
**PROCESS STANDARDIZATION, PRODUCT EVALUATION AND SHELF LIFE
DETERMINATION OF DRAGON FRUIT JAM, JELLY PUREE AND JUICE**

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ABSTRACT

Protocols for the production of acceptable and profitable dragon fruit jam, jelly, puree and juice were established. Results of experiments indicated that the different types of peel damage in dragon fruits such as peel burns, cured scars, spots and dried scales are acceptable for processing into fruit jam, jelly puree and juice. No critical limits for moisture content, total soluble solids and pH for in-coming raw materials were set since it was found that as long as all physical requirements/specifications of peel-damaged fruits are met, the fruits are acceptable for processing. Nutritional values of each of the products in terms of moisture, ash, fat, carbohydrate, protein, sugar and sodium contents, Kcal of energy, pH and titratable acidity were determined for product labelling purposes. Yeast and mold count of all dragon fruit products was maintained at 0 count for a period of eight months. Results of consumer evaluation clearly indicate that all dragon fruit products are very acceptable. The generated technology for the production of dragon jam, jelly, juice and puree developed new products which are proven to have high consumer acceptability and can provide additional income. Since the project was already on its pilot scale, it is being recommended for technology transfer for possible commercialization of the potential technology adopters.

Keywords: Pitaya, Phytoalbumin, Jam, Jelly, Juice, Puree, Microbial Count, Sensory Property, Proximate analysis

INTRODUCTION

Pitaya is the common name of the dragon fruit, *Hylocereus undatus* (Haw.) Britton and Rose. It is also called “dragon fruit” because of the bright pink to red, green tipped overlapping scales covering the fruit. The fruit has been considered the most beautiful among the cactus family. It is rich in fiber, vitamin C and minerals. It is also rich in phytoalbumins known for its antioxidant properties. The fruit can be eaten as dessert, juice, cocktails and ice cream mix ingredients. In the Philippines, especially in Cavite, it is a newly introduced fruit which is now gaining popularity. At present, the area planted with the fruit in Cavite has been increasing because of its commercial value.

Commercial and backyard farms in Cavite can produce as much as 25 tons per hectare (Silan, 2007). The fruit is highly seasonal and the harvest season starts from April while peak season is from August to September. Despite increasing volume of harvest, the fruits have been plagued by piercing and sucking insects causing unsightly damage to the fruit peel with the flesh still intact. Consequently, this damage rendered the fruit unmarketable due to unattractive appearance. Farmers claimed that about 35% of the total yield is lost due to this damage. In addition, the fruit is non-climacteric (TFNet, 2004) and does not undergo normal ripening after harvest, as most fruits do, and could not, therefore, be stored at ambient temperature for more than ten (10) days (Zee et al., 2004). Thus, at peak of harvest, there is a market glut and surplus is wasted.

The high loss due to the seasonality of fruiting and peel damage suggest that processing techniques should be developed to keep the product available throughout the year and make use of the flesh from damaged fruits.

This prompted the researchers of Cavite State University to come up with a project on the development of products from peel-damaged and excess fruits during the peak season. These products had undergone sensory evaluation, microbial analysis and proximate analysis. Appropriate packaging and label for dragon fruit processed products was also developed (Tepora et.al, 2009). However, there is still a need to standardize the process, determine the shelf-life of the products, identify potential problems during mass production of these products.

MATERIALS AND METHODS

A. Process Standardization

1.1. Raw material specification. Initial experiments have identified the tolerable degree of severity of fruit damage for processing. Defects were classified and possible effects of the damage to processed products were evaluated on laboratory scale. Determination of sensory properties, microbial properties and physical properties of the experimental samples for jam, jelly, juice and puree was done following the process implemented in the previous study.

Specifications for raw materials were established for each type of product. Moisture content, total soluble solids and titratable acidity of incoming fruits were determined. Variability of values for these parameters was noted and tolerable limits were identified based on the properties of the corresponding products.

1.2. Process specification. The dragon fruit jam, jelly, puree and juice were mass produced based on the laboratory formulation developed on a laboratory scale. After setting the raw material specifications, up-scale formulation, cooking conditions in terms of time, temperature and processing equipment was established. Process specifications from washing, peeling, pulp preparation, juice extraction, mixing of ingredients, heating, filling into containers, processing,

exhausting, sealing, labeling and storing with the implementation of Good Manufacturing Practices (GAP) was established.

Washing method. Different washing methods were evaluated. Efficiency of washing treatments such as 1) tub washing with untreated and chlorinated water by batch, and 2) continuous washing in running water with treated and untreated water were evaluated. Microbial load of fruit surface was determined using standard plate count (SPC) method.

Peeling, pulp preparation and juice extraction methods. The manner of peeling and holding time during pulp preparation and juice extraction was established so as not to allow significant physical, chemical and microbial changes prior to actual cooking. These conditions had specified the manageable production volume per batch in pilot testing. Peeling was done by halving, quartering with stainless steel knife and peeling off by hand on a per fruit basis (one fruit peeled before cutting another).

Three juice extraction methods were used: T1-pressing through cheese cloth, T2-standing blended pulp for 6-24 hrs to let pulp float and T3-using electric juice extractor .

Ingredient formulation and mixing. Up-scale ingredient formulation based on laboratory formulation generated by the previous study. Adjustment was made whenever significant deviation from the standards occur. Moisture, acidity and soluble solid adjustments was specified in each product.

Processing condition. Time and temperature of processing by batch was specified. Cooking time should conform to set commercial process standards to attain the recommended shelf-life for fruit jams, jellies, purees and fruit juices.

Filling, exhausting and sealing. Filling temperature, fill weights and filling process and headspace allowance was specified for each of the products. Exhausting time and temperature to create vacuum was specified.

B. Product Evaluation and Shelf-life Determination

2.1. Proximate Analysis. Moisture, ash, total fat, total carbohydrates and protein of dragon fruit jam, jelly, puree and juice blend was conducted at the Food and Nutrition Research Institute in addition, pH, energy, total reducing sugar and titratable acidity was also determined.

2.2. Microbiological Tests. Yeast and mold counts were determined in the laboratory. All products were serially diluted up to 10^{-2} dilutions. One millimeter of the dilutions were plated on Nutrient Agar (NA) for bacterial count determination and Potato Dextrose Agar (PDA) for the growth of yeast and mold count determination. The colonies were counted and the colony-

forming units per millimeter (cfu/ml) were determined after incubation for 24-48 hrs (NA plates) and 5 days (PDA plates) at room temperature.

2.3. Sensory Evaluation. The products were subjected to sensory evaluation by trained panelist using prepared score sheets with the corresponding scale. The products were evaluated based on sensory attributes such as: color, texture, sweetness, clarity, viscosity, dragon fruit flavor, off-flavor and general acceptability.

2.4 Determination of Product Acceptability. The finished products were subjected to evaluation by at least 100 consumer panels to determine degree of product acceptability. Results of the consumer acceptability were presented using mean and standard deviation.

RESULTS AND DISCUSSION

Process Standardization

1.1 Raw Material Specification

1.1.1. Effect of peel-damage to sensory properties of dragon fruit products

Peel defects of dragon fruits were classified as peel burns, scars with hardened area, spots and spots with dry scales. No significant difference in sensory properties of dragon fruit jam was manifested among dragon fruit jam samples produced from peel-damaged dragon fruits (Table 1). This would indicate that the different types of peel damage in dragon fruits did not affect the quality of pulp responsible for the sensory properties of dragon fruit jam. The thick peels of dragon fruit could have protected the pulp from any damage or deterioration even if peel abnormalities and defects were observed on the surface of dragon fruits peels.

Table 1. Mean sensory scores for dragon fruit jam produced from peel-damaged fruits

ATTRIBUTE	FRUIT DEFECT			
	A Peel burns	B Scars with hardened area	C Spots	D Spots with dry scales
Color	1.9	1.9	1.8	1.8
Texture	2.7	2.8	2.6	2.7
Sweetness	2.5	2.4	2.5	2.6
Flavor	2.8	2.8	2.7	2.8

Off-flavor	1.3	1.2	1.4	1.3
General Acceptability	3.5	3.3	3.4	3.4

n=10

Mean scores within rows are not significantly significant at 5% level

Scoring scale:

Color : 1=brown to 5=yellow

Texture: 1=very soft to 5=very hard

Sweetness: 1=not sweet to 5=extremely sweet

Dragon fruit flavor: 1=imperceptible to 5=extremely perceptible

Off-flavor: 1=imperceptible to 5=extremely perceptible

General acceptability: 1=unacceptable to 5=extremely acceptable

The same results were observed in dragon fruit jelly, juice and puree (Tables 2-4).

Table 2. Mean sensory scores for dragon fruit jelly produced from peel-damaged fruits

ATTRIBUTE	FRUIT DEFECT			
	A Peel burns	B Scars with hardened area	C Spots	D Spots with dry scales
Color	1.9	1.8	1.9	1.8
Clarity	3.3	3.4	3.4	3.5
Texture	1.8	1.8	1.9	1.8
Sweetness	4.0	3.9	4.0	3.8
Flavor	1.8	1.9	1.7	1.7
Off-flavor	1.2	1.2	1.3	1.1

General Acceptability	3.8	3.9	3.7	3.9
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n=10

Mean scores within rows are not significantly significant at 5% level

* scoring scale is the same as in previous tables

Table 3. Mean sensory scores for dragon fruit juice produced from peel-damaged fruits

ATTRIBUTE	FRUIT DEFECT			
	A Peel burns	B Scars with hardened area	C Spots	D Spots with dry scales
Color	3.8	3.9	3.7	3.8
Texture	2.6	2.8	2.7	2.5
Sweetness	2.9	3.0	3.1	3.0
Flavor	2.3	2.4	2.5	2.5
General Acceptability	3.5	3.7	3.7	3.6

n=10

Mean scores within rows are not significantly significant at 5% level

* scoring scale is the same as in previous tables

Table 4. Mean sensory scores for dragon fruit puree produced from peel-damaged fruits

ATTRIBUTE	FRUIT DEFECT			
	A Peel burns	B Scars with hardened area	C Spots	D Spots with dry scales
Color	3.9	3.8	4.0	3.8
Texture	3.5	3.6	3.4	3.6
Sweetness	3.5	3.4	3.6	3.5
Flavor	3.2	3.1	3.3	3.2
General Acceptability	3.6	3.5	3.7	3.6

n = 10

Mean scores within rows are not significantly significant at 5% level

Fruits adversely damaged with open cracks and cuts in dragon fruit were found unacceptable for processing due to very perceptible acidic fermented odor of the fruit. Dragon fruits with cracks and cuts are not considered suitable for processing.

Any other abnormal defects in the pulp such as rotting, softening, hardening, presence of insect eggs and maggots, automatically served as basis for rejection of raw fruit materials for processing.

1.1.2. Physico-chemical requirements for raw materials

No critical limits for moisture content, total soluble solids (TSS) and pH of raw material were set since it was found that as long as all physical requirements/specifications of peel-damaged fruits are met, the fruits are acceptable for processing. Since there are technologically acceptable means of adjusting and maintaining total soluble solids and acidity levels of fruit materials during processing, no critical limits for the two parameters were set. Likewise, no critical limits for moisture and pulp content were set, considering that it is the aim of the processing technology to maximize the use of whatever juice and pulp the peel-damaged fruits contain. As long as the physical requirements are met, no limitations are set for moisture and pulp contents of peel-damaged fruits used as raw materials.

1.2 Process Specification

1.2.1 Washing method. Tub washing of dragon fruits with either tap or chlorinated water was not able to reduce microbial load of peel surfaces below standard limit (Table 5). Washing of dragon fruits in running tap water was able to reduce microbial counts of peel surfaces of dragon fruits below standard limit. The most effective washing method is by washing the fruit first in running water and later dipping in 100 ppm chlorinated water for 15 min.

Washing in running water can be an acceptable washing method, provided that quality of tap water is always ensured. Quality of washed fruits, on the other hand, can always be assured by initially washing descaled dragon fruits in running water and then dipping in chlorinated water (100 ppm) for 15 min.

Table 5. Average plate counts of fruit peel surfaces washed with different methods

WASHING METHOD	CFU/cm ²
T1 - Tub washing with tap water	> 1.0 x 10 ³
T2 - Tub washing with chlorinated water, 100ppm	> 1.0 x 10 ³
T3 - Washing in running tap water	4.6 x 10 ²
T4 - Washing in running water and dipping in chlorinated water (100ppm) for 15 min	1.7 x 10 ²

*Standard limit for yeast and molds = less than 1.0 x 10³ cfu/ cm²

1.2.2. Peeling, pulp preparation and juice extraction

Pressing blended pulp and filtering through cheese cloth manually appeared to take so much time, inefficient, less hygienic and may encourage contamination during extraction. Standing of blended pulp for a period of time facilitated easy separation of pulp and juice as the pulp was easily scraped on top of the mixture. The method, however, may allow fermentation of the mixture which can affect sensory properties of products.

Extraction of juice by an electric extractor facilitated faster juice extraction, was less labor intensive and can be best used for commercial processing (Table 6).

Table 6. Juice and pulp yield of different juice extraction methods

TREATMENT	JUICE YIELD, %	PULP YIELD, %	TIME DEVOTED TO EXTRACTION, hr/40kg fruits
T1 – pressing through cheese cloth*			
T2 – standing for 6-24 hrs	43.9	56.0	6-24
T3 – electric juice extractor	71.4	28.5	1

* discontinued, process considered not feasible

1.2.3. Ingredient formulation and mixing

1.2.3.1 Jam and Jelly. The maximum manageable production volume per production batch for jam and jelly is 20 kg. Formulation used was 1 part extracted pulp to 1 part sugar, 1% (of total mixture) gelatin and 1% calamansi concentrate. Food color was added at the rate of 10 g red and 5 g violet food color per 5 kg pulp.

1.2.3.2. Juice and Puree. Dragon fruit juice and puree were produced at 25 kg fruit per production batch. To conform to basic commercial standards for fruit juices, dragon fruit juice was formulated using 1:1 water to juice ratio, Total Soluble Solids was adjusted to 12°Brix with addition of sugar, pH was adjusted to 3.5-4 by addition of citric acid, and 0.1% (of total volume) sodium benzoate was added. For dragon fruit puree, TSS of juice was adjusted to 15°Brix with refined sugar, pH was adjusted to 3.5-4 by addition of citric acid and 0.1% (of total volume) sodium benzoate was added.

1.2.4. Cooking

1.2.4.1. Jam and Jelly. Forty-five minutes under medium fire is the normal cooking time for fruit jams. As adopted, it efficiently and effectively preserves the fruit as indicated by the results of shelf-life determination. The cooking condition also resulted to acceptable sensory and microbiological properties of the jam and jelly produced.

1.2.4.2. Juice and Puree. Pasteurization of dragon fruit juice and puree at 85°C for 15min was able to preserve the products as indicated by their microbial properties and by the results of shelf-life determination.

1.2.5 Filling and Sealing. Basic hot filling and sealing techniques with high degree of sanitation and hygienic practices were adopted. A half-inch allowance for headspace for jam and jelly was used, while ¾ inch headspace allowance was adopted in juice and puree.

Product Evaluation and Shelf-life Determination

2.1. Proximate Analysis and Nutritional information

Sample of dragon fruit jam, jelly, puree and juice was submitted to Food and Nutrition Research Institute (FNRI) for analysis (Table7).

Dragon fruit Jam. The dragon fruit jam contains 11.9% moisture, 0.6% ash, 356 Kcal of energy, 1.2% fat, 83.9% carbohydrates, 2.4% protein, and 68.8% sugar. It also contains 32 mg of sodium and has a pH of 4.7.

Dragon fruit Jelly. Dragon fruit jelly contains 11.3% moisture, 0.6% ash, 352 Kcal of energy, 0.0% fat, 87% carbohydrates, 1.1% protein, and 80.1% sugar. It also contains 12 mg of sodium and has a pH of 4.0.

Dragon fruit Puree. Dragon fruit puree contains 83.1% moisture, 0.3% ash, 66 Kcal of energy, 0.0% fat, 16.4% carbohydrates, 0.2% protein, and 13.3% sugar and 0.2% titratable acidity. It also contains 32 mg of sodium and has a pH of 4.8.

Dragon fruit Juice (Clear). Dragon fruit juice (clear) contains 89.5% moisture, 0.3% ash, 41 Kcal of energy, 0.0% fat, 10.2% carbohydrates, 0.0% protein, and 8.7% sugar and 0.1% titratable acidity. It also contains 27 mg of sodium and has a pH of 4.9.

Dragon fruit Juice (Pulpy). Dragon fruit juice (pulpy) contains 90.7% moisture, 0.3% ash, 36 Kcal of energy, 0.0% fat, 8.9% carbohydrates, 0.1% protein, and 7.5% sugar and 0.1% titratable acidity. It also contains 24 mg of sodium and has a pH of 4.9.

Table 7. Nutritional composition of dragon fruit jam, jelly, puree and juice

ANALYTE	PRODUCTS				
	JAM	JELLY	PUREE	JUICE (CLEAR)	JUICE (PULPY)
Moisture, g	11.9	11.3	83.1	89.5	90.7
Ash, g	0.6	0.6	0.3	0.3	0.3

Energy, kcal	356	352	66	41	36
Total fat ,g	1.2	0	0	0	0
Total carbohydrate,g	83.9	87	16.4	10.2	8.9
Protein,g	2.4	1.1	0.2	0	0.1
Total sugar,g	68.8	80.1	13.3	8.7	7.5
Titrateable acidity			0.2	0.1	0.1
pH	4.7	4	4.8	4.9	4.9
Sodium (mg/100g)	32	12	32	27	24

* Analysis conducted by Food and Nutrition Research Institute (FNRI) FASL Report No. 09-232a , FASL Report No. 09-232b

2.2. Microbiological Properties

Yeast and mold count of all dragon fruit products was maintained at 0 count for a period of eight months (Tables 8). Shelf-life requirement for sugar preserves is 6 months, hence, the result of microbial evaluation at the 8th month indicate that the process adopted is acceptable for commercial processing.

Table 8. Average yeast and mold counts (with PDA) of dragon food products on storage

PRODUCT	YEAST AND MOLD COUNT, Cfu/MI				
	initial	2 nd	4 th	6 th	8 th
Jam	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Jelly	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Juice	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Puree	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

2.3. Sensory Properties

The insignificant differences in the sensory properties of the products with storage time up to 8 months (Tables 9-12) are indicative of the preservation effects of the processes used. Sensory properties of food may deteriorate on storage as a result of improper or under processing, hence, it can be considered that the standardized process was sufficient and efficient enough to preserve the products.

Table 9. Mean scores for sensory properties of dragon fruit jam on storage

QUALITY ATTRIBUTE	Storage Period (months)				
	initial	2 nd	4 th	6 th	8 th
Color	3.0	2.9	3.0	2.9	3.0
Texture	2.9	2.9	3.0	3.0	2.8
Sweetness	2.7	2.6	2.7	2.7	2.6
Flavor	2.9	2.8	2.8	2.9	2.9
Off-flavor	1.2	1.0	1.0	1.1	1.2
General Acceptability	3.9	4.0	4.0	3.9	3.9

n=10

Mean scores within rows are not significantly significant at 5% level

Scoring scale:

- Color :1=brown to 5=yellow
- Texture :1=very soft to 5=very hard
- Sweetness :1=not sweet to 5=extremely sweet
- Dragon fruit flavor :1=imperceptible to 5=extremely perceptible
- Off-flavor :1=imperceptible to 5=extremely perceptible
- General acceptability :1=unacceptable to 5=extremely acceptable

Table 10. Mean scores for sensory properties of dragon fruit jelly on storage

Quality Attributes	Storage Period (months)				
	initial	2 nd	4 th	6 th	8 th
Color	3.1	3.0	3.0	2.9	2.9
Clarity	3.4	3.4	3.4	3.3	3.4
Texture	3.5	3.4	3.5	3.4	3.5
Sweetness	3.9	3.8	3.9	3.8	3.8
Flavor	2.0	2.0	2.0	1.9	2.0
Off-flavor	1.2	1.2	1.2	1.1	1.0
General Acceptability	4.2	4.3	4.3	4.4	4.4

n=10 Mean scores within rows are not significantly significant at 5% level

Scoring scale:

Clarity :1=opaque to 5=clear

Texture :1=runny to 5=tough

* Scoring for texture, color, sweetness, flavor, off-flavor and general acceptability is the same as in jam

Table 11. Sensory properties of dragon fruit juice on storage

Quality Attributes	Storage Period (months)				
	initial	2 nd	4 th	6 th	8 th
Color	3.8	3.8	3.8	3.7	3.7
Texture	2.7	2.5	2.7	2.6	2.5
Sweetness	3.1	3.2	3.1	3.0	3.1
Flavor	2.5	2.5	2.5	2.6	2.5

General Acceptability	3.8	3.7	3.7	3.9	4.0
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n=10

Mean scores within rows are not significantly significant at 5% level

Scoring scale:

Color : 1=light brown to 5=colorless

Texture: 1=diluted to 5=highly concentrated

Sweetness: 1=not sweet to 5=extremely sweet

Dragon fruit flavor: 1=imperceptible to 5=extremely perceptible

General acceptability: 1=unacceptable to 5=extremely acceptable

Table 12. Sensory properties of dragon fruit puree on storage

Quality Attributes	Storage Period (months)				
	initial	2 nd	4 th	6 th	8 th
Color	3.9	3.8	3.9	4.0	3.8
Texture	3.6	3.5	3.5	3.4	3.5
Sweetness	3.5	3.4	3.5	3.3	3.5
Flavor	3.2	3.1	3.1	3.0	3.1
General Acceptability	3.8	3.8	3.7	3.8	3.9

n=10

Means scores within rows are not significantly significant at 5% level

* scoring in all sensory attributes is the same as in dragon fruit juice

Determination of Product Acceptability

Results of consumer evaluation clearly indicated that all dragon fruit products are very acceptable as indicated by the average acceptability scores of 100 consumer respondents (Table

13). Although the products are still new and the consumers are not yet used to consuming such products, relatively high acceptability scores were given to the products. It is expected that acceptability of the products may increase as the consumers get familiarized with the products.

Table 13. Mean¹ scores² for consumer acceptability of dragon fruit products

PRODUCT	SCORE	DESCRIPTIVE EQUIVALENT
Jam	4.29	Very acceptable
Jelly	4.27	Very acceptable
Juice	4.28	Very acceptable
Puree	4.4	Very acceptable

¹ n=100

² Scoring scale: 1=unacceptable to 5=extremely acceptable

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

Based on the results of the study the following conclusions were drawn:

1. Protocols for the production of acceptable and profitable dragon fruit jam, jelly, puree and juice was established.
2. Yeast and mold count of all dragon fruit products was maintained at 0 counts for a period of eight months.
3. Results of consumer evaluation clearly indicate that all dragon fruit products are very acceptable as indicated by the average acceptability scores of 100 consumer respondents

Recommendation

The generated technology for the production of dragon jam, jelly, juice and puree developed new products which are proven to have high consumer acceptability and can provide additional income. Since the project was already on its pilot scale, it is being recommended for technology transfer for possible commercialization of the potential technology adopters.

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