

Eriobotrya japonica (Loquat) juice production parameters and their effect on sensory attributes and phenolic content

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Abstract— The aim of this study is to assess the juice production potential of a highly perishable fruit, namely loquat and the effect of basic thermal and chemical treatment on the sensory attributes and phenolic content. The scarcity of loquat-based products on the market limits its consumption to raw loquat fruit. It is highly perishable and thus quickly loses its postharvest commercial quality. Loquat transformation into juice would increase the shelf life of loquat-based products. Loquat fruit to loquat juice conversion value ranged between 1.79, 1.78, 2.41 and 2.39Kg of loquat fruit to produce 1kg of diluted fresh loquat juice, diluted fresh loquat juice with citric acid, pasteurized diluted loquat juice and pasteurized diluted loquat juice with citric acid respectively. The dilution factor was 0.2. All the Sensory attributes; taste, texture, appearance, aroma and overall-acceptance were significantly higher for both unpasteurized loquat juices when compared with the pasteurized ones. Total Soluble Solids (TSS) values and TSS/Titratable-Acidity of the two pasteurized loquat juices were significantly higher than those which were not, given that water-activity and pH did not differ. TSS was significantly and negatively correlated with all the sensory attributes. Finally yet importantly, the phenolic content of the untreated fresh loquat juice scored significantly the lowest while the phenolic effect of the other juices did not differ significantly from each other. When the phenolic content per 100gr TSS where the loquat juice with 1% citric acid scored significantly the highest than all of the other juices which did not differ significantly from each other.

Keywords— Loquat, Fruit to juice conversion value, Total Soluble Solids, Phenolic content, Water activity.

I. INTRODUCTION

Loquat (*Eriobotrya japonica* Lindl) belonging to the family Rosaceae and subfamily Maloideae, is a subtropical evergreen fruit tree and very well adapted to temperate areas [1]. Loquat Fruits are spherical or oval in shape, possess orange or yellow color, with soft and juicy flesh and a tough thin skin. Loquat is well adapted, cultivated and commercially spread in many regions although in the Mediterranean countries; it is underutilized for its production and thus consumption [2] [3]. Loquat is non-climacteric fruit [4] [5] the fruits are not suitable for storage and transportation and have a relatively short postharvest life. In the. The fruit-ripening period in

Mediterranean region is concentrated in a few months of the year: March, April, and May [6].

Loquat fruit is popular for its healthiness, juiciness taste, and high content of phytochemicals such as carotenoids and flavonoids [7]. Loquat fruit is consumed largely as fresh fruit, but recently significant amount of work is done to induce it as a major ingredient in various processed food products, such as jellies and jams [8].

The development of loquat fruit has two stages: the growth stage, and maturation stage with ripening-related changes [9] [8]. The quality of loquat fruit is closely related to sugar accumulation and Total Soluble Solids/Titratable Acidity (TSS/TA) ratio [10]. The extractable juice rate decreases after low-temperature storage, and finally In the

last phase of loquat fruit senescence there is loss of flavor and taste, and gradual decrease in juiciness until a dry and firm texture -leather like- is reached [9]. Ethylene and CO₂ production gradually decline during fruit maturation [11] [12].

Parameters like total acids [13], total soluble solids (TSS) and their ratio (TSS/TA) are very important in determining fruit quality [14] [15]. The high quality loquat fruits possess total soluble solids more than 12 Brix. The major soluble sugars in loquat fruit are fructose, glucose and sucrose and the major sugar alcohol is sorbitol [16]. Good flavor of loquat is closely related to the ratio between sugar and acid. Titratable acidity [13] of loquat fruit with good taste ranges from 0.3 to 0.6%. Titratable acidity [13] of loquat fruit with good taste ranges from 0.3 to 0.6% [17]

Aroma compounds are also important in contributing to the unique flavor of loquat fruit. The most potent of the aromatic compounds is phenylacetaldehyde [13]. Color/appearance, is the visible marker of loquat fruit ripening level and mainly the color of peel and flesh would result in juice color. Lutein and β -carotene were the major carotenoids in the peel of both red- and white-fleshed cultivars and β -cryptoxanthin in some red-fleshed cultivars, and β -carotene were the most abundant carotenoids in the flesh [18]. In addition, phenolic compounds, including several hydroxycinnamic acid derivatives and flavonoid glycosides, were identified from loquat fruit, and these can serve as antioxidative agents of excellent value for human health [19].

Loquat juice might be a food ingredient that provides flavor and freshness. It might also reduce the waste due to degradation of the very high perishability of loquat fruits even in fridge.

II. MATERIALS AND METHODS

2.1. Loquat fruits

In our study, loquat fruits (*Eriobotrya japonica* Lindl) were collected from orchards southern of Lebanon at around 140 days post anthesis.

2.2. Physico-chemical properties

Juicer: Excel Pro Juicer Silver JE880 (Kenwood) was used.

Brix Value: Brix Value was measured using Portable hand held RFM700 refractometer (Bellingham and Stanley LTD. United Kingdom).

Weight determination: Weight was measured using Portable electronic balance Model 727 was used to measure the weight with an accuracy of ± 1 gr (Jata Hogar).

pH: Microcomputer based pH /conductivity /TDS /salinity and temperature pocket meter Model pH/EC80 was used to measure the pH (Jenco VisionP).

Titrateable Acidity: TA was determined in triplicate by titration with 0.1 N NaOH up to pH 8.1 and expressed as g/100g malic acid, using phenolphthalein as indicator [20].

Volume Determination: 10mL glass graduated cylinder, with sub gradations of 0.1mL (Graduated cylinder, tall form, BLAUBRAND®, class A, Boro 3.3, DE-M).

Water activity: It was determined using Pawkit water activity meter. Samples were flattened to cover the bottom of the cup and then water activity was measured at room temperature [21].

2.3. Procedure

After having the loquat fruit they were deseeded and juice was extracted resulting in Fresh loquat Juice (FLJ). The loquat juice produced was diluted following this ratio: 250g water per 1 kg juice. This was done to be similar to recommended Brix Value between 10 to 11 similar to Honeydew melon and that of orange juice [22] [22]. Then this juice resulted in four different parts. One diluted loquat juice (DLJ), two diluted loquat juice plus citric acid (1%) (DLJCA), three pasteurized loquat diluted juice (PDLJ) and last but not least part four being pasteurized diluted juice plus citric acid (PDLJCA) (Fig. 1).

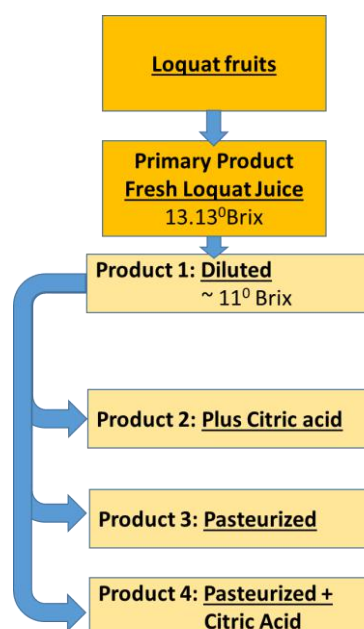


Fig.1 Summary of study flow

Each one kg of loquat fruit gave around 445gr fresh juice and 555gr leftovers. Please note that the pasteurization procedure was 85°C for 7 minutes similar to that used by Hurtado [23].

2.3. Sensory Analysis

The sensory attributes attained from 60 taste panelists include: taste, with 1 having worst taste and 9 having the best; texture, with 1 having the worst texture and 9 having the best; appearance, with 1 having the worst and 9 having the best appearance; aroma, with 1 having no aroma and 9 having best aroma; and overall acceptability, with 1 having lowest acceptability and 9 having the highest acceptability. In addition to that, the sensory average score of each loquat juice was calculated by taking the mean of the different sensory attributes.

2.4. Phenolic content

Phenolic content was done using spectrophotometer method - HACH™ method # 8047 [24]. The 4-aminoantipyrine method measures all ortho- and meta-substituted phenols.

2.5. Statistical analysis

All tests and analysis were run in triplicates. General linear model performed via SPSS (statistical Package for the Social Sciences, version 17.0) was used to study the difference between the physicochemical properties and the score of the sensory attributes of the four different products. Least significant difference was used for mean separation of the physicochemical properties while Bonferroni test was used for the mean separation of the sensory attributes,

Furthermore, partial correlation was applied between the different sensory attribute and the physicochemical properties taking the type of product as a control variable.

TSS was significantly and negatively correlated with all the sensory attributes while other physicochemical properties were not significantly correlated with them.

III. RESULTS

3.1 Physicochemical

3.1.1 Water Activity (aw) and pH of the fresh loquat juice and that of the four products

The aw and the pH of the fresh juice and the four products did not differ significantly. All the pH-s were lower than 4.6 thus they are in the high acid product category and there was no significant difference between the pH of fresh juice and the different products. The aw of the different juices was around 0.96-0.97 (Table 1).

Table 1 Water activity and pH of Loquat Juices

	pH	Water Activity
	Mean ± SE	Mean ± SE
FLJ	3.60a ±0.13	0.97a ±0.01
DFLJ	4.00a ±0.16	0.96a ±0.01
DFLJCA	3.60a ±0.16	0.96a ±0.01
PDLJ	3.97a ±0.16	0.97a ±0.01
PDLJCA	3.57a ±0.16	0.97a ±0.01

• Within Columns, means with different alphabets are significantly different.

• D: Diluted, F: Fresh, L: loquat, J: juice; P: pasteurized, CA: Citric Acid;

3.1.2 Loquat juice conversion values

It was recorded that 2.22 loquat fruits were needed to produce 1kg of FLJ which was significantly lower than the conversion values of the pasteurized loquat juices with and without citric acid and significantly higher than diluted fresh loquat juices with and without citric acid (Table 2). This was mirrored in the kg juice per kg fresh loquat juice where the diluted loquat juice with and without citric acid were significantly lower than those of the pasteurized loquat juice with and without citric acid (Table 2).

Table 2 Different conversions to Loquat Juices

	Kg juice / kg loquat fruit	Kg juice / kg Fresh Juice
	Mean ± SE	Mean ± SE
FLJ	2.22a ±0.04	1*
DFLJ	1.79b ±0.05	0.8a ±0.01
DFLJCA	1.78b ±0.05	0.8a ±0.01
PDLJ	2.41c ±0.05	1.08b ±0.01
PDLJCA	2.37c ±0.05	1.06b ±0.01

• Within Columns, means with different alphabets are significantly different.

• D: Diluted, F: Fresh, L: loquat, J: juice; P: pasteurized, CA: Citric Acid;

• *: It is the primary juice from which all other juices are done

3.1.1 Total Soluble Solids (TSS), Titratable acidity (TA) and TSS per TA

The total soluble solids was measured in terms of °Brix. The diluted fresh loquat juices with and without citric acid had the significantly lowest TSS followed by the TSS of the fresh loquat juice which in turn had a significantly lower TSS than that of the pasteurized loquat juices with and without the addition of citric acid them possessing the significantly highest TSS (Table 3).

The diluted fresh loquat juices with and without citric acid had the significantly lowest TA followed by the TA of the fresh loquat juice which in turn had a significantly lower TA than that of the pasteurized loquat juices with and without the addition of citric acid them possessing the significantly highest TSS (Table 3).

As for the TSS/TA values, those of the diluted fresh juice with and without the addition of citric acid were significantly the highest compared to fresh loquat juice, pasteurized loquat juices with and without citric acid addition, which did not differ significantly from each other (Table 3).

Table-3 Total Soluble Solids (TSS), Titratable Acidity (TA) and TSS/TA of the different loquat juices

	TSS (°Brix)	TA (g/100gr)	TSS/TA
	Mean ± SE	Mean ± SE	Mean ± SE
FJ	13.13a ±0.25	0.643a ±0.014	19.371a ±0.016
DFJ	10.67b ±0.33	0.547b ±0.016	19.519b ±0.01
DFGCA	10.33b ±0.33	0.529b ±0.016	19.544b ±0.018
PDJ	14.33c ±0.33	0.742c ±0.016	19.319a ±0.018
PDJCA	13.67c ±0.33	0.706c ±0.016	19.347a ±0.018

- Within Columns, means with different alphabets are significantly different.
- D: Diluted, F: Fresh, L: loquat. J: juice; P: pasteurized, CA: Citric Acid;

3.2 Sensory attributes

3.2.1 Taste and aroma

The taste scores of the fresh loquat juice and the fresh diluted loquat juice with and without citric acid did not differ significantly from each other and scored significantly higher than the pasteurized loquat juice and the pasteurized loquat juice with citric acid (Fig. 2). Note that the fresh loquat juice and the diluted fresh loquat juice with and without citric acid addition had a score ranging from 7.26 till 8.00 while the pasteurized loquat juices with and without citric acid addition scored below 5 (Fig. 2).

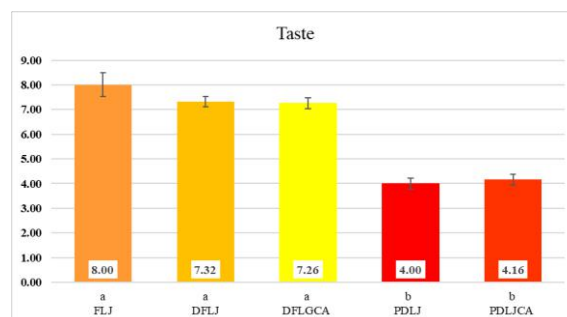


Fig.2 Taste scores of the different Loquat juices

- Within category means with different alphabets are significantly different.
- D: Diluted, F: Fresh, L: Loquat, J: juice; P: pasteurized, CA: Citric Acid;

As for the aroma scores the fresh loquat juice scored significantly the highest followed by the diluted fresh juice with and without citric acid addition, which scored significantly higher than pasteurized loquat juice with and without citric acid addition (Fig.3). Furthermore, the fresh loquat juice and the diluted fresh loquat juice with and without citric acid addition had a score ranging from 6.04 till 8.26 while the pasteurized loquat juices with and without citric acid addition scored below 5 (Fig. 3).

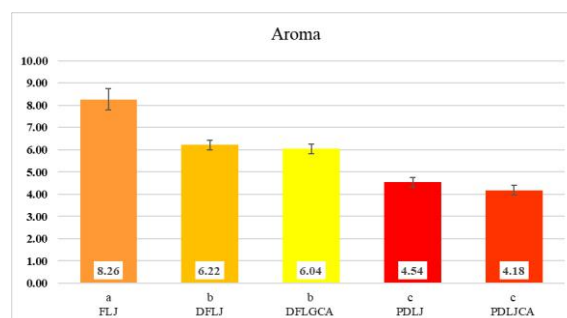


Fig.3 Aroma scores of the different Loquat juices

- Within category, means with different alphabets are significantly different.
- D: Diluted, F: Fresh, L: Loquat, J: juice; P: pasteurized, CA: Citric Acid;

3.2.2 Texture and appearance

The texture score of the pasteurized loquat juice with and without citric acid addition scores were significantly the lowest followed by those of the diluted fresh loquat juice with citric acid addition, then by the diluted fresh loquat juice and ending, in a significantly ascending order, with the fresh loquat juice (Fig. 4). In addition to that, pasteurized loquat juices with and without the addition of citric acid scored below 5, and those scores of fresh loquat juice, diluted fresh loquat juice with and without citric acid ranged from 6.08 to 8.37 (Fig. 4).

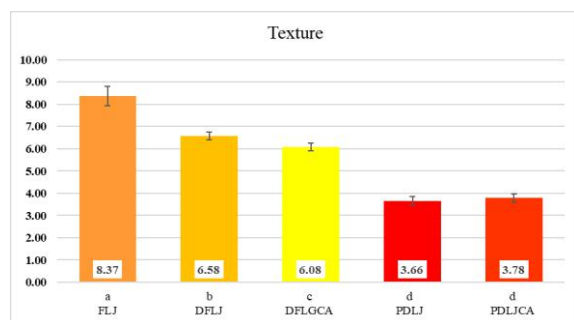


Fig.4 Texture scores of the different Loquat juices

- Within category, means with different alphabets are significantly different.
- D: Diluted, F: Fresh, L: Loquat, J: juice; P: pasteurized, CA: Citric Acid;

As for the appearance sensory attribute, it was significantly the highest value for the fresh loquat juice, followed by the diluted loquat juice with and without citric acid addition, which possess significantly indifferent scores, ending with the significantly lowest values for the pasteurized loquat juice with and without citric acid addition (Fig. 5). In a similar pattern to the previous sensory attributes, the scores of the fresh loquat juice and diluted fresh loquat juice with and without citric acid addition ranged between 6.64 and 8.36 while those of pasteurized loquat juices with and without citric acid were below 5 (Fig. 5).

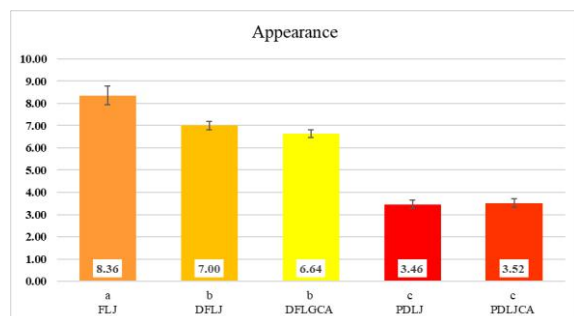


Fig.5 Appearance scores of the different Loquat juices

- Within category, means with different alphabets are significantly different.
- D: Diluted, F: Fresh, L: Loquat, J: juice; P: pasteurized, CA: Citric Acid;

3.2.3 Overall acceptance and average score

The overall acceptance, which summarize the satisfaction of the panelist, followed the same pattern of the taste score values. The overall acceptance scores of the fresh loquat juice and the fresh diluted loquat juice with and without citric acid addition did not differ from each other and the values range from 7.25 to 8.33. Furthermore, the pasteurized loquat juice with and without citric acid addition overall acceptance scores did not differ significantly from each other, both scoring significantly lower than the fresh and fresh diluted loquat juices with

and without citric acid with values ranging from 4.63 to 5.02 (Fig. 6).

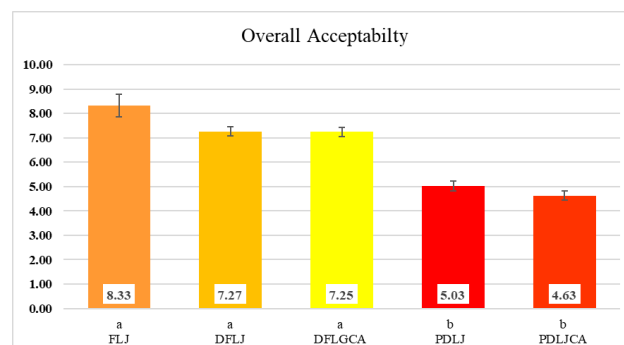


Fig.6 Overall acceptance of the different Loquat juices

- Within category, means with different alphabets are significantly different.
- D: Diluted, F: Fresh, L: Loquat, J: juice; P: pasteurized, CA: Citric Acid;

The average score, which summarize the score of all the sensory attributes, of the fresh loquat juice did not differ significantly from the diluted fresh loquat juice, both average scores being significantly higher than the all the other loquat juices. The fresh loquat juice with citric acid average score was significantly higher than the pasteurized loquat juices, which had the significantly lowest average scores. The diluted fresh loquat juice and the diluted fresh loquat juice plus citric acids values, for overall acceptance and average score, were significantly higher than those values of the pasteurized diluted loquat juice and pasteurized diluted loquat juice (Fig. 6) (Fig. 7). The average score of the fresh loquat juice and the diluted fresh loquat with and without citric acid were between 6.65 and 8.39 and those of the pasteurized loquat juice with and without citric acid were below 5 (Fig.7).

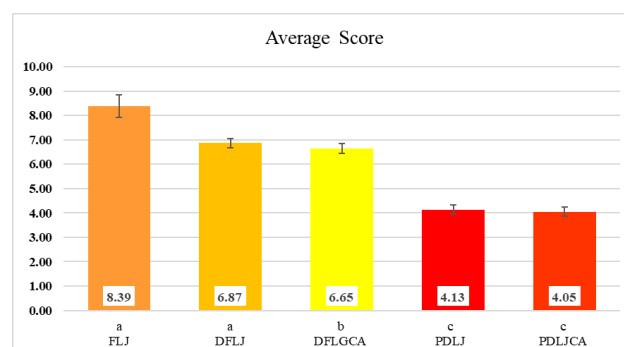


Fig.7 Average scores of the different Loquat juices

- Within category, means with different alphabets are significantly different.
- D: Diluted, F: Fresh, L: Loquat, J: juice; P: pasteurized, CA: Citric Acid;

3.3 Phenolic Content

The phenolic content (mg/L) of the different loquat juices was significantly the lowest in the diluted fresh loquat juice followed by the fresh loquat juice, which was significantly lower than the rest of the loquat juices.

However, due to the different TSS of the juices, the phenolic content [25] was measured per 100gr TSS. This has showed that the phenolic content per 100 gr TSS was significantly the highest in the Diluted Fresh loquat juice with citric acid. There was no significant difference in this parameter in phenolic content per 100 gr TSS between all the other juices (Table 4).

Table.4 Phenolic content of Loquat Juice

	mg/L	Mg/100gr TSS
	Mean \pm SE	Mean \pm SE
FLJ	26.44a \pm 0.98	203.11a \pm 8.48
DFLJ	21.15b \pm 1.06	199.36a \pm 9.79
DFLJCA	28.91ac \pm 1.06	279.98b \pm 9.79
PDLJ	30.75c \pm 1.06	214.42a \pm 9.79
PDLJCA	29.90c \pm 1.06	219.05a \pm 9.79

- Within Columns, means with different alphabets are significantly different.
- D: Diluted, F: Fresh, L: loquat, J: juice; P: pasteurized, CA: Citric Acid;
- *: It is the primary juice from which all other juices are done

IV. DISCUSSION

The pH of the loquat juice in all forms, which did not differ significantly, ranged from 3.6 to 4.0 and thus it can be categorized as high acid fruit juice. This is in accordance to the pH recorded by Curi et al. who studied the processing potential of jellies from subtropical loquat cultivars [26]. The aw of the different Loquat juice also did not differ significantly and was in the range of 0.96 – 0.97.

The loquat fruit to loquat juice conversion values are an indicator of the amount of fruits needed per one kg of juice. As expected the diluted fresh loquat juices with and without citric acid needed the least amount of fruits followed by the fresh loquat juice and that the pasteurized juices. This reflected itself by the TSS of the different juices. Where the TSS of the fresh loquat juice is around 13.13°Brix, which is an indicator of good quality fruits since it is higher than 12% TSS [17]. Furthermore, it is in accordance to Song et al. who studied the loquat fruit development and ripening process who reported similar Brix values at 140 post-anthesis days [10].

As for the TA the fresh loquat juice and the diluted fresh loquat juices with and without citric acid had a TA within

the range of 0.53% and 0.64%. In addition, those of the pasteurized loquat juices with and without citric acid were around 0.7%. As for the fresh loquat juice, it is in accordance to the value reported by Song et al. [10]. Furthermore, these values when combined with the sensory attributes results are in accordance with Tian et al. [17] who stated that TA of good tasting loquat fruit ranges from 0.3 to 0.6%. This might explain the sensory attributes results where the fresh loquat juice, diluted fresh loquat juice with and without citric acid scored significantly higher than the pasteurized loquat juices with and without citric acid. May be readjusting the TA of the pasteurized juices would improve their sensory scores.

When the TSS/TA is tested the interesting part that significance between the values of the fresh loquat juice and the pasteurized loquat juices with and without citric acid disappeared. This might be to the effect of the dilution, citric acid addition and pasteurization, which are factors that should be further investigated.

As for the phenolic content the diluted fresh juice had the lowest phenolic content, which can be explained by the lower TSS. However, by adding citric acid and with no pasteurization the phenolic content of the fresh loquat juice with citric acid was comparable to fresh juice and the pasteurized loquat juice with and without citric acid. Addition of citric acid might have induced chemical denaturation of oxidizing agent in the fresh juice hindering its deterioration. As for pasteurization it could have induced thermal denaturation of the oxidizing agent thus the effect of the citric acid was not noticed. However, looking at the fact that the addition of citric acid with no pasteurization resulted in the highest value of phenols per 100 gr TSS, with the other not significantly different, lead us to assume that the pasteurized loquat juices with and without citric acid had the highest phenolic content is due to the significantly highest TSS. Pasteurization also resulted in significantly lower sensory scores on all level. Thus, pasteurization process of loquat juice should be further investigated to get the better temperature time combination with or without additives.

V. CONCLUSION

Loquat juice is a high acid juice. Pasteurization process should be further investigated further and adjustment of the resulting juice to TA between 0.3 and 0.6 by water should be investigated. Addition of citric acid should be advised to ready to drink fresh juice to preserve the phenolic content

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