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Quality Evaluation of Ginger Candy Prepared by Osmotic Dehydration Techniques

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Abstract

The study was carried out to develop and compare Ginger candy from fresh indigenous and China Ginger. Ginger was immersed into the sugar solution with the concentrations of 50%, 60% and 70% sugar solution. Moisture, ash, protein, fat, crude fiber and total sugar content and organoleptic quality and microbial status of the prepared candy were analyzed. Moisture, ash, protein, fat and crude fiber content was found to be lower with increased concentration of sugar solution used, whereas total sugar content was found to be higher. Total bacterial count was increased with increasing the concentration of sugar solution. The best characteristic of Ginger candy was found with 50% sugar solution, with highest nutrient and lowest microbial load than candy prepared with 60% and 70% sugar solution.

Keywords

Ginger Candy, Sugar Solution, Nutritional Composition, Organoleptic Quality, Sensory Score, Microbial Load

1. Introduction

Ginger (*Zingiber officinale*) is the underground stem (rhizomes) of a perennial herb. The useful parts of this crop are the rhizomes [1] which are used as spices for its aroma and pungency. The aroma of ginger is pleasant and spicy and its flavor penetrating, slightly biting due to presence of antiseptic or pungent compounds, which make it indispensable in the manufacture of a number of food products. Ginger (*Zingiber officinale* Rose.) is an important commercial spices crop in tropical and subtropical countries including Bangladesh [2] [3]. Ginger requires warm and humid climate for better growth and it is well suited for the cultivation in hilly region. In Chittagong Hill tracts region, it is a leading cash crop because of its greater potentiality of growing due to suitable climatic condition [4].

Fresh ginger are seasonal, perishable spices in nature and available in large quantities during the peak season in the local market. After harvesting it cannot be kept for longer period due to higher water activity (a_w) and during storage its suffer from weight loss, shrinkage, rotting and sprouting. Due to lack of processing and value addition practice in ginger, during harvesting season, a huge quantity of fresh produce becomes unmarketable [5]. Ginger is normally stored in pit but within few days sprout and roots are found. However, the high moisture content (70% - 75%) of Ginger makes it susceptible to microbial contamination and insect infestation, resulting in significant loss and deterioration of product quality. Shelf life of Ginger can be extended by normal drying, but the color and structure will be loss during normal drying process. To overcome this problem partial dehydration in sugar solution is preferred.

The rhizome is used worldwide as spices for flavouring in a number of foods and food-products and also used in medicine. Ginger has great medicinal values. Flavones, flavonoids and Flavonols are chemical compounds in ginger, active against microorganisms [6]. Ginger or *Zingiber officinale*, which is used in traditional medicine, has been found to possess antioxidant effect that can control the generation of free radicals [7]. The pungent taste of ginger is due to gingerol, zinzerone and shogool [8]. Ginger is rich in secondary metabolite, such as oleoresin. Gingerol increase the motility of the gastrointestinal tract and have analgesic, sedative and antibacterial properties [9]. Ginger stimulates the production of saliva [10]. It promotes the release of bile. It is used as a stimulant and carminative and also for dyspepsia and colic [10]. Ginger may also decrease joint pain from arthritis, may have blood thinning and cholesterol lowering properties and may be useful for the treatment of heart diseases and lungs diseases [11]. Ginger is effective for treating nausea caused by sea sickness, morning sickness and chemotherapy [12]. It is also effective for the treatment of inflammation, rheumatism, cold, heat cramps, and diabetes [13] [14]. The main bioactive components of Ginger are the Gingerols, which possess antioxidant, anticancer, and anti-inflammatory attributes [15]. Several studies suggest that Ginger may work better than placebo in reducing some symptoms of motion sickness. Ginger has a sialagogue action, stimulating the production of saliva, which makes swallowing easier.

Osmotic dehydration (OD) is an important technique of food preservation and processing in which foods especially fruits and vegetables are immersed in the osmotic solution containing concentrated salt, sugar, alcohol or starch. The osmotic agent used may be fructose, corn syrup, glucose, sodium chloride or sucrose. Cell membrane of fruits and vegetables works as semi permeable membrane which permits water to move from low concentrated fruits and vegetables to high concentrated osmotic solution [16]. The dehydration occurs primarily due to an osmotic water flow and solute activity gradients across the semi permeable membranes. Osmotic dehydration is actually a simultaneous diffusion process, brings some benefits reducing the damage of heat to the flavor, color, inhibits the browning of enzymes and decreases the energy costs [17]. Comparing to other conventional methods, Osmotic Dehydration treatment is a simple procedure which requires no mechanical aid and involves decreased cost of energy. It is easy to perform at room temperature, which ensures the retention of color, texture and nutrients. OD treatment also involves limited loss of volatile compounds and less oxidative changes [18]. Moreover, ginger is locally produced in Bangladesh, which is sufficient to meet the demands. Thus, ginger is imported from China and readily available in the local market. The aim of this study was to develop a processed ginger candy through the combination of osmotic dehydration and mechanical drying.

2. Materials and Methods

Materials

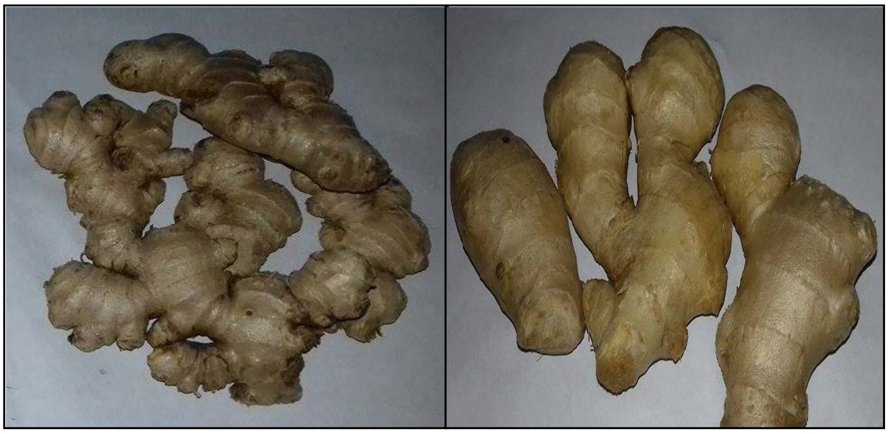
The research was conducted in November 2015 to May 2016, at vegetable Technology Section, Institute of Food Science and Technology, Bangladesh Council of Scientific and Industrial Research, Dhaka. Fresh ginger of two varieties (Bangladeshi indigenous and China) and sugar was used to prepare the candy and were collected from the local markets of Dhaka (**Figure 1**). The sample was packed in polyethylene bag and stored at refrigeration temperature (2˚C - 5˚C) in airtight box at the laboratory until use.

Methods

Fresh gingers were selected and collected according to their uniform size, freshness and cleanliness (free from dirt, twigs, soil, dust). The gingers were then washed to clean the dirt that is still attached and washed gingers were peeled to remove outer layer. Peeling was done slowly one by one and dipping under water for reducing direct air contact and peeled gingers were further washed for removing of remaining husk. Then boiled at 80˚C temperature for 20 minutes followed blanched gingers ware cut into around $1cm^3$ pieces. Cutting was done slowly and immersed in the solution of 3% salt and 0.05% sodium meta-bi-sulphite for 10 to 15 minutes avoiding of dis-coloration of ginger. These sliced gingers were boiled with different concentration (50%, 60% and 70% Brix) of sugar solution in addition with 0.3% citric acid as flavoring agent for 30 minutes. Sucrose was used as osmotic agent (**Figure 2**). Brix Hydrometers are used to measure the Brix. After cooling, gingers were stored at room temperature for about 20 hours followed by draining to reduce free water attached to Gingers and then dried at 55˚C - 60˚C for 3 - 4 hours in mechanical dryer to obtain the moisture content of ≤10%. Prepared Ginger candy were then wrapped in polythene pouch and kept in a cool place in an airtight plastic box for storage.

Proximate Nutrient Analysis

Moisture content of collected samples was determined by drying the samples



(a) (b)

Figure 1. Bangladeshi (a) and Chinese (b) fresh ginger.

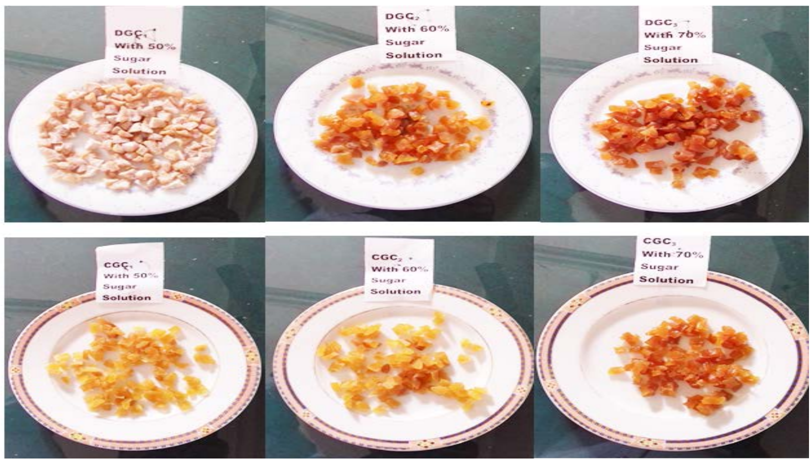


Figure 2. Bangladeshi and china ginger candy with 50%, 60% and 70% sugar solution, (DGC: Bangladeshi Ginger Candy, CGC: China Ginger Candy).

at 105˚C in a drying oven till a constant weight was attained [19]. Ash content was determined in triplicate using a muffle furnace at 600˚C for 8 h by AOAC method [19]. Protein content was determined by the Micro-Kjeldahl method as described by AOAC [19] by first determining the percent nitrogen content and then converted to % crude protein by multiplying with the factor 6.25. Total sugar content of the sample was determined by Lane and Eynon method [20]. The total lipid content of sample was determined using Soxhlet apparatus [19]. Crude fiber was determined by Acid-Alkali Hydrolysis as followed by AOAC [19]. Available carbohydrate content was determined by difference, *i.e.* by subtracting the sum of the values of moisture, ash, protein, fat and crude fiber from 100 (per 100 gm) [19]. The energy content of the samples was determined by calculating the amount of protein, fat and carbohydrate of respective food items and by using the following equation [21].

$$\text{Energy} = (\text{Protein} \times 4.1) + (\text{Fat} \times 9.3) + (\text{Carbohydrate} \times 4.1)$$

Microbiological Analysis of Ginger Candy

Microbial examinations of Ginger candy were performed to assess Bacterial, Fungal and Yeast load under laboratory condition. Standard plate count, Fungal and Yeast count and enumeration of total coliform of Ginger candy were examined. All media and equipment were sterilized by steam Sterilization at 15 psi for 20 minutes at 121˚C in an autoclave. For analysis, 10 gm of each sample was aseptically weighted and diluted to 1:10 (10 gm in 90 ml) with sterilized distilled water and mixed well. Standard plate count (SPC) was estimated by decimal dilution technique followed by the pour plate method and Spread Plate method for Fungus and Yeast. In the Pour Plate Method, 0.1 ml and 1 ml samples were pipetted onto sterilized Petri plates. Sterilized agar medium was cooled to about 45˚C and was poured on the plates. The media was mixed well by a gentle swirling motion. The Petri plates were then allowed to solidify. The plates were incubated at the 37˚C temperature for 24 - 72 hours. In this study for each sample there were 2 Petri plates for 0.1 ml and other 2 for 1 ml [22] [23]. For Spread Plate Method approximately 15 ml of previously autoclaved media was poured in a sterilized Petri plate and was kept at room temperature until the agar was solidified. In Potato dextrose agar (PDA) plate, 0.2 ml sample was dropped and then the sample was spread on the agar plate with the help of sterilized bent glass rod (spreader). By this method, yeast and mould counts were determined [24] [25]. The plate was then incubated at the room temperature for 24 to 72 hours. All steps of this media were done under laminar airflow. Isolation and enumeration of total coliform were performed by Most Probable Number (MPN) method. The MPN method using lauryl tryptose sulfate broth (LST) [26] is a statistical, multi-step assay consisting of presumptive, confirmed and completed phases. In the assay, serial dilutions of a sample are inoculated into broth media. From the gas positive (fermentation of lactose) tubes, the other 2 phases of the number of organisms was estimated from statistical tables. Typically only the first 2 phases were performed in coliform analysis for *E. coli* [27].

Sensory Evaluation of Ginger Candy

The food sample was prepared at Vegetable Technology section and the taste testing was carried out at the Quality Control section of institute of food science and technology (IFST) of Bangladesh council of scientific and industrial research (BCSIR) Dhaka. Seven subjects (employees of Institute of Food Science and Technology of BCSIR) participate in the evaluation of taste. Sensory evaluation of Ginger candy was carried out for Color, Flavor, Texture and Overall acceptance by the panel of seven judges. Samples were presented in succession and panelists were asked to rate evaluation variables according to 9-point Hedonic scale as described by Larmond [28]. The 9-point Hedonic scale was used, where the lowest point 1 = extremely dislike and the highest point 9 = extremely like.

3. Results

Nutritional Composition of Raw Ginger and Ginger Candy

The chemical composition of raw indigenous ginger was found as moisture 89.78%, ash 0.66%, protein 1.76%, fat 0.33%, total sugar 1.18%, crude fiber

0.93%, carbohydrate 6.55% and energy 37.01 kcal. The data for chemical composition of final product are presented in Table 1. All samples were analyzed five times, for 6 months with an interval of 1 month, to know the change in nutrient content of the ginger candy. The concentration of sugar solution influences some of the characteristics of Ginger candy. Table 1 showed a trend of gradual decrease of ash, protein, fat, sugar, crude fiber and energy content with increasing moisture content. Whereas freshly prepared candy with 50% sugar solution was shown to contain 7.47% moisture, after 1 month the moisture content was shown to increase to 8.82% and nutrient content was decreased. After 2 months the moisture content was increased to 10.35% and nutrient content was decreased. Similarly, after 4 month the moisture content was increased to 11.74% and nutrient content was moderately decreased compare to initial month. Candy with 60% and 70% sugar solution was followed with similar trend of having moderately decreased nutrient content during storage. China ginger candy also followed a similar trend of decreasing nutrient content with increasing moisture (Table 2). As at the initial month freshly prepared candy with 50% sugar solution was shown to contain 8.44% moisture and after 4 months the moisture content was increased to 12.45% and nutrient content was moderately decreased compare to initial month. Candy with 60% and 70% sugar solution was followed the similar trend of decreasing nutrient content with increasing moisture during storage.

Table 1. The average nutritional composition of indigenous (Bangladeshi) raw ginger and ginger candy with different sugar solution.

	Analysis of sample*	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Crude fiber (%)	Total Sugar (%)	Carbohydrate (%)	Energy (Kcal)
Raw Indigenous Ginger		89.78	0.66	1.76	0.33	0.93	1.18	6.55	37.01
Ginger Candy with 50% Sugar Solution	0	7.47	0.87	3.15	0.27	1.71	63.97	86.53	370.15
	1	8.82	0.85	2.96	0.20	1.52	63.15	85.65	365.12
	2	10.35	0.84	2.84	0.16	1.39	62.40	84.42	359.22
	3	11.02	0.83	2.74	0.13	1.31	61.72	83.97	356.69
	4	11.74	0.83	2.69	0.12	1.30	61.13	83.32	353.73
Ginger Candy with 60% Sugar Solution	0	7.25	0.82	2.93	0.23	1.64	65.53	87.13	371.34
	1	8.56	0.79	2.78	0.17	1.50	64.64	86.20	366.37
	2	9.67	0.77	2.67	0.14	1.36	63.83	85.39	362.32
	3	10.66	0.73	2.58	0.12	1.30	63.08	84.61	358.57
	4	11.47	0.72	2.50	0.08	1.26	62.44	83.97	355.26
Indigenous Ginger Candy with 70% Sugar Solution	0	7.04	0.78	2.78	0.18	1.60	69.12	87.62	372.28
	1	8.67	0.70	2.65	0.13	1.30	68.07	86.68	367.43
	2	9.64	0.64	2.55	0.11	1.17	67.15	85.89	363.61
	3	10.63	0.56	2.46	0.09	1.09	66.33	85.17	360.1
	4	11.29	0.54	2.42	0.09	1.06	65.65	84.60	357.60

*0 = Just after preparation; 1 = After 1 month; 2= After 2 months; 3 = After 3 months; 4 = After 4 months.

Table 2. The average nutritional composition of Chinese raw ginger and ginger candy with different sugar solution.

	Analysis of sample*	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Crude fiber (%)	Total Sugar (%)	Carbohydrate (%)	Energy (Kcal)
Raw Chinese Ginger		90.62	0.73	1.72	0.30	1.21	1.08	5.40	31.99
Ginger Candy with 50% Sugar Solution	0	8.44	1.30	3.06	0.15	2.06	62.62	84.99	362.37
	1	9.62	1.23	2.92	0.11	1.92	61.91	84.20	358.19
	2	10.77	1.12	2.78	0.08	1.82	61.23	83.43	354.19
	3	11.68	1.09	2.68	0.07	1.78	60.58	82.70	350.70
	4	12.45	1.01	2.62	0.07	1.75	60.01	82.10	347.99
Ginger Candy with 60% Sugar Solution	0	8.29	1.17	2.94	0.17	1.84	67.41	85.59	364.52
	1	9.93	1.02	2.80	0.12	1.75	66.20	84.34	358.37
	2	10.67	0.78	2.69	0.08	1.70	64.23	84.08	356.49
	3	11.62	0.71	2.61	0.08	1.68	63.45	83.30	352.96
	4	12.38	0.68	2.55	0.08	1.68	62.78	82.63	349.97
Indigenous Ginger Candy with 70% Sugar Solution	0	8.17	0.82	2.88	0.14	1.70	70.27	86.29	366.87
	1	9.72	0.78	2.74	0.11	1.61	69.06	85.04	360.90
	2	10.63	0.76	2.63	0.074	1.52	67.94	84.39	357.46
	3	11.59	0.70	2.54	0.07	1.48	67.02	83.62	353.89
	4	12.25	0.65	2.47	0.06	1.46	66.21	83.01	351.42

*0 = Just after preparation; 1 = After 1 month; 2 = After 2 months; 3 = After 3 months; 4 = After 4 months.

Effect of Sugar Solution on Nutritional Composition of Ginger Candy

In case of indigenous Ginger Candy (Table 1), shows that there was a tendency of decreasing water content with increasing sugar solution used and on the contrary the lower the concentration of sugar solution used the higher the water content was found. At the initial month the moisture content of candy (with 50% sugar solution) was 7.47 and it was decreased accordingly from 7.25 to 7.04 with increasing the sugar concentration from 60% to 70%. From Table 1, it was also found that at the final month the moisture content of candy with 50% sugar solution was 11.74 and it was decreased accordingly from 10.47 to 11.29 with increasing the sugar concentration from 60% to 70%. There was a tendency that the higher concentration of sugar solution used, the lower ash content and on the contrary the lower the concentration of sugar solution used and the higher the ash content found. At the initial month, the ash content of candy with 50% sugar solution was 0.87 and it was decreased accordingly from 0.82 to 0.78 with increasing the sugar concentration from 60% to 70%. It was also found that at the final month the ash content of candy with 50% sugar solution was 0.83 and it was decreased accordingly from 0.72 to 0.54 with increasing the sugar concentration from 60% to 70%. There was also a tendency that the higher concentration of sugar solution used with lower protein content and on the contrary the lower the concentration of sugar solution used the higher the protein found. At the initial month the protein content of candy with 50% sugar solution was 3.15 and it was decreased accordingly from 2.93 to 2.78 with increasing the sugar concentration from 60% to 70%. It was also found that at the final month the protein content of candy with 50% sugar solution was 2.69 whereas it was found to decrease accordingly from 2.50 to 2.42 with increasing the sugar concentration from 60% to 70%. Crude fiber and Fat content was also shown to follow the similar trend of decreasing with increased sugar solution used. On the other hand, total sugar and carbohydrate content was shown to follow the opposite trend of increasing with increasing the sugar solution. In case of China ginger candy (**Table 2**), show the same trend, as moisture, ash, protein, fat and crude fiber content was decreased with increased sugar solution and on the other hand, total sugar and carbohydrate content was increased with increasing the sugar solution.

In case of indigenous Ginger candy, It is shown that candy with 50% sugar solution was found of having the highest average score of organoleptic test for flavor, which was of 8.25, whereas the lowest score of 7.63 was found in candy with 70% sugar solution. It was found that the highest score for color 8.25 was given for candy with 60% sugar solution and the lowest score of 7.25 was given for candy with 70% sugar solution and the highest score for texture 8.63 was given for candy with 50% sugar solution where a score of 7.75 was obtained for candy with 70% sugar solution. The average score indicating that the flavor and texture of Ginger candy with 50% sugar solution was more acceptable than candy with 60% and 70% sugar solution and in case of color candy with 60% sugar solution is better.

In case of China Ginger candy, it is shown that candy with 60% sugar solution was found of having the highest average score of organoleptic test for flavor, which was 8.63, whereas the lowest score of 7.63 was found in candy with 70% sugar solution. It was found that the highest score for color 8.63 was given for candy with 60% sugar solution and the lowest score of 7.63 was given for candy with 70% sugar solution and the highest score for texture 8.75 was given for candy with 60% sugar solution where a score of 8.00 was obtained for candy with 70% sugar solution. The average score indicating that the color, flavor and texture of Ginger candy with 60% sugar solution was more acceptable than candy with 70% sugar solution which indicates Ginger candy with 60% sugar solution was more acceptable than candy with 50% and 70%.

Microbial Analysis of Bangladeshi Indigenous and China Ginger Candy

The total viable bacterial counts for candy samples were shown in **Table 3**. From the results, it was found that at the initial month the bacterial load of indigenous Ginger candy with 50%, 60% and 70% sugar solution was >10 cfu/gm and in case of China Ginger candy the load was 30, 50 and 150 respectively. The bacterial load was increased with increasing time duration, as after 1 month in case of indigenous Ginger candy the load was 10, 20 and 10 cfu/gm for candy

Table 3. Total microbial load on ginger candy.

Parameter		Standard plate count			Total Yeast and Mold count			Total Coliform count		
		50%	60%	70%	50%	60%	70%	50%	60%	70%
Initial Month	Deshi Ginger	<10 cfu/gm	<10 cfu/gm	<10 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
	China Ginger	30 cfu/gm	50 cfu/gm	150 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
After 1st month	Deshi Ginger	10 cfu/gm	20 cfu/gm	10 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
	China Ginger	100 cfu/gm	200 cfu/gm	300 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
After 2nd month	Deshi Ginger	30 cfu/gm	50 cfu/gm	60 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
	China Ginger	250 cfu/gm	350 cfu/gm	550 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
After 3rd month	Deshi Ginger	50 cfu/gm	60 cfu/gm	70 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
	China Ginger	250 cfu/gm	600 cfu/gm	800 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
After 4th month	Deshi Ginger	70 cfu/gm	80 cfu/gm	100 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil
	China Ginger	550 cfu/gm	850 cfu/gm	950 cfu/gm	Nil	Nil	Nil	Nil	Nil	Nil

with 50%, 60% and 70% sugar solution where the load for China Ginger candy was 100, 200 and 300 cfu/gm respectively. After 2 and 3 months of storage candy with 50%, 60% and 70% sugar solution was found increased bacterial load for both indigenous and China Ginger candy. Finally, after 4 months of storage bacterial load was increased to 70, 80 and 100 cfu/gm for indigenous Ginger candy and in case of China Ginger candy increased to 550, 850 and 950 cfu/gm respectively for candy with 50%, 60% and 70% sugar solution. The total fungal counts of the sample are also shown in Table 3. It was found that the fungal count for both indigenous and China Ginger candy with 50%, 60% and 70% sugar solution was nil, after 4 months of observation. Most probable number (MPN) method with lauryl tryptose sulfate broth (LST) media was used for total coliform count. Total coliform counts were found negative in all candy samples both for indigenous and China Ginger candy after 4 months of storage (Table 3). This means that candy with 50%, 60% and 70% sugar solution of both indigenous and China Ginger candy contained no coliform.

4. Discussion

Drying of food can lead to impaired growth of microorganisms [29]. High water content foods are usually susceptible to be easily damaged by microorganisms and especially mold are grown and endanger the health of the consumer [30]. Chemical test results showed that higher concentration of sugar used that decreases the water content, because when gingers are soaked in sugar solution will experience an osmotic pressure and that pressure move the sugar molecules on the cell wall (extra cell) of ginger until the sugar solution enter into it, as a result the water within the cells of ginger out. Water content in ginger candy from all treatments are still relatively safe as the water content of food permitted for a maximum of 25% [31]. In addition, water content in food or food ingredient may affect the texture, taste, freshness, durability of materials and consumer acceptance [32].

Ash content in ginger candy from all treatments was found relatively safe as the maximum permitted value of ash is of 1.0%. There was a tendency that the higher concentration of sugar solution used, lower the protein content and on the contrary the lower the concentration of sugar solution used the higher the protein content contained in Ginger candies. Fruits and vegetables are not ordinarily thought of as a source of lipids, but we find that most of them contain between <1 percent of total lipid, usually listed as fat. Ginger candy was found to have the same percentage of fat. Changes in fat content occur mainly due to oxidation because fats and oils slowly take up oxygen and become rancid when it is stored and ultimately reduced. The fat content of ginger candy is usually lower than that of fresh ginger, this might happened due to oxidation and most of these fats in ginger are volatile [33].

The existence of crude fiber content comes from the ginger itself, however there was a tendency that the higher concentration of sugar solution used, lower the crude fiber and on the contrary the lower the concentration of sugar solution used the higher the crude fiber content contained. With increasing the concentration of sugar solution, the network of the cell wall changes which increase the progressive dissolution of pectin substances due to the enzyme activity [34]. There is a tendency that the higher concentration of sugar solution used, the higher the sugar found and on the contrary the lower the concentration of sugar solution used lower the sugar content contained in these ginger candies. Because during osmotic process water flow out of the food into the solution with a simultaneous transfer of solute from the solution into the food.

Color is one determinant of quality of food products in addition to the nutritional value itself. The visual assessment of color usually comes first, because the color is a view that can attract consumers so that there are many terms of the color of love. In addition, color can be used as an indicator of freshness or maturity. Both indigenous and China ginger candy with 60% sugar solution were the most preferred product to the panelists, this is possible because the color of gingers was still beautiful. Higher concentrations of sugar sometimes create caramelization and turn the products into dark brown and even black. Bangladeshi ginger candy with 50% sugar solution and China ginger candy with 60% sugar solution were the most preferred product to the panelists, this might be due to the beautiful or unique flavor of gingers were still feels fresh. The higher concentration of sugar replaces the beautiful ginger flavor and the panelists like it less and gave a low value. Texture is a trait or a physical condition and morphology of agricultural products which includes the level of hardness, tenderness, flexibility, elasticity, roughness and smoothness of materials. Texture usually depends on the with maturity level of the material itself (the fruit) and fruits with low level of maturity has a higher level of hardness compared with fruits that are ripe and texture is more soft or mushy. Indigenous ginger candy with 50% sugar solution and China ginger candy with 60% sugar solution were the most preferred product to the panelists, this is possible because the texture of Gingers was still beautiful (**Table 4**). This might be due to a variety of treatments

Table 4. Mean sensory score of Ginger candy with different sugar solutions.

Sensory attributes	Bangladeshi Ginger candy			China Ginger candy		
	Product type			Product type		
	DGC_1*	DGC_2*	DGC_3*	CGC_1*	CGC_2*	CGC_3*
Color	7.88	8.25	7.25	8.38	8.63	7.63
Flavor	8.25	7.63	7.63	8.25	8.63	7.63
Texture	8.63	8.38	7.75	8.38	8.75	8.00
Overall acceptance	8.00	8.13	7.75	8.50	8.63	7.63

*DGC: Bangladeshi Ginger Candy, CGC: Chinese Ginger Candy; DGC_1 and CG_1: With 50% sugar solution, DGC_2: With 60% sugar solution, DGC_3: With 70% sugar solution.

of soaking in different sugar solutions. In higher concentration of sugar solution, more sugar molecules enter and the more sugar is retained inside the cells of ginger, causing shrinkage as the progressive dissolution of pectin substances can occur due to the enzyme activity that causes changes in texture in fruits and vegetables [34].

The total bacterial content increased accordingly with increasing the sugar concentrations of these ginger candies. It is possible due to higher amount of sugar provide more carbon and energy sources than lower amount of sugar. On the other hand, China ginger candy contain more bacterial load than indigenous ginger candy. China ginger candy with 70% sugar solution contain higher amount of total microbial load, but they are not higher than the acceptable level after 4 months of preparation. According to USDA, [35] satisfactory level is $<10^4$ $cfu \cdot g^{-1}$, marginal level $< 10^5$ $cfu \cdot g^{-1}$ and unsatisfactory result $\geq 10^5$, that means these candy was microbiologically safe. Ginger candy without refrigeration or thermal processing in hermetically sealed container, ginger candies remain good condition at least 90 days without fungal growth [36]. But our study shows that there is no fungal growth in these candies after 4 months of preparation.

5. Conclusion

The different sugar solutions have effects on the characteristics of ginger candy *i.e.* on moisture, ash, protein, crude fiber and total sugar content and on color, flavor and texture. The best quality of ginger candy was found with 50% sugar solution. The protein and fat content of candy with 50% sugar solution of indigenous ginger candy was higher among all other candies. The crude fiber and ash content of candy with 50% sugar solution of China ginger candies was higher among all other candies. China ginger candy with 70% sugar solution contains higher amount of sugar among all Ginger candies prepared. The total sugar content of candy with 50% sugar solution was lower than candy with 60% & 70% sugar solution and higher sugar content is not desirable for children and diabetic patient. We know that the higher the water content is, the tendency of the food is damaged more easily, but candy with 50% sugar solution contains less microorganisms than the other candy. Total bacterial count was increased with increasing the concentration of sugar solution for both indigenous and China ginger candy. It was obtained that, sample of indigenous ginger candy with 50% sugar solution was best with lowest microbiological counts, and with no coliform and fungal counts. On the other hand, the color, flavor and texture of China ginger candy with 60% sugar solution were most preferred because the beautiful or unique ginger flavor was still felt; the color was not broken; the taste was sweet enough and texture was more tender. Higher sugar makes the candy darker; aroma was lost, causing shrinkage of the texture, and made the candy more sugary, which is unpopular. This study will help the food producer or the confectionary manufacturer to select the appropriate concentration of sugar solution for making ginger candy and at the same time consumers can reduce the spoilage of ginger by making candy, which is nutritious.

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Competing Interest Statement

The authors declare no competing financial interests.

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