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Shelf Stability and Optimization of Drying Time and Temperature of Guayabano (Annona muricata) Candy

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Abstract

This study was divided into three parts. Part one dealt with the determination of storability ambient conditions of unblended and blended Guayabano candy treated with alum or lime, processed using the fast and slow methods, and oven-dried at 800C. Results showed that the Guayabano candy had a maximum storability of almost 3 weeks. Termination of shelf-life was marked by the presence of molds and accumulation of moisture on product surface. Blended samples were preferred over unblended samples for aesthetic and economic reasons. The latter had nonuniform size and shape and processing incurred wastage due to trimmings. Treatments with alum and lime did not have direct effect on shelf stability. Similarly, extent of processing using the slow and fast methods and final moisture content did not affect shelf stability. The second part aimed to verify part 1 results. The kind of packaging material used in wrapping the products affected shelf stability. Water cellophane was a better moisture barrier compared to Japanese paper. The third part was a preliminary study on the optimum drying times of Guayabano candy dried at either 80 or 900C, an increase in the drying temperature from 80 to 900C did not result in the expected reduction in the number of drying hours due to case hardening. In case hardening, product surface hardened due to high temperature which' served as barrier to moisture migration towards the surface. Desired moisture content that is between 14 to 15 percent was attained after 46 hours of drying but product had a distinct bitter taste and very dark brown color. Acceptable sensory quality was perceived after 38 hours of drying but moisture content was 18.20%. Guayabano candy dried at 900C was preferred more by sensory panelists over the lot dried at 800C. This can be due to the pleasant flavor imparted by the caramelized sugar.

Keywords: Annona muricata, soursop candy, shelf stability, dehydration

Introduction

The soursop or guayabano (*Annona muricata*), a tropical fruit, is a native of West Indies in tropical America (Coronel, 1986). The Spaniards introduced it into the Philippines. It belongs to the family *Annonaceae*. It was the first species in the genus to be described and illustrated. It is a small tree that produces large, irregularly shaped fruits.

The soursop fruits are usually harvested when full-grown and still firm, shiny green or yellowish green in color with the spines set far apart. When picked prematurely, the fruits soften, but will be poor in quality. These are often attacked by birds and bats, or fall to the ground when left to ripen on the tree.

The white flesh of the fruit consists of numerous segments, mostly seedless, and the black pointed seeds are distributed sparsely throughout. At its best, the flesh is creamy white, juicy rather than fibrous, sub-acid and highly nutritious (Coronel, 1986).
The ripe *guayabano* is mostly eaten fresh and ripe, although it can be processed into juice (in cans or tetra packs) ot as concentrates that is best for punches and mixes, as ice cream, preserve, candy, jam and jelly.

Guayabano is a highly perishable crop that deterioration accelerates the moment it is picked from the tree. In the Philippines, the tree is usually grown in backyards. The fruit is used mostly for home and domestic consumption. Poor transport systems, absence of postharvest storage facilities and lack of knowledge on proper handling discourage farmers to have large-scale production of the crop. Long-distance transport cause mechanical damages on the fruit leading to poor interior quality, and rapid microbial contamination. It also facilitates enzymatic and chemical deterioration. However, these problems are usually overcome when the fruit is picked mature firm and handled properly. The fruit is allowed to ripen at ambient conditions. The unripe, mature fruits, however is prone to develop black spots that impart bitter taste and poor texture during ripening. Processing of the unripe mature fruit has been suggested as a method of reducing postharvest losses (Coronel, 1986).

In Davao Oriental, *guayabano* is considered a subsistence tropical fruit crop. Aside from its high peirishability, its value in the market is low when sold as fresh. Some value can be added to it when sold in processed forms such as juices, concentrates, and candies.

Processing of unripe *guayabano* will enhance the market value of *guayabano* as a fruit; enhance nutritive composition of the fruit; improve prices of the raw material which will benefit the farmers producing the crops; and the labor required for processing and marketing provides a source of income for the people directly involved.

A study on the shelf stability of *guayabano* candy dried at 800C, packed and stored at ambient conditions was conducted earlier by Magkidong (2000). This study aimed to verify the previous results. It also aimed to determine the optimum drying times of the product at different drying temperatures and their effect on the shelf stability and sensory properties of the product.

Objectives of the Study

The specific objectives of the study were: a) to determine the shelf stability of the *guayabano* candy dried at 800C in an air-oven, through visual inspection verified by the microbiological analysis on the total plate count (TPC) and yeast and mold count (YMC); b) to determine effects of moisture content, thickness, and packaging material. c) to determine the optimum drying hours; and d) to determine the effect of drying on taste preference, color, texture and general acceptability of the products by the taste panel through sensory evaluation using the 9 point and Hedonic scales, respectively.

Review of Related Literature

Soursop or Guayabano (*Annona muricata*)

The name guayabano or Annona identifies a tree from Antilles and Eastern Coast of Mexico, where it was known in the Aztec as cuahitle and nanahuitle. The migration of the original Spanish forms, guayabano and guayabana, have enriched the Philippine language (Femandez, 1997).

The fruit, a syncarp, is broadly ovoid or ellipsoid, and usuålly irregularly shaped oblique or curved due to improper carpel development. There are several types of soursops; one is guanaba azucaron (sweet) which is eaten raw and used for drinks and guanaba acida (very sour) which is used only for drinks.

It is a common backyard tree particularly in rural areas. In the Philippines, it flowers most months of the year, but flowering peaks in May to June, with the fruits ripening in November and cember (Fernandez, 1997).

Fresh and Processed Guayabano Products

Guayabano of less acidic flavor and less fibrous consistency are cut into sections and the flesh eaten with spoon. The seeded pulp may be torn or cut into bits and added in fruit cups or salads, or chilled and served as dessert with sugar and little milk or cream.

The ripe fruit is easily bruised and punctured and must be handled with care. Finn fruits are held for a few days at room temperature. When eaten ripe they are soft enough to yield to the slightest pressure for one’s thumb. Having reached this stage, the fruit can be held 2 to 3 days longer in refrigerator. The skin will blacken and become unsightly while the flesh is still unspoiled and usable (Morton, 1987).

Food Dehydration

Of all food preservation methods, that of drying foods has received the most widespread and enthusiastic publicity in recent years. Drying is one of the oldest methods of food preservation. Methods used for drying food have become sophisticated over time. Today, the variety of dried fruits and other foods in the marketplace has created a highly profitable industry. For many people, drying food at home is a convenient way to preserve foods.

Food dehydration is a method of preserving food that fits today's lifestyles. Drying food offers one of the most economical and energy-efficient ways of preserving a variety of foods. It is estimated that drying costs less thap canning and one-tenth the cost of freezing. Drying not only preserves foods but also offers new and different nutritious snacks such as dried fruits, fruit rolls and meat jerkies (Tokar, 1997).

The purpose of drying is to preserve food by lowering the amount of water or moisture in the food material to a point where microbial growth (bacteria, yeast and mold) and chemical reactions (enzymatic deterioration) cannot destroy the food during storage. Though drying itself does not destroy enzymes, the dried food (especially pretreated dried food) is considered to be low enough in moisture to prevent enzymatic deterioration. Because drying removes moisture, the food shrinks and decreases in size, becoming lighter in weight and easier to store. If higher temperatures are used, the food cooks rather than dries. When the temperature is too high, the food cooks on the outside and the moisture cannot escape, causing "case hardening" and molding of the food. Low humidity aids the drying process, especially if the food naturally contains a lot of water. To dry food, the water must move from the food to the surrounding air. If the surrounding air is humid, drying of the food will be slowed down. Air currents speed up drying by moving the surrounding moist air away from the food surface and drawing fresh dry air into contact with the food. An oven is ideal for occasional drying of meat jerkies, fruit leathers and banana chips (Wagner et al., 1992).

Osmotic Dehydration

Fruits in general contain more than 75% water and get spoiled very quickly, if not stored properly. Even proper storage fails to preserve the fruits for a long per10d unless these are dehydrated. The osmotic dehydration techniques not only enable the storage of the fruits for a longer period, but also preserve flavor, nutritional characteristics ang prevent microbial spoilage. Osmotic dehydration can remove 50% of the water from fresh ripe fruits (e.g., bananas, mangoes. apotas, papayas, apples and other tropical fruits). In osmotic dehydration, the fruits are subjected to osmosis by dipping or spreading them in aqueous sugar syrup under specific conditions so that the water from the fruits migrates to sugar syrup. Major dehydration of the fruit takes place in this process step.

Determining Dryness of Fruit

Drying food is a slow process. Drying time depends on type of food, thickness and type of dryer. Speeding up the drying time by increasing the temperature ends up in "case hardening". While the food may appear dry on the outside, it can be moist on the inside. Moisture left in the food will cause the food to mold. One must look, feel and taste the food to determine its dryness. When the food has cooled, it is cut through the center of the thickest part. There should be no visible signs of moisture. A darker, wet interior indicates the need for extended dehydration. To test for doneness, a piece of food is removed during the end of the drying period and cooled to room temperature. Dried fruit is pliable, springy and will not stick together if folded. Fruit peels away from plastic wrao (Wagner et al., 1992).

Packaging and Storing of Dried Fruit

Dried foods must be properly stored to maintain low moisture content and to prevent microbial deterioration. Before packing the foods, the dried pieces are cooled. Immediately after the product has cooled, the food usually are equilibrated for 5 to 10 days before storing by placing food in a covered container and rechecking each day to see if the. product is sufficiently dw•, if not, the food is further dehydrated. Storing of dried foods is done by packing them in clean, dry, insect-proof containers as tightly as possible. A recommended dry storage method is to place the dried food in plastic bags, press out air, seal or close and place in tightly sealed glass jars. Packaged dried food should be stored in a dry; cool place at about 60 OF (Wagner et al., 1992).

Materials and Methods

Shelf stability of blended and unblended *guayabano* candy treated with alum or lime and processed using the slow and fast methods

This experiment consisted of 8 experimental treatments with. treatments 1, 3, 5, and 7 as blended and treatments 2, 4, 6 and 8 as unblended (Table 1).

Table 1. Amount of ingredients used for each treatment per 1 kilogram *guayabano* pulp

Ingredient	Treatment			
	1 and 2* (slow method)	3 and 4* (slow method)	5 and 6* (slow method)	7 and 8* (fast method)
Guayabano pulp (kg)	1.0	1.0	1.0	1.0
Refined sugar (g)	725.8	725.8	725.8	725.8
Alum (g per liter of water)			2.1	10.5
Lime (g)	-	5.3	-	-
Cornstarch (g) (for blended treatments)	63.0	63.0	63.0	-
Water for syrup (liter)	1.0	1.0	1.0	1.0

* = unblended *guayabano* pulp

Treatments 1 and 2 served as control; treatments 3 and 4 were treated with lime; treatments 5 and 6 were treated with alum; while treatments 7 and 8 were treated with alum using five times the amount used for treatments 5 and 6. Treatments 1 to 6 were processed for one week (slow method), while treatments 7 and 8 were processed for one day (fast method). The fast method involved processing or cooking of *guayabano* pulp until syrup is. slightly viscous, followed by blending, and then drying. Several days, of soaking-cooking in syrup done in the slow method was eliminated in this method. All treatments were dried at 80^{0}C for about 32 hours in a mechanical air-oven dryer.

All samples were wrapped in Japanese paper (0.04 mm) and packed in polyethylene (PE) bags (0.06 mm).

Shelf stability of *guayabano* candy, wrapped in water cellophane, packed in polyethylene bags, and stored at ambient conditions

The second part of this study attempted to validate previous results on storability of *guayabano* candy held at ambient temperature. Unripe *guayabano* pulp was processed using the fast method as recommended by Magkidong (2000). The samples were treated with alum and processed using the slow method. Initial and final moisture content, thickness, and percentage shrinkage were monitored. The candies were divided into two lots with one lot wrapped in Japanese paper and the other in water cellophane. Microbial analysis was done initially after processing, and for each batch during the 3rd and 4th week of storage.

Optimization of drying time and temperature of blended *guayabano* pulp treated with alum and dried at 80 and 90^{0}C

Unripe *guayabano* treated with alum was processed using the fast method. This was divided into two treatments, one subjected to 80^{0}C (Treatment 1). A 32 —hour drying was adapted from Magkidong (2000). Treatment 2 was subjected at 90^{0}C for more than 50 hours.

General Preparation and Processing

Figure 1 shows the schematic diagram for the preparation of *guayabano* candy. Mature unripe, *guayabano* fruits were washed, weighed, and peeled. The peeled *guayabano* was sliced and seeds were removed with a knife. Each fruit was further cut into smaller pieces and soaked either in lime solution (5.3g/l water) or in alum (10.5g alum/l water) for 15 to 20 min. Guayabano for unblended treatment was further sliced to about % of an in in thickness and approximately 1 in in length. After soaking in lime or alum solution, the pulp was thoroughly washed with water and drained. Syrup containing 2 cups (ca 725.8 g) white sugar in 1 1 water was prepared. The sliced *guayabano* was cooked in syrup in slow fire until syrup was slightly sticky. The cooked *guayabano* was allowed to cool at room temperature and blended until a very fine and homogenous consistency was attained. About 12 tsp (ca 63 g) of cornstarch per kg of raw pulp was added into the blended *guayabano* and was further cooked until the mixture was very sticky and slightly dry. The blended and unblended *guayabano* were spread in brownie pans made of aluminum foil and dried at 80^0c for about 32 hours. Drying was monitored until the *guayabano* slabs (blended) were dry enough and became pliable and leathery. Sufficient dryness w.as also determined visually when interior of sample was no longer moist and sample no longer adhered to the pan when removed. The dried slabs were cooled and sliced to the desired size, approximately about 1 and 2 in. in length and width. Each piece was coated with confectioner's sugar and individually wrapped in either Japanese paper or water cellophane. The finished product was packed in polyethylene bags, sealed with an electric sealer and stored at ambient conditions until the onset of spoilage. Presence of molds and moisture were used as indices for product spoilage.

Sensory Evaluation

Sensory evaluation was carried out to determine the acceptability of the products using standard procedures (Gatchalian, 1989). A 3-digit code number was assigned to each sample and presented to the panelists, The sensory evaluation was conducted using the 9-point Hedonic scale and 9-point scale, The 9-point scale was used in the evaluation of the product in terms of color and texture. Hedonic scale was used to determine general acceptability. Samples from different treatments were presented to 10 to 15 panelists.

Moisture Content

About 12-15 g of sample for each treatment was placed in aluminum foil and subjected to an air oven dryer along with the sample in trays. The initial moisture of the samples prior to drying was determined. About 2.0 g of blended *guayabano* candy was placed in a pre-weighed and pre-dried aluminum foil. Each sample was prepared in triplicates and subjected to 65 0 C for 2 days until weight became constant. The foils were dried together with the samples in the tray at different time increments (Cagampang and Rodriguez, 1991).

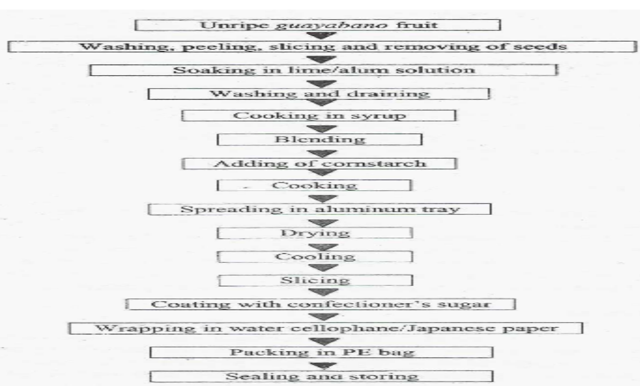

Figure 1. Process flow in the preparation of *guayabano* candy

Microbial Analysis

Approximately 5 g of sample from each treatment was aseptically macerated and added in 0.1% diluent (peptone broth) to obtain an initial 1:10 dilution. One ml from the initial dilutions was transferred to 9 ml diluent to obtain 1: 100 dilutions. From the first dilution (1:10), 1 ml was inoculated in the petri-dish and about 10-15 ml of molten agar medium at 45^0C was added. The medium and inoculum were immediately mixed, allowed to set, inverted and incubated at the appropriate temperature. Plates for Total Plate Count were incubated for 1 day and 2 days for yeast and mold at $30\text{-}35^0$C (Raymundo et al., 1991).

Statistical Treatment

The experiment was arranged in randomized complete block design (RCBD) (Amerine et al., 1965). Duncan's Multiple Range Test (DMRT) at p = 0:05 was used to determine the differences among treatment means.

Results and Discussion

Shelf stability of blended and unblended *guayabano* candy treated with alum or lime and processed using the slow and fast methods, dried at 800C and stored at room temperature

Moisture Content. Moisture content of each treatment was monitored before and after drying. Values were significantly different among treatments (Table 2). This can be attributed to varying lengths of cooking times for the blended samples and non-uniformity of thickness for the unblended samples. Treatment 5 (blended, with alum) processed for one week had the highest initial moisture content while Treatment 2 (unblended, control) had the lowest. Moisture content of samples after drying, however, was only significantly different between the blended and unblended samples. Blended samples had higher moisture values than the unblended samples. The thinner yet non-uniform slices of unblended *guayabano* pulp allowed faster migration of water from the interior to the surface of the product.

Table 2. Mean % moisture, thickness, and % shrinkage of blended and unblended *guayabano* candy dried at 80°C

Treatment	% Moisture Content Before Drying	% Moisture Content After Drying	Thickness Before Drying (mm)	Thickness After Drying, (mm)	% Shrinkage
1-blended (control)*	43.01 *bcd*	27.05 *a*	14.43 *b*	12.16 *a*	21.51 *c*
2- unblended (control) *	39.37 *d*	11.52 *b*	13.00 *bc*	8.55 *cd*	36.46 *a*
3-blended, treated w/ lime*	40.00 *cd*	24.03 *a*	14.54 *a*	11.64 *a*	20.66 *c*
4-unblended, treated w/ lime*	43.43 *bcd*	9.12 *b*	13.49 *ab*	8.5 *cd*	37.98 *a*
5-blended, treated w/ alum*	50.78 *a*	27.20 *a*	12.67 *c*	9.29 *bc*	29.37 *b*
6-unblended, treated w/ alum*	46.69 *ab*	11.20 *b*	12.97 *bc*	7.91 *d*	39.9 *a*
7-blended, treated w/ alum**	45.31 *bc*	26.78 *a*	14.54 *a*	10.30 *b*	31.9 *b*
8-unblended, treated w/ alum**	44.12 *bcd*	10.16 *b*	12.93 *c*	8.20 *cd*	39.11 *a*

Mean scores within a column with common letters do not differ significantly at 5 % level of significance using DMRT

* processed using the slow method

** processed using the fast method

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Thickness and Shrinkage. The thickness before and after drying varied significantly among treatments. The desired uniform thickness aud size of the products were not attained due to the absence of processing eqyipment and facilities such as pulp slicer. This led to so much waste due to trimmings from sliced unripe guayabano pulp. Wastage, however, was minimized by blending the pulp. Blending, also allowed minimal work during preparation of samples for drying. Thickness after drying, however, did not significantly differ among treatments. 2, 4, 6, and 8 (unblended samples) but varied significantly among blended samples except for treatments 1 and 3. Percentage of shrinkage after drying was not significantly different among unblended samples with values higher than that of blended samples. Higher rate of shrinkage was brought about by higher moisture removal during drying. Shrinkage of blended samples, however, varied significantly between treatments 1 or 3 and 5 or 7.

Microbiological analysis. Spoilage of the samples was determined visually by presence of molds which was usually followed by the accumulation of moisture on product surface. Shelf-life of all treatments except treatment I and 5 was approximately 2 weeks. Treatments 1 and 5 had 3 weeks (Table 3). Total plate counts of treatments 2 and 4 were significantly higher compared to other treatments. The yeast and mold count (YMC) which was highest in Treatment 2 did not significantly differ among the other treatments. Treatments using alum and lime did not have a significant effect on lowering the microbial load and improving the storability of the products.

Visible mold growth was observed on *guayabano* candy wrapped in Japanese paper after the 4 weeks of storage with TPC of 2.3x102 colony forming unit (CFU) per gram sample and YMC of 5 CFU/g sample (Table 4).

The onset of spoilage in *guayabano* candy wrapped in water cellophane was observed after the 5th week of storage with TPC of 3.76x102 CFU/g sample and YMC of 10 CFU/g sample. Samples wrapped in water cellophane had longer storability than samples wrapped in Japanese paper. Accumulation of moisture on product surface was also evident on samples wrapped in Japanese paper. In this experiment, the wrapping materials had a direct effect on storability of the product. Water cellophane seemed to be a better barrier against external moisture and contamination than Japanese paper which encouraged moisture absorption on product surface. Proper sanitation and thorough cleaning of food contact surfaces during preparation and processing, holding time prior to packing, and packing of products are critical areas where cross contamination usually occurs. Initial microbial load is increased upon contact with insufficiently cleaned contact surfaces and no amount of processing will lead to a satisfactory decrease in spoilage microorganisms without compromising product quality. Longer holding time during product cooling and packaging also serve as incubation period for growth of vegetative bacteria and mold (Frazier, 1988).

Table 3. Approximate shelf-life, total plate count (TPC) and yeast and mold count (YMC) of blended and unblended *guayabano* candy dried at 80 °C and stored at room temperature

Treatment	Shelf-life (week)	Microbiological Analysis (CFU/g sample)	
		Total Plate Count	**Yeast and Mold Count**
1-blended (control)*	3	3.97×10^2 *b*	1.5×10^1 *b*
2- unblended (control) *	2	1.71×10^5 *a*	1.75×10^2 *a*
3-blended, treated w/ lime*	2	2.70×10^4 *b*	2.0×10^1 *b*
4-unblended, treated w/ lime*	2	1.44×10^5 *a*	3.5×10^1 *b*
5-blended, treated w/ alum*	3	1.31×10^3 *b*	5.0×10^{-1} *b*
6-unblended, treated w/ alum*	2	1.38×10^4 *b*	1.5×10^1 *b*
7-blended, treated w/ alum**	2	5.64×10^3 *b*	1.0×10^1 *b*
8-unblended, treated w/ alum**	2	1.12×10^4 *b*	1.5×10^1 *b*

Mean scores within a column with common letters do not differ significantly at 5 % level of significance using DMRT

* processed using the slow method

** processed using the fast method

Table 4. Microbiological analysis using total plate count (TPC) and yeast and mold count (YMC) of *guayabano* candy dried at 80 °C and wrapped in Japanese paper and water cellophane

Week	Microbiological Analysis CFU/g sample			
	Total Plate Count		**Yeast and Mold Count**	
	Japanese paper	**water cellophane**	**Japanese paper**	**water cellophane**
0	0 *b*	0 *b*	0 *b*	0 *b*
3	0 *b*	0 *b*	0 *b*	0 *b*
4	2.3×10^2 *a*	0 *b*	5.0×10^0	0 *b*
5		3.76×10^2 *a*		1.0×10^1

Mean scores within a column with common letters do not differ significantly at 5 % level of significance using DMRT

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Optimization of drying time and temperature of blended *guayabano* pulp treated with alum and dried at 80 and 90^{0}C

Drying at 80^{0}C was prolonged for more than 50 hours and moisture loss was constantly monitored. In Figure 2, the rate of moisture loss at 80^{0}C was faster during the first 24 hours of drying. A slower rate occurred after 24 hours until the end of the drying period. Moisture contents of 14 to 15 percent is already acceptable to prevent or greatly delay mold growth (Frazier, 1988). A moisture content of 13.63% was attained after 32 hours of drying at 80^{0}C (Table 5). An attempt to decrease the drying hours considered a much higher temperature (i.e., 90^{0}C) for T2. Drying at 90^{0}C showed an accelerated moisture loss during the first 17 hours, followed by a slower rate, and a faster rate after 36 hours of drying until the end of the drying period. Drying at this temperature, however, resulted in longer drying hours and an acceptable moisture content of between 14 to 15 % was achieved after 46 hours of drying but color of the sample was already very dark brown with a bitter taste. Burnt flavor was not yet detected, after 38 hours of drying, however, moisture of 18.20% was obtained.

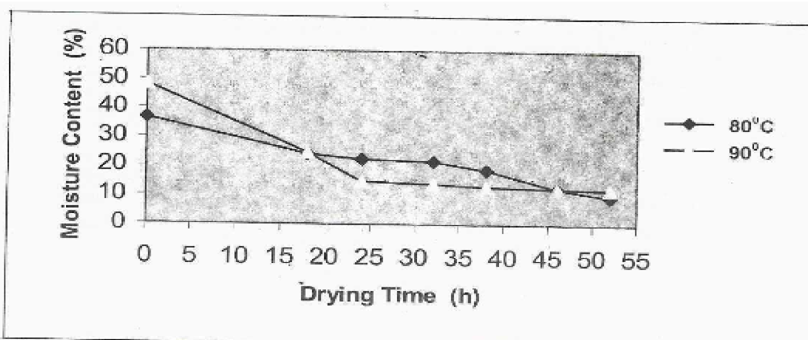

Figure 2. Moisture loss of *guayabano* candy dried at 80 and 90°C

Table 5. Mean % moisture content, thickness and % shrinkage of *guayabano* candy treated with alum and dried at 80 and 90 °C

Drying Temperature (^{0}C)	% Moisture Content Before Drying	% Moisture Content After Drying	Thickness Before Drying	Thickness After Drying	% Shrinkage
T1-80	48.22	13.63	14.54	10.30	29.13
T2-90	36.62	18.20	14.99	10.98	26.80

Table 6. Mean scores on color, flavor, texture and general acceptability of *guayabano* candy dried at 80 and 90°C

Drying Temperature (^{0}C)	Sensory Attribute			General Acceptability
	Color	Flavor	Texture	
T1-80	2.09	4.98	5.49	7.07
T2-90	6.58	6.05	3.58	7.29

Sufficient dryness *guayabano* candy determined visually was characterized by a pliable and leathery texture, non-sticking in pan when removed, and absence of moisture when cut.

Candies dried at 90^0C had more pronounced sweetness than those dried at 80^0C. This can be due to the increase in concentration of sugar brought about by the drying effect. Caramelization of sugar by high temperature and longer drying hours imparts a dark brown color on T2 with a mean score of 6.58 as evaluated by panelists while that of T1 was near to light brown (2.09) as shown in Table 6. Texture of T2, however, was between soft and moderately soft (3.58) while that of Tl was moderately soft (5.49). Soft texture ofT2 can be attributed to the enhanced gelatinization of starch by the baking effect achieved at 90^0C drying temperature. Both samples were moderately liked with slight preference on T2 over T 1. The low rate of moisture loss at 90^0C drying was may be attributed to case hardening where surface hardens due to excessive high temperature while inner part remains soft. The hardened surface serves as a barrier for water to migrate into the surface, thus, leaving the inner part still moist.

Summary and Conclusions

Guayabano fruit is usually eaten ripe due to its pleasant sweetness (with sourness in other varieties) and creamy soft texture. However, this is not as valued and marketed as heavily as the other fruit crops such as mango, banana and pineapple. It is sometimes left on the tree to rot or be devoured by pests and birds prior to falling. Available technology allows processing of the ripe fruit into various products such as concentrates, purees, juice, etc. However, the fruit tends to develop defects as it ripens, especially when it is off season, so that good quality ripe fruit intended for processing is seldom available. An attempt to enhance marketability of the product even during off-season was done by utilizing the unripe mature fruit.

In this study, mature unripe *guayabano* was processed -into candy and storability and optimum time/temperature were determined based on the retention of good sensory attributes.

Storability *guayabano* candy was almost 3 weeks. Termination of shelf-life was-marked by the presence of molds and accumulation of moisture on product surface. Blended samples were preferred over the unblended samples due to high wastage incurred due to trimmings of the latter. Visual assessment of unblended sample was poor due to non-uniformity of size. Treatments with-the use of lime and alum did not have a direct effect on product storability. Longer processing by plumping in concentrated sugar solution and cooking did not guarantee longer shelf-life Final moisture retention also did not have a direct correlation on rate of spoilage, (i.e., lower moisture retention value of dried products does not mean longer shelf-life).

For the second part of the study, mature unripe *guayabano* candy treated with alum was processed using the fast method, dried at 80^0C, and stored at room temperature. Storability was improved. Effect of wrapping materials is singled out as a factor affecting shelf-life. Water cellophane is a better barrier against moisture and microbial contamination from the environment. Japanese paper allowed more rapid accumulation of moisture on product surface after prolonged storage at room temperature.

Drying for 30 to 35 hours at 80^0C with a ‘thickness of 12 to 15 mm is sufficient to achieve final moisture of 10-15 % that would kill pathogenic and some spoilage microorganisms. Drying at 90^0C improved texture, palatability due to enhance color, and acceptability of *guayabano* candy, however, moisture removal is longer due to the baking effect of high temperature on starch. Starch. tends to gelatinize at certain high temperature and water molecules are trapped into its matrix leading to inhibited water migration from the interior to the product surface. This condition is also exhibited when vase hardening occurs. Case hardening is a phenomenon where product surface hardens due to high drying temperature while interior is still soft. Hardened surface serves as barrier to moisture migration into the product surface (Wagner, et al., 1992).

Recommendations

This study recommends further evaluation on other processing methods as well as on the present dehydration process for the improvement of product storability. Use of other inexpensive packaging materials may be considered to improve stability and aesthetic value products. Verification study is also needed on the optimization of drying time and temperature to lower energy cost due to long hours of drying while maintaining desirable product sensory quality. Enhancing of flavors and improving nutritional quality of *guayabano* candy can be adapted by blending with fruit flavor or fruit bits (e.g., mango, tamarind, pineapple etc.) and fortifying with vitamin C and other vitamins.

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