that kinetics of browning index and the changes of sugar content. Sample F_3 went for rapid color changes by non-enzymatic browning and thus liking intensity for color went down sharply whereas the same for the sample F_1 went down slowly due to change of color slowly. Initially the highest liking intensity for color of sample F_3 might due to well-developed color immediate after preparation of fruit bar which was at the highest sensation of the consumers. Concerning to taste, it is quite surprising of low liking intensity of sample F_3 for taste on the first day of sensory evaluation. However, on day 15, liking intensity increased and right after started to go down. This might due to improper sugar-acid ratio.

Conclusions

The pineapple fruit bar was prepared having four different formulations varying in quantity of pineapple pulp, starch and sugar. Fixed amount of citric acid, salt and sodium benzoate was used for all fruit bar. Mixture design was used to formulate the ingredients of the bar. The extreme vertices design was used to run the experiment. The model was statistically significant at $p<0.05$ and data are sufficient for fitting the linear model. The fitted linear quadratic model for overall acceptability and browning index showed the general relation among the major ingredients concerning to these responses. Non-enzymatic browning during storage of fruits bars was studied by measuring absorbance at 420nm. Non-enzymatic browning was 10-20 times higher at 40^0C compared to atmospheric storage condition. For finding the kinetics of the changes of absorbance, data were fitted to zero-order model. Rate constant of four formulations were varied from 0.042×10-3/hr to 0.083×10-3/hr at 30 ± 1^0C. The rate constant increased to 0.458×10-3/hr to 0.958×10-3/hr at 40^0C. The highest liking intensity for color, taste and overall acceptability was found for formulation F4. Reducing sugars of four formulations were varied within the range of 40-43% and after 45 days it increased within the range of 41-44%. A decreasing trend was observed for both non-reducing and total sugars of all four formulations irrespective of the components of the samples.

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