INFLUENCE OF PROCESSING ON PHYSICOCHEMICAL, NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION OF Ficus Carica L. (FIG) PRODUCTS

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ABSTRACT

The influence of processing on the physicochemical, nutritional and phytochemical composition of Ficus carica L. (fig) products was evaluated. Mature figs were washed, cut in quarters, pulped and then the pulp was processed into fig jam and fig nectar. The physicochemical parameters studied were pH, total soluble solids (TSS) and titratable acidity (TA) along with iron, calcium and phosphorus content. Nutritional these were analyzed for their proximate composition, total carbohydrates, vitamin C and \( \beta \) carotene. Different phytochemicals determined were total phenolics, total flavonoids, total anthocyanins and tannins. The results revealed that processing of fig fruit pulp into jam and nectar resulted in a significant (p< 0.05) increase in physicochemical properties like TSS and TA but a significant (p< 0.05) decrease in pH, iron, calcium and phosphorus. Processing of fig pulp into fig jam and fig nectar decreased the nutritional and phytochemical composition when compared with the fig pulp. Moisture, ash, crude fiber, crude protein, crude fat, vitamin C, \( \beta \) carotene, total phenolics, total flavonoids, total anthocyanins and tannins decreased significantly (p< 0.05) except significant (p< 0.05) increase in the carbohydrate and thereby energy value.

Key words: Anthocyanins, Flavonoids, Ficus carica L., Fig jam, Fig, Fig nectar, Nutritional, Phenolics, Physicochemical, Processing, Phytochemical, Tannins.

INTRODUCTION

Fruits and vegetables are known as protective foods and high consumption of fruits and vegetables has been associated with a lowered incidence of degenerative diseases including cancer, heart disease, inflammation, arthritis, immune system decline, brain dysfunction and cataracts. These protective effects are considered, in large part, to be related to the various antioxidants contained in them. There is overwhelming evidence to indicate that free radicals cause oxidative damage to lipids, proteins, and nucleic acids. Antioxidants, which can inhibit or delay the oxidation of an oxidisable substrate in a chain reaction, would therefore seem to be very important in the prevention of these diseases. This created a new perspective concerning the potential of diet in preventing serious diseases in future. However, the health promoting capacity of fruits and vegetables strictly depend on their processing history.

Processing is expected to affect content, activity and bioavailability of nutrients and bioactive compounds. This aspect is of great importance as only a small amount of fruits and vegetables are consumed in their raw state, while most of them need to be processed for safety, quality, availability and economic reasons (Nicoli et al. 1999).

The common Fig (Ficus carica L.) is a tree native to southwest Asia and the eastern Mediterranean region, belong to botanical family Moracea. Fig is one of the first plants that was cultivated by humans and is an important crop worldwide for dry and fresh consumption. Its edible part is commonly referred to as a “fruit” although it is a synconium, that is, a fleshy, hollow receptacle with a small opening at the apex partly closed by small scales. Previous reports concerning the nutrient composition of dried figs have indicated that it has the best nutrient score among the dried fruit, being

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an important source of minerals and vitamins (USDA, 2002). The figs are widely consumed fresh, either peeled or not. Fresh fruits naturally have a short, post-harvest life of 7–10 days, but with a combination of cooler conditions and a CO₂-enriched atmosphere, the fruit can be stored for up to 2–4 weeks (Sozzi et al. 2005). Figs are also very popular as dried fruit, since drying prolongs their storability. Figs are an excellent source of minerals, vitamins and dietary fibre (Vinson, 1999; Vinson et al. 2005); they are fat and cholesterol-free and contain a high number of amino acids (Slavin, 2006; Solomon et al. 2006). Similarly to other fruit species, figs contain sugars and organic acids that influence their quality. They also contain phenolic substances, which contribute importantly to their quality; especially because it has been proven that their consumption can have a positive effect on human health. The content level of phenolics is usually influenced not only by the cultivar, but also varies significantly from one fruit part to the other; moreover, it is heavily dependent on the growing technology in the orchard (Veberic et al. 2005). The presence of phytosterols (433 mg/100 g dry basis) has also been reported in fig fruit (Jeong and Lachance, 2001). Although figs are an important fresh fruit variety in many countries, as well as a delicious dried fruit consumed in most parts of the world, there are only a few reports dealing with the phenolic contents of these fruit, and there is dearth of information on the effects of processing methods on the physicochemical, nutritional and phytochemical composition of fig products. On the basis of these considerations, the evaluation of the influence of food processing on natural occurring antioxidants and nutritional composition of fig products is a key factor in finding technological conditions necessary to preserve or improve their original activity and bioavailability. So, the aim of our research was to investigate the influence of processing on the physicochemical, nutritional and phytochemical composition of fig products.

**MATERIALS AND METHODS**

**Procurement and Preparation of samples**

Fig (Ficus carica L.) fruit was purchased from local market of Anantapur, Andhra Pradesh (India). Fully mature fruits were selected, washed thoroughly with distilled water and non edible portion of fruits were removed and was processed into fig pulp, fig jam and fig nectar (Figure 1, 2 and 3).

**Physicochemical analysis:** Titratable acidity, pH and total soluble solids were determined by methods as given by Ranganna (1997). Iron in the mineral extract was determined by Wong’s method given by Raghuramulu et al. (2004). Calcium was determined by the method of Hawk et al. (1957) and phosphorus by the method of Fiske Subba Rao as given by Raghuramulu et al. (2004).

**Nutritional analysis:** Moisture, ash, crude fiber were determined using standard methods of AOAC (1990). Crude fat was determined by method of Huber and Newman (1975). Crude protein was determined in the sample by following the method given by Lowry et al. (1951), while the carbohydrate content was estimated by anthrone method (Hedge and Hofreiter, 1962). Vitamin C content was analyzed by the method given by Ranganna (1997). β-carotene was extracted on alumina column and determined spectrophotometrically (Raghuramulu et al. 2004).

**Determination of phytochemical constituents:** Tannins were estimated by Vanillin hydrochloride method given by Price et al. (1997). Defatted sample (500mg) was transferred to a centrifuge tube and 10 ml of acidic- methanol (1%) was added and shaken for 20 mins on a shaker. The tubes were centrifuged for 10 mins and supernatant transferred to volumetric flask (25ml). To the residue in the centrifuge tubes 5 ml of acidic-methanol (1%) was added and extraction procedure was repeated. Final volume was made upto 25 ml. The sample was taken in triplicate, to this 5 ml of Vanillin- HCl reagent was added and the intensity of the colour developed was read at 500nm. The absorbance was plotted against

- Selection of sound fruits
- Washing of the fruits
- Peeling and weighing (300gm)
- Slicing of the fruits into halves
- Blending of fruits in a blender
- Filtering of pulp through a muslin cloth
- Packing in glass bottles
- Stored in refrigerator until further use

**FIG 1:** Flowchart for the preparation of fig pulp
Selection of sound fruits (300gm)  
Washing of the fruits  
Peeling and weighing  
Slicing of the fruits into halves  
Blending of fruits in a blender  
Filtering of pulp through a muslin cloth  
Collection of filtrate in a beaker  
Brix reading of pulp using an Abbe refractometer  
Gradual addition of white sugar (1g/g of fruit) to the pulp  
Cooking of mixture until 68° Brix is reached  
Hot filling in jars  
Hot sealing of bottles manually  
Rapid cooling to ambient temperature by immersing bottles in tray of ice

**FIG 2**: Flowchart for the preparation of fig jam

catechin standard and the concentration of sample was intercepted.

**Sample preparation** for other phytochemicals viz. total phenols, total flavonoids and total anthocyanins was carried out according to Counet and Collin, 2003. Sample (75 gm) was taken and ground in a blender with 150 ml of extraction solvent consisting of Acetone (70%), water (28%) and acetic acid (2%). Mixture was shaken for 1 hr at 4°C and centrifuged at 17000 X g for 15 mins. Supernatant was removed and the pellet was extracted again, supernatants were pooled and 70 per cent of volume was evaporated at 30°C. Then the volume was made up to 300 ml with water.

**Total phenols** in the samples were determined following method given by Caboni et al. 1997. Diluted extracts (3.6 ml) were mixed with Folin-Ciocalteau reagent and after 3 mins, 0.8 ml sodium carbonate (20%) was added. Mixture was heated at 100°C for 1 min and after cooling, absorbance was measured at 750nm. Gallic acid was used as standard.

**Total flavonoids** were determined by the method given by Lamaison and Carnat, 1990. Diluted extracts (1 ml) were mixed with 1 ml of reagent (AlCl3.6H2O, 2% in methanol), Absorbance was read at 430nm after 10 mins. Quercetin was used as the standard.

**Anthocyanin quantification** was performed by pH-differential method given by Guisti and Wrolstad, 2001. Extract was diluted in pH 1.0 solution (0.1M HCl, 25mMKCl) and in a pH 4.5 solution (0.4M, CH3COONa). Absorbance of mixture was read at 534 and 700 nm against distilled water.

Absorbance of anthocyanin in sample= \((\text{Abs}_{535} - \text{Abs}_{700})_{\text{pH 1.0}} - (\text{Abs}_{535} - \text{Abs}_{700})_{\text{pH 4.5}}\)

Statistical analysis: The data obtained was analyzed statistically for analysis of variance in a completely randomized design (Sendecor and Cochran, 1994).

**RESULTS AND DISCUSSION:**

Table 2 lists the physico-chemical properties and mineral composition of fig pulp, jam and nectar. Fig fruit pulp had 4.7± 0.3 pH, 10.2± 0.2 °Brix total soluble solids (TSS) and 0.72± 0.8 g (g citric acid /100g fresh mass) titratable acidity (TA). The transformation of fruit pulp into jam and nectar naturally increased TSS because of the added sugar. However, jam had higher TSS than nectar as
formulation of nectar took in dilution with water. pH of jam and nectar were comparatively lesser than the fruit pulp as citric acid was added as a preservative in both the products which brought down the pH in jam and nectar. TA was also found to be higher in jam and nectar as compared to the fruit pulp due to the addition of citric acid as preservative (Ordonez-Santos LE and Vazquez-Riascos A, 2010). Iron content of fig jam and nectar decreased significantly when compared with the fig pulp which can be due to the addition of sugar to the fruit pulp in the processing of fig jam and nectar. However, the decrease in the iron content of fig nectar was lesser when compared with fig nectar which can be due to the fact that certain food processing procedures enhance the proportion of diffusible iron as compared to the unprocessed food. The constituent organic acids in fruit juices namely citric, ascorbic and malic acids might be potentially responsible for enhancing the iron availability (Hazell and Jonson, 2007). Calcium content was found to decrease slightly in products viz. fig jam and nectar as compared to fig fruit pulp. Heating (60-70°C) of tissue causes disruption of membranes and decompartmentation of cell constituents. Heat induced firming is believed to start with damage to cell membranes that causes increase in impermeability. This leads to liberation of Ca$^{2+}$ and its diffusion to the cell formation of Ca$^{2+}$ and Mg$^{2+}$ ionic cross linkages between carboxyl groups of pectin (Haard and Chism, 2005). Compared with the fig fruit pulp, tremendous decrease in phosphorus content of 91 and 80% ($p<0.05$) was observed in fig jam and nectar respectively. However, fig nectar had comparatively higher content of phosphorus than fig jam due to uptake of minerals from water used in the preparation of nectar (Rickman et al, 2007).

Influence of processing on the nutritional composition of fig is presented in Table 3. As clear from Table 2; moisture, ash, crude fiber, crude fat and crude protein content was lowest in fig jam as compared to nectar and pulp. Addition of sugar in jam and nectar resulted in an increase in total carbohydrates and calorific value. Data pertaining to these parameters of fig pulp was found coinciding with data given by Morton (1987). However, crude fiber content was found to be slightly higher than the reported value which can be attributed to varietal differences. Crude fiber content when compared with fig fruit pulp decreased by 22 and 67% ($p<0.05$) in fig jam and nectar. This decrease can be attributed to the addition of sugar and in the preparation of jam whereas, the addition of sugar and dilution with water.

### Table 1: Ingredients used in making fig pulp, jam and nectar

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Pulp</th>
<th>Jam</th>
<th>Nectar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig fruit (Kg)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sugar (Kg)</td>
<td>-</td>
<td>1</td>
<td>0.600</td>
</tr>
<tr>
<td>Citric acid (gm)</td>
<td>-</td>
<td>2.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Values are mean ± SEM of 3 observations

### Table 2: Influence of processing on the physicochemical and mineral composition of fig pulp, jam and nectar

<table>
<thead>
<tr>
<th>Sample/Parameters</th>
<th>Pulp</th>
<th>Jam</th>
<th>Nectar</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>4.2 ± 0.1</td>
<td>3.7 ± 0.3</td>
<td>3.4 ± 0.4</td>
</tr>
<tr>
<td>Total soluble solids (°Brix)</td>
<td>6.8 ± 0.3</td>
<td>68.0 ± 0.1</td>
<td>48.0 ± 0.6</td>
</tr>
<tr>
<td>Titratable acidity (g citric acid/100g fresh mass)</td>
<td>0.19 ± 0.9</td>
<td>0.20 ± 0.4</td>
<td>0.21 ± 0.4</td>
</tr>
<tr>
<td>Iron (mg %)</td>
<td>6.2 ± 0.7</td>
<td>1.6 ± 0.5</td>
<td>6.7 ± 0.8</td>
</tr>
<tr>
<td>Calcium (mg %)</td>
<td>28.2 ± 0.8</td>
<td>26.7 ± 1.1</td>
<td>27.6 ± 0.9</td>
</tr>
<tr>
<td>Phosphorus (mg %)</td>
<td>17.9 ± 1.1</td>
<td>1.3 ± 0.1</td>
<td>2.7 ± 0.5</td>
</tr>
</tbody>
</table>

Values are mean ± SEM of 3 observations

### Table 3: Influence of processing on the nutritional composition of fig pulp, jam and nectar

<table>
<thead>
<tr>
<th>Sample/Parameters</th>
<th>Pulp</th>
<th>Jam</th>
<th>Nectar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (g %)</td>
<td>87.7 ± 0.5</td>
<td>19.9 ± 0.2</td>
<td>49 ± 0.4</td>
</tr>
<tr>
<td>Ash (g %)</td>
<td>0.5 ± 0.1</td>
<td>0.2 ± 0.6</td>
<td>0.4 ± 0.1</td>
</tr>
<tr>
<td>Crude fiber (g %)</td>
<td>1.6 ± 0.6</td>
<td>1.2 ± 0.6</td>
<td>0.5 ± 0.3</td>
</tr>
<tr>
<td>Crude Protein (g %)</td>
<td>9.8 ± 0.8</td>
<td>5.4 ± 0.5</td>
<td>8.6 ± 0.9</td>
</tr>
<tr>
<td>Crude Fat (g %)</td>
<td>0.43 ± 0.9</td>
<td>0.08 ± 0.7</td>
<td>0.15 ± 0.8</td>
</tr>
<tr>
<td>Carbohydrate (g %)</td>
<td>12.9 ± 1.3</td>
<td>30.1 ± 1.2</td>
<td>38.2 ± 1.3</td>
</tr>
<tr>
<td>Vitamin C (mg/100g fresh mass)</td>
<td>23.9+12.2</td>
<td>3.7+0.9</td>
<td>11.5+0.8</td>
</tr>
<tr>
<td>β carotene (mg/100g fresh mass)</td>
<td>0.16+0.3</td>
<td>0.01+0.1</td>
<td>0.12+0.2</td>
</tr>
<tr>
<td>Energy (Kcal)</td>
<td>94.9 ± 1.0</td>
<td>142.7 ± 1.1</td>
<td>189.6 ± 1.3</td>
</tr>
</tbody>
</table>

Values are mean ± SEM of 3 observations

Figures in the parenthesis indicate % increase/decrease over the fruit pulp values.
water in case of fig nectar. Crude protein content decreased in fig jam and nectar as during heat treatment proteins undergo denaturation/ degradation and thus reduction in the crude protein content (Whitaker, 1981). Crude fat content estimated in fig pulp and its products indicated a decrease of 65% and 39% (p<0.05) respectively in fig jam and nectar. Higher percent decrease in fat content in jam as compared to nectar can be due to thermal degradation of fats at higher temperatures (Fennema, 1997). Carbohydrate content was found to significantly increase in fig jam (133%) and nectar (196%) (p<0.05) when compared with fig fruit pulp. This increase in carbohydrate content can be due to addition of sugar during the formulation of products. However, fig nectar had more carbohydrate content as compared to fig jam as no considerable heating is involved in the processing of nectar (Whistler and Daniel, 1985). Vitamin C was found to decrease by 84% in fig jam and 49% in fig nectar when compared with fig fruit pulp. This tremendous decrease in vitamin C content in jam is due to the addition of sugar and use of heat treatment in the processing. Comparatively lesser decrease in vitamin C was seen in fig nectar as no considerable heat treatment is used in the processing of nectar. Also, these losses of vitamin C are probably due mainly to oxidation; in particular the oxidation of vitamin C to dehydroascorbic acid which is followed by the hydrolysis of the latter to 2,3- diketogulconic acid, which then undergoes polymerization to other nutritionally inactive products (Dewanto et al, 2002). \( \alpha \) carotene decreased by 93 % and 25 % (p<0.05) in fig jam and nectar respectively. This decrease is due to the addition of sugar during the processing of jam and nectar. Besides, preparation of jam involves heating above 100 °C which causes degradation of \( \alpha \) carotene. Carotenoids are thus susceptible to loss of provitamin \( \alpha \) activity through oxidation during processing (Salunkhe et al. 1991). Energy calculated was comparatively higher for the fig jam and nectar as compared with the fig fruit pulp. However, energy content of fig nectar was higher than fig jam owing to the thermal degradation of macronutrients during the processing of jam. When compared with each other, jam had lesser nutritional composition than fig nectar as processing of jam includes addition of sugar and use of high heat treatment which leads to degradation of nutrients whereas, in fig nectar the reduction can be due to dilution with water and addition of sugar (Ordonez-Santos and Vazquez-Riascos, 2010).

Phytochemical content of fig pulp and its products is presented in Table 4. Table 4 shows decrease in all the phytochemical components studied in fig jam and nectar samples when compared with pulp. The decrease in all phytochemical components studied can be due to addition of sugar in the products and use of heat in the processing which leads to the various physicochemical changes the fruits. Total phenolics were found to decrease by 25% and 52% in fig jam and fig nectar respectively, when compared with the fig pulp. Phenolic compounds are antioxidants and are subjected to oxidation during storage and processing of foods (Titchenal and Dobbs, 2004). Physical and biological factors such as temperature increase and enzymatic activity may result in the destruction of phenolics. Enzymes such as polyphenol oxidase are responsible for the browning reaction of phenolics but they are normally inactivated during jam preparation due to high temperatures applied. However, there could be losses of bioactive phenolics due to the cooking process that may decrease their functional properties (Kim and Zakour, 2004). The decrease in the phenolic content of fig nectar can be attributed to the oxidation of polyphenols by endogenous polyphenol oxidase and ascorbic acid oxidase (Giovanelli et al. 2001 a). The significant (p<0.05) decrease in the flavonoid content of fig jam and nectar when compared with pulp can be due to the addition of sugar in the processing which

<table>
<thead>
<tr>
<th>Sample/Parameters</th>
<th>Pulp</th>
<th>Jam</th>
<th>Nectar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total phenolics</td>
<td>161.2±0.8</td>
<td>133.3±0.2(25)</td>
<td>77.8±0.7(52)</td>
</tr>
<tr>
<td>(GAE mg %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total flavonoids</td>
<td>4.4±0.9</td>
<td>0.4±1.1(98)</td>
<td>2.0±0.6(45)</td>
</tr>
<tr>
<td>(Quercetin mg %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total anthocyanins</td>
<td>0.5±0.9</td>
<td>0.14±0.7(79)</td>
<td>0.40±0.7(33)</td>
</tr>
<tr>
<td>(mg %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tannins</td>
<td>100.6±0.4</td>
<td>16.6±1.0(83)</td>
<td>22.5±0.7(77)</td>
</tr>
<tr>
<td>(GAE mg %)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are mean ± SEM of 3 observations
Figures in the parenthesis indicate % increase/decrease over the fruit pulp values

TABLE 4: Influence of processing on the phytochemical composition of fig pulp, jam and nectar
does not contribute to the flavonoid content of the products. As reported by Crozier et al. 1995; Price and Rhodes, 1997 this decrease is probably due to chemical or thermal degradation of the flavonoids during processing. However, fruit nectar processing can increase the flavonoid content as extraction processes can release flavonoids from the rind (Sluis et al. 1997) and this explains comparatively lesser decrease in the flavonoid content of fig nectar than fig jam. On the basis of anthocyanin content of fig fruit pulp, jam had significantly (p<0.05) lowest concentration of total anthocyanins. A loss of 79 % in fig jam and 33% (p<0.05) in fig nectar was observed due to processing. This decrease was more extensive as, several factors like pH, temperature, light, oxygen, metal ions and sugars are believed to affect the stability of anthocyanins in fruits and vegetables during processing and storage (Rhim, 2002). Significant loss (p<0.05) of tannins in fig jam and fig nectar than fig pulp was observed due to thermal degradation of tannins. The considerable decrease of tannins in the products can be due to extraction and release of tannins from the cell matrix, due to breakage of bonds with proteins (Rehman and Shah, 2001).

CONCLUSION

Processing of fig fruit pulp into jam and nectar resulted in a significant increase in physico chemical properties like TSS and TA but brought down a significant decrease in pH and mineral composition. Also, processing of fig fruit pulp into jam and nectar brought down the nutritional and phytochemical composition of the products except significant increase in the carbohydrate and thereby energy value. Although there is a decrease in the nutritional and phytochemical composition of fig products than pulp but it can be said that processing of fig fruits into jam and nectar ensures the safety and quality of the products without much loss of nutritional and antioxidant benefits, which is not feasible with the fig fruit as such owing to its perishable nature.

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