Cactus-Pear Juices

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ABSTRACT

This paper presents a review of cactus-pear juice production. Its technological characteristics are considered, as well as the main difficulties in obtaining high-quality juice. Acidity, pigments, aroma, and other components play an important role in the cactus pear juice processing. Betalain and chlorophyll are present in purple and green cactus pear juices, and heat treatment of the juices affects their color, but the purple juice is more stable. Some lengthy thermal treatments cause an unattractive taste, like hay, and certain changes of aroma in the products.

Some blends with other fruit juices, such as pineapple, could be an advantage in the technological process. The pineapple juice and the addition of citric acid decrease the pH of the blends, a positive action for their microbiological stability.

Another cactus-pear juice alternative is juice from the orange cactus pear, but it has been studied less and requires, as with some aspects of the other types of juice, further investigation.

Keywords: Cactus-pear juice, juice processing, microbiological stability, pasteurization.

INTRODUCTION

One of the most frequently utilized fruit and vegetable technologies is juice production. Juices are much appreciated for their nutritive value, and, thanks to modern technologies and GMP, juices are now more similar to the raw fruit and vegetables from which they come. One Spanish expert in juices (Gasque, F., personal communication) even calls them liquid fruit.

Juices, in general, are a good source of sugars, vitamins, and minerals; all valuable components to human health. The current food trend toward healthier diets makes juice consumption an important natural food alternative, and improves the availability of its nutritive compounds. Fruit and vegetable juices could play an important role in enhancing human health.

In some countries, e.g., Chile, cactus-pear juice is consumed at home, in vegetarian restaurants, or in local health-food stores. However, due to certain technological problems associated with its production, no commercial products are produced at the industrial level.

Cactus-pear cultivars produce green, yellow, purple, and red fruits, with the purple fruits being the most attractive. Cactus-pear juices could be a natural product with a rapid presence in the market of the different production countries, especially if the production technologies are optimized.

The objective of this paper is to present a review in terms of cactus pear juice production, including its technological characteristics and the main difficulties as described in several research papers in obtaining good quality juice.

TECHNOLOGICAL CHARACTERISTICS

The chemical and mineral composition described by different authors shows that cactus pears have nutritive value similar to other fruits. Although its soluble solids content in the pulp reaches values higher than 17%, mainly constituted by 53% glucose and fructose (Russell and Felker, 1987; Sawaya et al. 1983; Sepúlveda and Sáenz, 1990; Kuti and Galloway, 1994).

Other components in cactus-pear pulp, such as protein (0.21% to 1.6%), fat (0.09% to 0.7%), fiber (0.02% to 3.15%) and ash (0.4% to 1%), are similar to other fruits (Askar and El Samahy, 1981; Paredes and Rojo,1973; Pimienta,1990; Sawaya et al., 1983; Sepúlveda and Sáenz, 1990; Rodriguez et al., 1996).

Cactus pears have a high level of ascorbic acid, which can reach levels near 40 mg/100 g (Pimienta, 1990; Sepúlveda and Sáenz, 1990; Rodriguez et al., 1996). Cactus-pear fruits are also rich in calcium and phosphorus, 15.4 to 32.8 mg/100 g; 12.8 to 27.6 mg/100 g, respectively (Sawaya et al., 1983; Sepúlveda et al., 1990). Potassium is another important mineral component with values of about 217 mg/100 g for the green-pulp cactus pear (Sepúlveda and Sáenz, 1990).

Other characteristics, in addition to its chemical composition and nutritive value, play an important role in cactus-pear processing (Table 1). Based on its high pH (5.3 to 7.1) (Pimienta, 1990; Sepúlveda and Sáenz, 1990), this fruit is classified within the low-acid group, (pH >4.5), requiring a thermal treatment of 115.5°C, or greater, to obtain good control of microorganisms The pH, low acidity, and high soluble-solids content make cactus-pear pulp a very attractive media for growth of microorganisms (Sepúlveda and Sáenz, 1990; Sáenz, 1995).

Table 1. Technological Characteristics of Purple and Green Cactus-Pear Pulp

Parameters	Green pulp*	Purple pulp**
pH	5.3–7.1	5.9–6.2
Acidity (% citric acid)	0.01–0.18	0.03–0.04
TSS (°Brix)	12–17	12.8–14.5
Pectins ($g.100g^{-1}$)	0.17–0.19	---
Vitamin C ($mg.\ 100g^{-1}$)	4.6–41.0	20.0–31.5
Ca ($mg.\ 100g^{-1}$)	12.8–27.6	---
Color		
L*	18.2–26.7	22.4–33.4
a*	4.2–5.5	10.0–18.4
b*	4.0–6.5	1.1–4.3
C*	5.8–8.5	10.1–18.9
H*	130.2–136.4	6.2–13.2
Viscosity (mPa•s)	73.9	119.2

Source: *Askar and El-Samahy (1981); *Pimienta (1990); *Sawaya et al. (1983); *Sepúlveda and Sáenz (1990); *Sáenz (1995);*Sáenz (1996); **Sáenz, Sepúlveda and Moreno (1995);**Sáenz and Sepúlveda (1999)

Pigments are another important component to be considered during cactus-pear processing. Green cactus pears contain chlorophylls, and purple cactus pears contain betalains; there is no information available about pigments present in orange cactus pear. All of these pigments must be preserved during processing, as they are responsible for the final attractive color of the product. Cactus pear pigment stability during fruit processing is being researched (Merin et al., 1987; Montefiori, 1990; Sáenz et al., 1993; Sáenz et al., 1997).

Pectic substances are partially responsible for cactus-pear pulp viscosity, and these components are a positive element during juice production. However, their presence in cactus-pear fruit is associated with the mucilage, another important, but problematic, component of this fruit, which produces an unpleasant viscosity that often is rejected by consumers.

Volatile components contribute to the flavor of the cactus pear fruits and their products. The main chemical compounds in a Mexican variety are alcohols, mainly ethanol (about 77%), 1-hexanol, and trans 2-nonen-1-ol and esters (ethyl acetate) (Flath and Takahashi, 1978). Di Cesare and Nani (1992) report that in an Italian variety the most important compounds are carbonyl compounds (about 40%); the alcohol content is close to 20%, markedly smaller than in the Mexican variety.
In Chile, organoleptic analysis performed on cactus-pear juices from ripe fruit has presented a "green note", as found by Di Cesare and Nani (1992).

In cactus-pear juices, several lengthy thermal treatments (100°C for 20 min) caused an unattractive hay taste (Carrandi, 1995). In the future, it would be worthwhile to study changes in the volatile compounds that occur during cactus-pear fruit processing.

CACTUS PEAR JUICES: CHARACTERISTICS AND DIFFERENT TYPES

Several years ago, Paredes and Rojo (1973) and Espinosa et al. (1973) performed the first research studies on cactus-pear juices. Results obtained in those studies were contradictory. Paredes and Rojo (1973) reported that the product had a pleasant flavor and taste without microbiological problems during shelf life or storage. But, Espinosa et al. (1973) found several difficulties related to juice preservation. Although these authors reported a pH reduction of the cactus-pear juice to 4.0 with the addition of lemon juice and carried out a mild thermal treatment (80ºC for 20-min), the juice obtained under these conditions presented acetic fermentation and the juice could not be preserved for a long period.

Carrandi (1995) evaluated green cactus-pear juice microbiological behavior and chemical and sensory characteristics. Treatments applied to the juice included two additives: 200 ppm of Kilol, a natural extract from grapefruit seeds, and 500 ppm of potassium sorbate, an artificial additive, normally accepted by several countries' food legislations. The juice was elaborated as follows. It was diluted with water (20:80 water:juice), then sugar (12 to 13°Brix) and citric acid (0.1% acidity) were added. Then it was pasteurized in a HTST system (98 to 100°C for 15 to 20 s), immediately bottled (364 mL) and sealed inside a UV-light chamber. Juice was cooled rapidly, and stored at 0 to 5ºC for 15 days. This author concluded that the evaluated additives were not sufficient to ensure the microbiological stability of cactus-pear juice because all the treatments presented a lactic-acid fermentation (produced by *Lactobacillus* bacteria) within 2 to 3 days.

Another approach to improving juice by controlling microbiological growth was carried out. It consisted in a more drastic thermal treatment (100°C for 20 min), to produce bottled juice. Results showed that juice microbiological stability was good. However, the final product did not resemble the original fresh juice due to changes in color and flavor.

Sáenz et al. (1997, studied the effect of different pH (5.2 and 4.0) and thermal treatments (80°C for 10 min) in purple cactus-pear juice. Evaluated treatments were:

1) A natural juice, without pH modification (pH = 5.2) and without thermal treatment
2) Juice without pH modification (pH = 5.2) and with thermal treatment
3) Juice with pH modification (pH = 4.0) and thermal treatment (80°C for 10 min)

The authors reported that the juice obtained had a red-purple color, with a slightly reddish appearance. They observed that although juice acidification and thermal treatment, applied for its conservation and microbiological stability, caused a visual color change, the purple-reddish color characteristic of this fruit juice remained. They concluded that the purple juice obtained presented a higher stability to pH changes and to thermal treatments than the green cactus-pears juice. This represents a clear advantage of the purple cactus-pear juice.

Recently, Saénz and Sepúlveda (1999) tested different formulations by blending purple cactus-pear juice with pineapple juice, citric acid, water, and sugar. The dilution of the juice could be an advantage for minimizing its viscosity, and the pineapple-juice blend lowered the pH, reducing the risk of microorganism growth.

All the blends (Table 2) were prepared with diluted cactus-pear juice (1:1, juice:water), adjusted to 13°Brix, a common sugar concentration for many fruit juices, and with different proportions of acid, as shown in Table 2. Formulations B and C were prepared with pineapple juice to adjust the acidity.

Table 2. Cactus-Pear Juice and Pineapple-Juice Blends Formulation

Components	**Blends**				
	A	**B**	**C**	**D**	**E**
Cactus pear juice	X	X	X	X	X
Water	X	X	X	X	X
Pineapple juice	----	X	X	X	X
Sugar	X	X	X	X	X
Citric acid	----	----	----	X	----
Acidity (% citric acid)	0.01	0.16	0.3	0.1	0.1

A = cactus-pear juice:water (1:1) + sugar
B = cactus-pear juice:water (1:1) + concentrated pineapple juice + sugar
C = cactus-pear juice:water (1:1) + concentrated pineapple juice + sugar
D = cactus-pear juice:water (1:1) + citric acid + sugar
E = cactus-pear juice:water (1:1) + concentrated pineapple juice + sugar

Source: Sáenz and Sepúlveda, 1999.

Table 3 shows characteristics of several juice blends. The color is similar in all the juice blends; and color was not affected by the decrease in pH, a behavior also observed by Sáenz et al. (1997) in another study on cactus-pear juice.

Table 3. Chemical and Physical Characteristics of the Cactus-Pear and Pineapple-Juice Blends

Characteristic	Blend				
	A	**B**	**C**	**D**	**E**
°Brix	13	13	13	13	13
Acidity (%)	0.01	0.16	0.3	0.1	0.1
pH	6.4	4.6	4.6	4.2	4.6
Color					
L*	19.6	20.4	20.8	19.8	20.1
a*	1.0	4.5	7.4	2.0	3.5
b*	0.5	0.5	0.7	0.3	0.4
C*	1.1	4.5	7.4	2.0	3.5
H*	0.46	0.11	0.09	0.15	0.11

Source: Sáenz and Sepúlveda, 1999.

The addition of pineapple juice and citric acid decreases the pH of the blends, a positive action for the microbiological stability of the cactus-pear juice.

The sensory attributes of the cactus-pear and pineapple-juice blends are shown in Table 4.

Table 4. Sensory Characteristics of the Cactus-Pear and Pineapple-Juice Blends

Blend	**Appearance**	**Color**	**Aroma**	**Acidity**	**Sweetness**	**Taste**	**Viscosity**	**Acceptability**
A	4.6 a	3.9 a	3.8 bc	1.9 a	3.5 b	4.2 c	3.3 a	6.7c
B	4.3 a	3.9 a	3.3 ab	2.9 b	3.2 b	3.3 b	3.4 a	5.0b
C	4.5 a	4.0 a	2.9 a	3.7 c	2.4 a	2.4 a	3.1 a	4.0a
D	4.4 a	4.1 a	4.2 c	2.9 b	3.2 b	3.8 bc	2.8 a	6.7 c
E	4.3 a	3.8 a	3.1 ab	2.9 b	3.3 b	3.2 b	2.9[a]	5.8 b

Source: Sáenz and Sepúlveda, 1999.

A significant difference in the acceptability of all the blends was observed. The acceptability ratings of these blends were: A = 6.7; B = 5.0, and C = 4.0. The judges rejected the most acidic sample (C) and preferred the pure, but diluted, cactus-pear juice (A). This formulation had a high pH (6.4). To assure juice stability, two other formulations were prepared with the addition of pineapple juice or citric acid (0.1% acidity, pH near 4.5): D contained cactus pear juice, water, sugar and citric acid and E contained cactus-pear juice, water, pineapple juice, and sugar.

The acceptability was D = 6.7 and E = 5.8, which was similar in preference to formulations A and D, the first one with only cactus pear juice and the second with citric acid. Formulation D shows pH = 4.2, color (L*=19.8, a*=2.0, b*=0.3, C*=2.0, H*=8.5); good appearance, color, aroma, acidity, sweetness and taste. The main differences between formulations A and D were aroma and taste. Apparently, aroma and taste of concentrated pineapple juice affected the delicate aroma and taste of the cactus-pear juice.

Blends A and D presented the same acceptability, although blend D was 10 times more acid than blend A, showing that blend D was more stable in terms of microbiological growth. According to the judges, blend D presented the best relation between acid and sugar content.

Another promising type of fruit for juice production is the orange cactus pear. Sepúlveda and Sáenz (1999) analyzed the characteristics of this fruit in order to process it into different products. Table 5 shows the technological characteristics of orange cactus pear pulp.

Table 5. Technological Characteristics of Orange Cactus-Pear Pulp

Characteristic	**Mean Values**	**±SD**
pH	6.1	± 0.0
Total soluble solids (°Brix)	14.8	±0.0
Acidity (g/100 g)	0.043	±0.0
Color		
L*	21.5	±0.2
a*	2.2	±0.4
b*	5.1	±0.2
C*	5.6	±0.2
H*	66.9	±3.2
Viscosity (mPa•s)	45.0	±0.1
Reducing sugars (g/100 g)	13.2	±0.7
Total sugars (g/100 g)	14.8	±0.1
Ash (g/100 g)	0.26	±0.0
Pectin (g/100 g calcium pectate)	0.04	±0.0
Vitamin C (mg/100 g)	24.1	±0.5

Source: Sepúlveda and Sáenz, 1999.

The pH, acidity, and total soluble solids content were similar to those reported by the same authors for the green and purple cactus pear pulp. The viscosity was lower than the value reported by Sepúlveda and Sáenz (1990), for the green cactus pear pulp (73.9 mPa•s). This behavior could have been influenced by the lower pectin content detected in this orange cactus-pear pulp, which was 50% less than that of the green cactus pear (Sepúlveda and Sáenz, 1990).

A sensory test was done to compare the three kinds of natural cactus-pear juices (green, purple, and orange) (Sepúlveda and Sáenz, 1999). The orange juice was pH 6.0, acidity 0.047%, and 15°Brix. The green juice was pH 6.2, acidity 0.075%, and 15.2 °Brix. The purple juice was pH 6.3, acidity 0.027%, and 15.5 °Brix. For sensory evaluation purposes, the juice was not diluted. Results showed that almost all of the juice quality characteristics were similar for the three products, but acceptability differed. On a 9-point scale, the ratings were 4.3 for the orange cactus-pear juice, 5.9 for the green, and 5.2 for the purple. The differences could be attributed to the better aroma and taste presented by the green juice compared with the purple and orange ones. However, Chilean consumers associated the cactus-pear juice with a green color, because green, exclusively, is the fruit they know.

CONCLUSIONS

With such good mineral and vitamin content, cactus-pear juices provide a technological alternative that can increase this fruit's consumption and consequent contribution to a healthy diet. Among the three types of cactus pears analyzed in this paper, the purple appears to be the most promising in terms of juice transformation. Its betalains give it the best advantage in color stability. The green cactus pear is the most challenging for juice production because of the presence of chlorophyll and its instability under thermal treatments that cause changes in its color and flavor. The orange cactus pear might also be a good juice-producing alternative, but requires further study. The cactus-pear juice blends must be assayed with other types of fruit with weaker aroma to avoid masking the delicate aroma of cactus-pear juice; pineapple juice seems to be inadequate for this purpose.

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