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Effect of Processing on Nutrient Composition and Antioxidant Capacity of Loquat Jam and Concentrated Syrup

Esraa, A.M. Mousa, Sahar, A. M. Sawy & *Doaa, F. Hassan

Special Food and Nutrition Research Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt

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ABSTRACT

Loquat fruit is nutritious food rich in vitamins, carotenoids, and polyphenolic compounds, offering a range of health benefits, such as antioxidant, anti-inflammatory, and immune-boosting properties. This study examined the effects of processing loquat fruit into syrup and jam on their functionality. Producing loquat jam and syrup from fresh fruits extends their shelf life beyond the typical 3-4 days at room temperature, allowing us to preserve their nutritional benefits and enjoy them longer. The chemical, physical, and biological properties of syrup and jam were compared with those of fresh fruit. The findings revealed that total soluble solids (TSS), Brix value, protein, and total carbohydrate levels increased in both syrup and jam. However, the mineral content was higher in syrup than in jam. Sensory evaluations indicated that jam scored higher for flavor, texture, aroma, and overall acceptability. Additionally, the viscosity (743.21 cP) and shear stress (96.77 dyn/cm3) of the jam were noted. Color analysis showed that syrup had higher *L**, *a**, and *b** values. Interestingly, the antioxidant activity of jam was higher than that of syrup and fresh fruit (73.56%). Despite this, the syrup had a higher content of phenolic acids (132.06 mg/100g), flavonoids (69.37 mg/100g), vitamin C (6.41 mg/100g), and total carotenoids. Finally, FTRI-AIR analysis identified functional groups, including those of phenolic acids, amino acids, carboxyls, and aromatics.

1. Introduction

Loquat, traditionally used in Chinese medicine for treating ailments like digestive issues, diabetes, and respiratory problems, owes its medicinal properties to its rich content of active ingredients such as carotenoids, vitamins, and polyphenolic compounds, which contribute to its anti-tumor, anti-diabetic, anti-inflammatory, antioxidant, antiviral, and other health benefits. (Ibrahim 2021). Eriobotrya japonica (*Thunb. Lindl.*). Figure 1 is a medium-sized green fruit tree that belongs to the Rosaceae family, often known as Loquat. It has been transplanted for over two thousand years and is native to Japan and China, but it was recently commercially available in over 30 countries, including Japan, Iraq, Turkey, Spain, Italy, Syria, and others. The plant's native English name is loquat; Arabic (Beshmelah); German (Loquate); French (bibassier); Chinese (luju,biba), and so on. It may grow to be 6 meters or taller, with thick and evergreen oval-oblong leaves. Fruit yellow to orange, pear-shaped, with three to four seeds, long four centimeters, and delicious taste (Alwash 2017).

Figure 1. Loquat Fruit

Although loquat grows well in Egypt the cultivation in 2007 was about 122.08 ha with a production of 1273 tonnes including tree species (premiere, advance, el sukary, Late Victoria, and early red)
(El Sabagh 2011).

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*Corresponding Author
Email: doaafathy23@yahoo.com

Loquat is currently used in jam, chutney, and jelly production, as well as being consumed as a fresh fruit (Koba et al., 2007). In China, fruits are used as a sedative, to reduce thirst and vomiting, and to cure wounds (Taniguchi et al., 2002). Loquat fruits are spherical or oval in shape, orange or yellow in color, and contain soft and luscious flesh. The majority of loquat processing product research focuses on dried fruits, jelly, probiotic yogurt, beer, and fermented fruit syrup. Loquat jam is another loquat processing product that can help alleviate the problem of loquat storage while still retaining some of the loquat's pharmacological action. (Ming Feng et al., 2024). In China, fruits are used as a sedative, to reduce thirst and vomiting, and to cure wounds (Taniguchi et al., 2002). Loquat fruits are spherical or oval in shape, orange or yellow in color, and contain soft and luscious flesh. The majority of loquat processing product research focuses on dried fruits, jelly, probiotic yogurt, beer, and fermented fruit syrup. Loquat jam is another loquat processing product that can help alleviate the problem of loquat storage while still retaining some of the loquat's pharmacological action. (Ming Feng et al., 2024). Loquat is highly adapted, grown, and economically distributed in many places, however in Mediterranean nations, it is underused for its production and hence consumption (Dimassi et al., 2020). Loquat is a nonclimacteric fruit (Blumenfeld, 1980) (Reig et al., 2016). The fruits are unsuitable for storage and transportation, and they have a limited postharvest life. The Mediterranean region's fruit-ripening season is focused on three months: March, April, and May (Calabrese et al., 2002). Ascorbic acid is regarded as an antioxidant vitamin and a heat-labile component, but lycopene and phenolic compounds are more resistant to thermal processing and are the primary antioxidants in processed foods (George et al., 2004). The harvested loquat fruit has a limited storage lifespan of 3-4 days at room temperature; however, processing into various products has been developed to extend the shelf life of loquat, while keeping in mind that processing may influence the ratio of nutritious components. The current study sought to determine the effect of processing on the nutrients and antioxidant capacity of loquat jam and concentrated syrup, which were chosen as preserving techniques in this study.

2. Materials and Methods

Materials

Loquat fruits (Eriobotrya japonica Lindl) were purchased from EL-Obour market in Qalubia Governorate, Egypt. Sugar and citric acid were obtained from a local market, while all solvents and chemicals (DPPH, methanol, ethanol) used were HPLC grade and purchased from Sigma Chemical Co. (USA).

Preparation of Loquat syrup

Loquats (Eriobotrya japonica Lindl.) were first sorted, and washed, and any inedible parts were removed. The fruit was then chopped. To a container heated over low heat, 250 grams of sugar were added for every kilogram of loquat fruit, along with 3 grams of citric acid and 400 milliliters of water. This mixture was cooked until the loquats softened. The softened fruit mixture was then mechanically extracted using a high-speed blender to create a natural fruit syrup. However, this syrup would still contain some pulp and other remnants. To obtain a more concentrated syrup, the mixture was further heated over low heat for approximately 20 minutes, allowing excess liquid to evaporate Next, the concentrated syrup was heated to 55°C, and 0.3% ascorbic acid was added. The mixture was then cooled. Finally, it was passed through a fine-mesh sieve to remove any remaining pulp before being stored in a glass bottle at -18°C for analysis.

Production of Loquat Jam

In loquat jam production, fruits were first cleaned, drained, and blanched in boiling water at 95 –100◦C for 30s, after quick cooling, stems, peels, and cores were removed, and the remaining pulp was homogenized for smoothness. (L10-L191, Jiuyang Inc., Jinan City, China. Two kilograms of this pulp were then mixed with sugar in a 5:1 ratio, heated to a simmer, and stirred continuously for 90 minutes. The final hot jam was transferred to sterilized glass bottles, sealed after cooling to 25°C, and stored at 4°C for analysis according to The method of Dawney et al. (2002).

Methods

Physico-chemical properties

Several physicochemical properties of the loquat jam and syrup samples were measured:

- **Brix Value:** A portable refractometer (RFM700, Bellingham and Stanley LTD., United Kingdom) was used to determine the Brix value.

- **pH:** The pH of the samples was measured using a microcomputer-based pH meter (model pH/EC80, Jenco VisionP) that also measures conductivity, TDS, salinity, and temperature.

- **Titratable Acidity:** TA was determined in triplicate by titrating the samples with 0.1 N NaOH solution to a pH of 8.1 The results were expressed as grams of malic acid per 100 grams of sample (g/100g) using phenolphthalein as an indicator **(AOAC, 2005).**

- **Viscosity:** A Brookfield digital rheometer (model HA DV ø ultra, Brookfield AMETEK Engineering Laboratories INC) was used to measure apparent viscosity at 20 ± 2°C. The measurement was performed using spindle SC4-18 at a speed of 10 rpm. The viscosity results were expressed in centipoise (cP).

- **Color evaluation:** The color differences of the loquat jam and syrup samples were measured using a tristimulus colorimeter (HunterLab Scan XE, Reston, VA) equipped with the CIE Lab color scale. The instrument was calibrated using a standard white tile with known *L**, *a**, and *b** values. The color of the samples was then measured in terms of lightness *(L*)*, redness *(a*)*, and yellowness *(b*)*.

Sensory Analysis

Ten taste panelists participated in a sensory evaluation to assess the quality of the loquat syrup and jam samples. Panelists evaluated the samples based on five attributes: taste (scored from 1 for worst to 9 for best), texture, appearance, aroma, and overall acceptability. The sensory average score for each loquat product was calculated by averaging the scores from all attributes (Dimassi et al., 2020).

Chemical analysis

The chemical composition of the loquat samples was analyzed according to AOAC (2005) methods. This included determining moisture content, T.S., protein, ash, and fat.

Mineral content (iron [Fe], magnesium [Mg], potassium [K], zinc [Zn], calcium [Ca], phosphorus [P], selenium [Se], and sodium [Na]) was digestion by using a microwave digestion system (Multiwave Go Plus) and determined by using microwave plasma Atomic Emission Spectroscopy (MP-AES) (model 4210, Agilent) made in Malaysia following the AOAC (2019) method.

Vitamin C content was determined using the AOAC (2005) method. β-carotene content was estimated following the method described by Okonkwo (2009).

Antioxidant analysis

- Total phenolic content (TPC) was assessed using spectrophotometry. The Folin-Ciocalteu reagent method (Chang et al., 2019) was employed to quantify TPC. Absorbance was measured at 735 nm. A standard curve was prepared using gallic acid, and the results were expressed as milligrams of gallic acid equivalents (GAE) per 100 grams of dry weight (dw) extract.

- Total flavonoid content (TFC) was determined by Spectrophotometry technique and Described by Liu et al. (2009).

- Absorbance was measured at 510 nm. A standard curve was prepared with catechin, and the results were expressed as milligrams of catechin equivalent (CE) per 100 grams of dry weight (dw) extract.

- Antioxidant activity was assessed using the 1,1-Diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay (Liu et al., 2009). This assay measures the percentage of DPPH free radicals scavenged by the sample. The DPPH radical scavenging activity was calculated by the following equation (1):

Scavenging effect % = (Absorbance of control at 517-Absorbance of sample at 517 /Absorbance of control at 517) x 100 (1)

High-performance liquid chromatography (HPLC) was used to fractionate phenolic and flavonoid components. Samples were prepared according to Jakopic et al. (2009) to assess phenolic acids and flavonoids. Chromatograms were obtained at wavelengths between 278 and 332 nm to detect phenolic compounds and flavonoids. Peak regions were then used to identify and quantify all components using the method described by Schieber et al. (2001).

Fourier-Transform Infrared Spectroscopy (FTIR- ATR)

The Fourier-transform infrared spectroscopy (FTIR) spectra of loquate syrup and jam were examined by an FTIR spectrometer (NICOLET iS10, Thermo Scientific Inc., USA) in the attenuated total reflection (ATR) mode [18] in Food Technology and Research Institute. The spectra were recorded in the wave number range of 600–4000 cm^{-1}.

Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) software, version 16 (SPSS Inc., 1999). One-way analysis of variance (ANOVA) was employed to assess significant differences between various groups for the measured parameters. Duncan's multiple range test (DMRT) was used as a post-hoc test to identify specific groups that differed significantly from each other ($p < 0.05$).

3. Results and discussion

Chemical composition of Loquat Fruits (LF), Loquat syrup and Loquat jam

Fresh loquat fruit was analyzed for its chemical composition, including moisture, protein, fat, ash, carbohydrates, total soluble solids (TSS), and pH (Table 1). The results showed a high moisture content of 86.32%, making loquat a suitable fruit for processing into jellies and jams. This is further supported by the presence of high total soluble solids(11.0 ° Brix), which suggests the presence of sugars, vitamins, phenolic compounds, and pectin – all desirable components for these products (Patricia et al., 2010). Table 1 illustrates the chemical composition of loquat fruit syrup and jam. Heat treatment significantly affects the composition, particularly the total soluble solids (TSS). TSS increases from 12.5% to 45.60% and 49.96% in syrup and jam, respectively, with significant differences between the two. Protein and ash contents, however, are relatively unaffected by heat treatment.

Carbohydrate content increases slightly in both syrup and jam compared to fresh fruit due to the addition of sugar during processing. Additionally, an increase in acidity is observed. TSS reaches 13.03 °Brix in juice and 59.5 °Brix in jam.

Hasegawa et al. (2010) reported that a fruit's acidity is mainly attributed to its organic acid content, which can vary depending on the cultivar and ripeness. Malic acid is the main organic acid detected in ripe loquats, with citric and succinic acids present in smaller amounts. These organic acids are primarily responsible for the fruit's tart flavor. The results presented are consistent with previous research by Abozeid and Nadir (2012) who reported similar TSS values, finding 13 °Brix in syrup and 76 °Brix in jam. Their study also showed a pH decline from fruit (4.32) to syrup (4.22) and jam (3.7). Dimassi et al. (2020) investigated the impact of citric acid addition and pasteurization on loquat syrup quality. Their findings align with the increase in TSS observed here, reporting a value of 13.67 °Brix. Their study additionally measured titratable acidity (T. A%) at 0.70%.

Table 1. Chemical composition of loquat fruit, syrup, and jam (%)

Samples	Moisture	T.S	Protein	Fat	Ash	Total carbohydrate	pH	Acidity	TSS Brix
Fruit fresh	$87.42^{a}\pm$ 1.26	$12.58^{a}\pm$ 1.26	$0.49^{b}\pm$ 0.05	$0.21^{a}\pm$ 0.01	$0.34^{a}\pm$ 0.03	$12.94^{c}\pm$ 0.7	$4.32^{a}\pm$ 0.07	$0.71^{a}\pm$ 0.07	$9.85^{c}\pm$ 0.37
Syrup	$54.34^{b}\pm$ 0.4	$45.66^{b}\pm$ 0.4	$0.66^{a}\pm$ 0.02	$0.13^{c}\pm$ 0.01	$0.30^{a}\pm$ 0.03	$14.12^{b}\pm$ 0.13	$3.36^{b}\pm$ 0.05	$0.22^{b}\pm$ 0.03	$13.03^{b}\pm$ 0.47
Jam	$50.04^{c}\pm$ 0.28	$49.96^{c}\pm$ 0.28	$0.616^{a}\pm$ 0.02	$0.176^{b}\pm$ 0.003	$0.35^{a}\pm$ 0.03	$15.26^{a}\pm$ 0.37	$3.32^{b}\pm$ 0.04	$0.24^{b}\pm$ 0.02	$53.83^{a}\pm$ 1.26

a,b,c significant differences between treatments ± standard division

Mineral contents

Table 2 shows the mineral content of loquat fruit, syrup, and jam. Potassium (K) stands out as the most abundant mineral across all samples, ranging from 230 to 280 mg/100g. It's followed by zinc (Zn) at 100 -120 mg/100g, phosphorus (P) at 54-64 mg/100g, and calcium (Ca) and magnesium (Mg) at 10-18 mg/100g and 12-20 mg/100g, respectively.

Notably, the levels of calcium and magnesium decrease in syrup and jam compared to the fresh fruit. This decline can be attributed to heat treatment during processing. This finding aligns with research by Hulya et al. (2011) and Abozeid and Nadir (2012). Their studies reported that boiling fruit, a common step in jam and jelly production, leads to mineral loss due to the high temperatures involved.

Table 2. Mineral composition (mg/L)

Samples	Ca	K	Fe	Cu	Zn	Na	P	Mg
Fresh fruit	18	266	4.3	6.3	110	35	57	13.5
Syrup	17	280	5.8	6.6	100	33	54	20
Jam	10	230	3.2	7.4	120	37	64	12

Sensory properties of loquat syrup and jam

Table 3 presents the sensory evaluation results for loquat syrup and jam. Interestingly, loquat jam received higher scores for flavor, color, aroma, texture, and overall appearance compared to the syrup. The total acceptability score for jam was 47.25 out of 50, while syrup received a score of 40. This preference for jam aligns with the findings of Hasegawa et al. (2010). Their research suggests that a balanced ratio of sugars and acids is crucial for overall fruit taste and contributes significantly to post-harvest quality. They emphasize the importance of considering both total soluble sugars (TSS) and total organic acids (TOA) – including malic, citric, and succinic acids – when comparing cultivars. Furthermore, the results seem to be influenced by processing methods, as reported by Dimassi et al. (2020). Their study compared fresh loquat syrup with citric acid to pasteurized versions. Fresh loquat syrup with citric acid received significantly higher average scores and overall acceptance compared to pasteurized syrups. Similarly, diluted fresh loquat syrup (with or without additional citric acid) achieved higher average scores than its pasteurized counterparts. This suggests that pasteurization might negatively impact the sensory qualities of loquat syrup.

Table 3. Sensory evaluation of each loquat syrup and jam

Treatments	Flavor (10)	Color (10)	Aroma (10)	Texture (10)	Appearance (10)	Overall acceptability (50)
Syrup	7.75^{b}+0.96	9.5^{a}+0.58	7.75^{b}+1.26	7.5^{a}+0.58	8^{a}+0.82	40^{b}+0.82
Jam	10^{a}+0.00	9.75^{a}+0.5	9.75^{a}+0.5	8.75^{a}+0.96	9^{a}+0.82	47.25^{a}+0.58

Effect of Loquat on Syrup and Jam Viscosity

Table 4 highlights the influence of loquat fruit on the viscosity of syrup and jam. As expected, jam exhibited a significantly higher viscosity (734.21 cP) compared to syrup (412.76 cP), which was due to the addition of sugar and citric acid, and the heat treatments. The higher viscosity of jam is further reflected in its shear stress value (96.77 dyne/cm³), which is considerably greater than that of syrup (54.42 dyne/cm³). Interestingly, both syrup and jam displayed the same shear rate (13.23 s^{-1}). This suggests that the applied force to deform the samples was identical, but the jam offered greater resistance due to its higher viscosity.

Table 4. Viscosity properties of loquat syrup and jam

Treatments	Viscosity (cP)	Shear stress (dyn/cm^3)	Shear rate (1/s)
Syrup	412.76^{b}+6.41	54.42^{b}+0.85	13.23^{a}+0.035
Jam	734.21^{a}+20.8	96.77^{a}+2.74	13.23^{a}+0.031

a,b,c significant differences between treatments ± standard division

Colorimetric Analysis

Table 5 presents the Hunter color parameters (*L*, a*, and b**) used to describe the color properties of fresh loquat fruit, syrup, and jam. The data reveals significant color differences between the samples. Jam exhibits the darkest color with the lowest *L** value (22.43). Additionally, it's the *a** (3.11) and *b** (6.69) values indicate a shift away from red and yellow hues, suggesting potential browning during jam processing. In contrast, syrup has a lighter color (higher *L** value) and displays a more prominent yellow color (higher *b** value) compared to jam and fruit. These findings align with observations by Ruiz et al. (2005). The decrease in *a** value for jam signifies a diminished red color, possibly due to pigment degradation or browning reactions during processing. Interestingly, the decrease in the *b** value suggests the boiling process might help retain yellow pigments. Furthermore, the decrease in *L** for jam could be linked to the accumulation of colored carotenoids, as reported by Abozeid and Nadir (2012), who found a positive correlation between *a** and *b** values and total carotenoid content. Overall, the colorimetric analysis provides valuable insights into the color characteristics of loquat products.

Table 5. Colorimetric Analysis of loquat fruit and syrup and jam

Treatments	*L**	*a**	*b**
Fruit	33.39^{b}+0.91	16.6^{a}+0.40	18.43^{a}+0.92
Syrup	38.47^{a}+3.32	15.45^{a}+0.07	19.92^{a}+2.87
Jam	22.43^{c}+1.92	3.11^{b}+0.70	6.69^{b}+1.33

Phytochemical and antioxidant activity

Fruits and vegetables are rich sources of various antioxidants, including phenolic acids, which contribute to their potential health benefits against chronic diseases like cardiovascular disease, cancer, and diabetes. Phenolic compounds are a diverse group of plant chemicals, with over 8,000 identified so far. Their distribution and accumulation in fruits are influenced by both genetics and environmental factors (Del Rio et al., 2013 and Crosier et al., 2009). Table 6 shows the antioxidant activity of loquat fruit, syrup, and jam measured by DPPH radical scavenging activity.

Fresh loquat fruit displayed the highest activity (75.48%), followed closely by jam (73.56%) with no significant difference between them. Table 3 presents the vitamin C and total carotenoid content across the samples. Vitamin C ranged from 4.56 to 6.41 mg/100g, and total carotenoids ranged from 3.12 to 9.82 μg/g. The decrease in vitamin C and carotenoids in jam is likely due to the heat treatments involved in its production. Hasegawa et al. (2010) reported similar vitamin C levels in other ripe Rosaceae fruits, with loquat values ranging from 5.28 to 8.20 mg/100g fresh weight. Their study also found β-carotene content of 7.8 μg/g fresh weight in an unspecified Brazilian loquat cultivar. Abozeid and Nadir (2012) reported vitamin C ranging from 1.29 to 4.2 mg/100g in jam and syrup, compared to 5.52 mg/100g in fresh fruit. β-carotene contents followed a similar trend, with jam having the lowest value (6.15 μg/g) and fruit the highest (9.18 μg/g). A study by Zang et al. (2015) found significant variations in total phenolic content among loquat cultivars, ranging from 30.58 to 43.70 mg Gallic acid equivalent (g) per gram dry weight (DW) in the peel and 9.90 to 13.73 mg g^{-1} DW in the pulp. They attributed this variation to both genetic and environmental factors.

The same study also reported that the DPPH radical scavenging activity was much higher in the peel fraction compared to the pulp across different cultivars, suggesting higher antioxidant activity in the peel. Ahumada et al. (2017) observed a decrease in total phenolic content and DPPH antioxidant capacity as loquat fruit ripened. Their findings suggest that harvesting at an earlier stage might be preferable to retain these health-promoting compounds.

Table 6. Antioxidant activity and phytochemical properties of loquat fruit, syrup, and jam

Samples	DPPH %	Vitamin C mg/100g	Carotenoids µg/g	TPC mg/100g as Gallic	TFC mg/100g as Catachin
Fresh fruit	75.48^{a}+1.32	5^{b}+0.62	9.82^{a}+0.08	11.63^{c}+0.69	5.97^{c}+0.57
Syrup	64.97^{b}+1.55	6.41^{a}+0.99	7.88^{b}+0.1	132.06^{a}+1.23	69.37^{a}+0.75
Jam	73.56^{a}+1.72	4.56^{c}+0.91	3.12^{c}+0.05	54.17^{b}+2.74	23.96^{b}+1.61

a,b,c significant differences between treatments± standard division
Values are means ±SD of three independent replicates. This means that the same column with different letters is significantly different ($p<0.05$).

Fractionation of phenolic components and flavonoids in loquat fruit and syrup and jam

Table 7 details the phenolic content of loquat syrup and jam. Interestingly, jam exhibits higher levels of both phenolic and flavonoid acids compared to syrup. The major phenolic compounds identified in the jam were pyrogallol, caffeine, chlorogenic acid, and catechol. For flavonoids, rutin, quercetin, kaempferol, and quercetin were the most prominent components. These findings align with research by Zang et al. (2015). Their study in China analyzed seven loquat cultivars for phenolic content and antioxidant activity. They identified eleven phenolic compounds, including various caffeoylquinic acids (such as 3-caffeoylquinic acid and 5-caffeoylquinic acid) and quercetin glycosides. Notably, 3-caffeoylquinic acid and 5-caffeoylquinic acid were the most abundant in both the peel and pulp of the analyzed cultivars in both fruit parts. Further supporting the presence of these beneficial compounds, Ahumada et al. (2017) reported that caffeic acid derivatives were the main phenolic group in loquats. However, their concentration significantly decreased during fruit ripening. This suggests that harvesting loquats at an earlier stage might be preferable to retain a higher content of these health-promoting phenolic acids. Xu et al. (2014) further expanded on the phenolic profile identified in loquat fruit. Their study in China foundvarious caffeic acid derivatives, including chlorogenic and neo-chlorogenic acids (mentioned earlier as major components in jam), alongside other phenolic acids and flavonoids like quercetin glycosides (a type of flavonoid also found in the jam).

Table 7. Fractionation of Phenolic Acids and Flavonoids by HPLC (mg/100g)

Phenolic acids	Syrup	Jam	Flavonoids	Syrup	Jam
Pyrogallol	46.536	66.31	Rutin	11.45	27.68
Gallic acid	15.276	27.370	Quercetrin	8.15	10.80
Catechol	26.349	35.069	Quercetin	11.21	21.84
Catechein	17.72	20.51	Kampferol	6.80	18.03
Chlorogenic acid	19. 4	37.190			
Benzoic acid	20. 132	26.613			
Caffeic acid	25.1	32.65			
Vanillic acid	25. 24	34.199			
Caffeine	40.650	49.828			
Ferulic acid	24. 58	35.04			
Ellagic acid	15.385	28.270			
Coumarin	16.61	19.58			

Fourier-Transform Infrared Spectroscopy (FTIR)

Fourier-Transform Infrared (FTIR) spectroscopy is a technique used to identify functional groups present in a molecule. By analyzing the FTIR spectra of loquat syrup and jam (Figures 2 and 3), we can explore potential structural differences between them.

Loquat Syrup

The FTIR spectrum of loquat syrup (Figure 2) displays four characteristic peaks:

3331.78 cm^{-1}. This peak indicates the presence of O-H stretching vibrations, likely from hydroxyl (OH) groups associated with phenols and alcohols.

- 1736 cm^{-1}: This peak suggests the presence of C=O stretching vibrations, potentially from carbonyl groups in esters or saturated aliphatic compounds.

- 1640 cm^{-1} This peak is attributed to N-H bending vibrations, which could be indicative of primary amines.

727 cm^{-1}: This peak signifies C-H bending vibrations, possibly from alkanes.

These peaks collectively suggest the presence of functional groups associated with phenols, amines, esters, saturated aliphatic compounds, and alkanes in loquat syrup.

Loquat Jam

The FTIR spectrum of loquat jam (Figure 3) reveals five distinct peaks:

- 33317.79 cm^{-1}: Similar to the syrup spectrum, this peak indicates O-H stretching vibrations.

- 1639 cm^{-1}: This peak suggests the presence of C=O stretching vibrations.

- 1063 cm^{-1} and 1037 cm^{-1}: These peaks are attributed to C-O stretching vibrations, potentially from carbohydrates.

- 667 cm^{-1} and 607 cm^{-1}: These lower wavenumber peaks are less commonly interpreted but could be indicative of specific bending vibrations within the molecule.

The jam spectrum shows a broader range of peaks compared to syrup, potentially reflecting the introduction of additional functional groups during jam processing (e.g., from added sugar).

Awwad and Salem (2014) investigated the functional groups of loquat leaves using FTIR. Their findings align with some of the observations in this study. The peak around 3410cm^{-1} in their study signifies N-H stretching from amino groups, which might be present in low concentrations in loquat fruit and masked by stronger peaks in our analysis. The fingerprint region (1520-1000 cm^{-1}) observed by Awwad and Salem likely corresponds to the C-O stretching vibrations we see in both syrup and jam spectra.

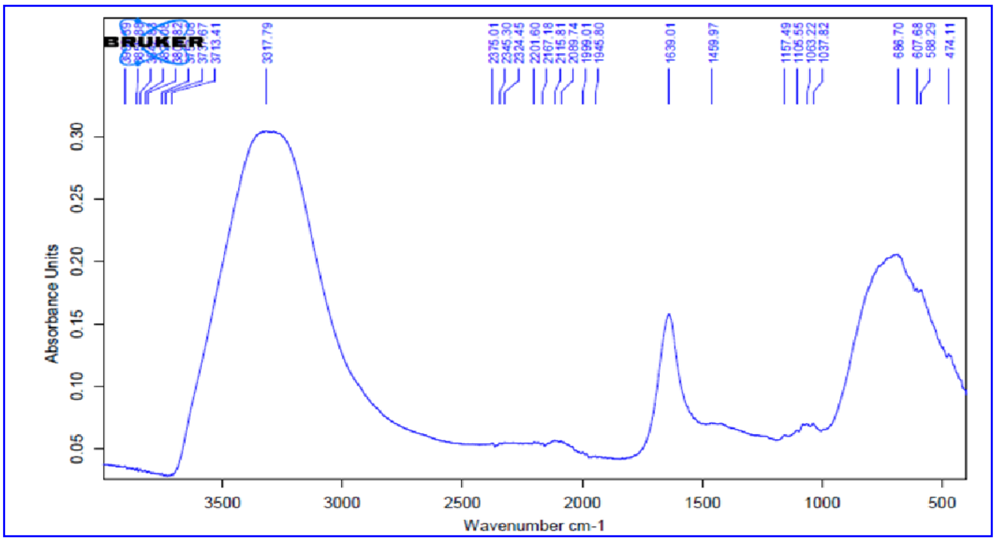

Figure 2. FTIR for loquat syrup

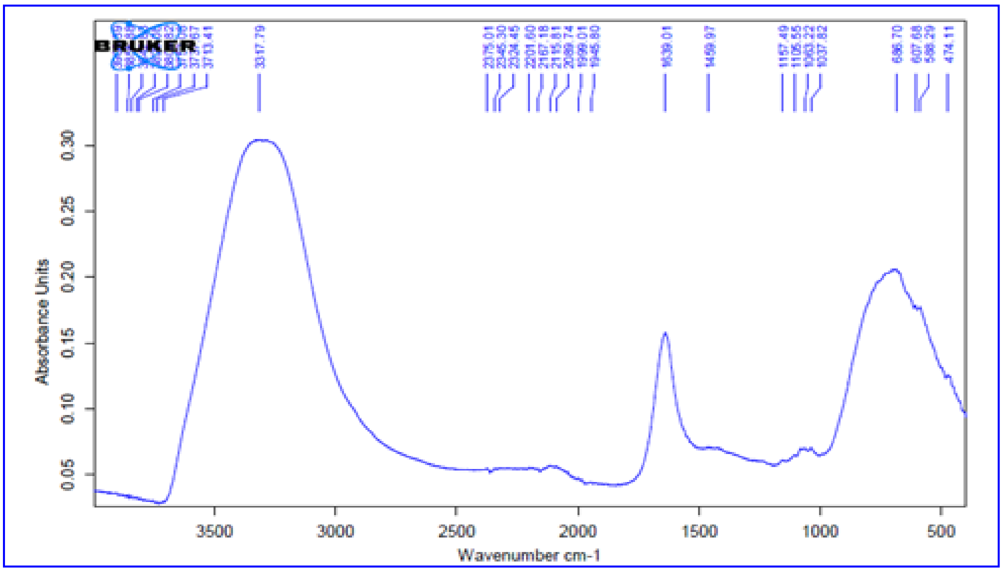

Figure 3. FTIR for Loquat jam

Conclusion

The current study's objective was to assess the impact of handling loquat natural products into syrup and jam and consider the impact of its chemical, physical, and biochemical properties. The syrup encompasses a high score for TSS, BRIX, mineral substance, color score, phenolic acids, flavonoids, vitamin C, and carotenoids. As for the jam, it has a high content of antioxidant action, tangible properties, thickness, and shear push.

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