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Shilan Muhammad

Abdulla<sup>a\*</sup>

Azhin Baxtyar

Mahmood<sup>b</sup>

Sokar Kamal Mahmood<sup>a</sup>

Sakar Kamal Hama Salh<sup>a</sup>

*a Food science and quality control, College of Agricultural Engineering Science-University of Sulaimani - Sulaimani- Iraq*

*b Kurdistan Institution for strategic & Scientific research, Sulaymaniyah, Iraq*

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## A Comparative Study of the Physicochemical Properties and Sensory Evaluation of Commercial Orange Juice sold in the Sulaimani Market with Local Preparation of Orange Juice

### ABSTRACT

Orange juice is one of the most popular juices on the market. The bulk of accessible fruit drinks are synthetic and may include a number of toxic and poisonous substances those are harmful to customers' health. This study compares the physicochemical parameters, sugar content, organic acids, and sensory evaluation of commercial and fresh orange juice samples. The orange fruit was treated to produce fresh juice, which has 100% fruit content and no sugars or diluents. Packaged juice samples were obtained from a local store, and all testing was completed prior to the expiration of the juice's shelf life. Total solids, ash content, and pH were among the physicochemical properties investigated, with values ranging from 9.507–13.145%, 0.110–0.447%, and 4.360–5.970, respectively. Sugar content was observed to be in the ranges of 2.118–5.278, 2.641–4.317, and 2.563–4.184 g/100 ml for glucose, fructose, and sucrose individually. Organic acids (ascorbic, acetic, and citric acid) were found to have concentrations ranging from 25.170–43.981, 1.307–5.760 and 311–411.33 mg/100 ml separately. Sensory evaluation revealed a significant difference ( $p < 0.05$ ) between homemade and commercial orange samples. According to the acquired results and cluster analysis, there is a significant difference between handmade and commercial juice parameters. Commercial items include more sugar than fresh samples. The findings of this study contribute to our understanding of the nutrition and quality of commercial and homemade orange juice samples. Commercial samples are not recommended for regular intake due to the significant differences between artificial and fresh orange juice samples.

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## INTRODUCTION

Fruits have long been included in the human diet. They are also considered food supplements, and their high content of water, carbohydrates, vitamins, and minerals, as well as their outstanding quality, make them worldwide recognized as essential to optimal nutrition (Wardlaw, 2004; Potter and Hotchkiss, 2006).

Orange (*Citrus sinensis*) is divided into three general and about eighteen distinct species (Etebu and Nwauzoma, 2014). It is cultivated extensively in Nigeria, as well as other tropical and subtropical locations across the world (Etebu and Nwauzoma, 2014). According to FAO Statistics (Ezeama, 2007), global production is at over 108 million tons. *Citrus sinensis* is recognized as amongst the most important fruit crops in the world's tropical and subtropical regions. They

\* Corresponding author: E-mail: [shilan.abdulla@univsul.edu.iq](mailto:shilan.abdulla@univsul.edu.iq)

contribute to the diets of many people across the world and are highly valued for their nutritional content (Ndubunma, and Ulu, 2011).

Processing these fruits into fruit juices is one method of preventing degradation and consequent loss (Wenkam, 1990; Vanamala *et al.*, 2006). Orange fruits are processed, generally on an industrial scale, to provide appropriate long-term preservation, storage, reduce transit costs, limit microbial development, and guarantee an off-season supply of juice (Goyle and Ojha, 1998). In Europe and around the world, orange juice is the most commonly used fruit juice. It's produced from the *Citrus sinensis* fruit's endocarp. According to the United States Code of Federal Regulations, Orange juice is an unfermented juice produced from matured oranges of the *Citrus sinensis* species. It has been scientifically proved that orange juice has numerous proven health advantages due to its high concentration of vitamins and other antioxidants such as hesperidin and flavones (Morand *et al.*, 2011). It also includes a range of important nutrients, including proteins, carbohydrates, organic acids, and minerals. The most prevalent component in orange fruits is ascorbic acid (vitamin C). It is required for the production of collagen, and a shortage of vitamin C causes scurvy, which results in tooth loss. Vitamin C contains a variety of additional health-promoting properties (Zvaigzne *et al.*, 2009).

The aim of this research is to assess and focus on the physicochemical and qualitative properties of orange juice. The nutritional content of commercial and homemade orange juice is compared. Many products of orange juice accessible in the Sulaimani market motivate the interest of regulatory authorities and assist ignorant customers in making healthier decisions.

## **MATERIALS AND METHODS**

### **Chemicals, Reagent and standards**

Throughout the analysis, all chemical materials were of analytical grade. Standard solutions of glucose, fructose and sucrose all with a purity of 99%, were purchased from Merck company (Darmstadt, Germany), acetonitrile CH<sub>3</sub>CN (99.9 %) HPLC grade from Caledon Company (Canada), Sodium phosphate KH<sub>2</sub>PO<sub>4</sub> (monobasic) solution (Biochem chemopharma, France), Glacial acetic acid (99.7%) (Biochem chemopharma, France), ascorbic acid (90.3%) and citric acid anhydrous (98%), were bought from CARLO ERBA Reagents (S. A. S, France). Phenolphthalein, phenol, sodium Hydroxide, and sulfuric acid were purchased from Scharlau Co. (Spain).

### **Equipment**

Digital pH meter (model Jenway 3510), C18 SepPak cartridge, Refractometer, Muffle furnace, oven, the system of HPLC contain RI detector (Hitachi), amine polar bonded phase column, interstation C18 column L1 (200mm × 4.6mm I.D. 10 µm), Column INTERSPHERE Sugar-2, 9 µm (7.8 x 300mm). An HPLC equipped with a pump delta chrom™ waters (e2695) separation module, a refractive index detector (R1830) analysis, RI detector (water/2414) (KNAUER Germany) with column temperature of 60°C. The type of ultrasonic bath is UC 002BM, (Telsa Stropkov, Slovak republic). Column INTERSPHERE Sugar-2, 9 µm (7.8 x 300mm) (UP) Serial No. 19L0076024 (GL Sciences, Japan) and the controller evaluation were with program clarity version CR21-0862.with software D13214581M.serial number (IQ, OQ and PQ).

### **Collection of Orange fruit**

Twenty-five kilograms of fresh and ripe orange (*Citrus sinensis* L.), the Iraqi national orange known as the "Baqubah orange," were purchased at a local market in Baghdad, Iraq, during the December 2021 harvest season. At random, a sample of uniform size and color was picked.

### **Extraction of Orange Juice**

Fresh oranges were cleaned thoroughly under tap water before being cleansed again with distilled water to eliminate foreign extraneous contaminants. The fruits were carefully washed before being peeled by hand with a kitchen knife. The pulp, seeds and skins were parted. The pulp size was reduced to improve extraction of liquid components and to facilitate mixing. The mixed pulp was removed with a sanitized towel and pasteurized at 90°C for 1 min. Before analysis, the final juice was poured hot into sterile bottles and kept at -2°C. The total weight of the orange was 25 kg, and it yielded 71.36 percent (m/m percent) orange pulp. Fruit juice accounted for 50.622 percent of the pulp output (Agbaje *et al.*, 2020). The following two groups were obtained from our

fresh orange juice: Group 1: pasteurized fresh orange juice, coded as "Fresh1"; and Group 2: unpasteurized fresh orange juice, coded as "Fresh2".

### **Collection of Trading Orange juice samples**

Orange juices were made up of five different brands that were purchased at Sulaimani's grocery stores and supermarkets. They were assigned the following codes: Group 3 consists of single-brand plastic fruit drinks, which are coded as (IT). Group 4 consists of three brands of bottled fruit juices (ER, TA, and IS). Group 5: a glass of fruit juice from a single brand, coded as (FN).

### **Physiochemical Analysis**

The pH of orange juice samples was determined using an AOAC (2012) Method 981.12 and calibrated pH meter (model Jenway 3510) with buffer solutions of pH 4.0 and 7.0. A calibrated refractometer was used to assess the total soluble solids of the juice sample, (TSS) (Gbarakoro *et al.*, 2020). The orange juice content, total acidity, fixed acidity, and volatile acidity were measured using an altered version of the method designated by Nielsen (2009). The AOAC (2010) technique was used to determine the moisture content, ash content, and total solids.

### **Determination the level of glucose, fructose and sucrose using HPLC**

#### **Stock solution preparation**

A stock solution (10%) of glucose, fructose, and sucrose was prepared with equal ratio of acetonitrile and distilled water (1:1) as a solvent (Liu *et al.*, 2006), (Ahuja & Dong, 2005).

#### **Standard Solution preparation:**

A series of standard solutions for glucose, fructose, and sucrose with varying concentrations of 0.5, to 5.5 % were prepared independently from their stock solutions (10%) using the same solvent (acetonitrile and distilled water (1:1)). To homogenize the solutions, they were all shaken vertically. A series of mixed standard solutions of glucose, fructose, and sucrose in the range of 0.5-5.5 %, were prepared. Then, for each standard solution, a chromatographic run was performed, and the chromatograms were recorded.

#### **Standard parameters for using HPLC for analysis of orange juice samples**

The liquid chromatographic technique was used to determine glucose, fructose, and sucrose concentrations. In a 250 mL beaker, 22 mL of 10 mM sodium phosphate (monobasic) solution was mixed with 78 mL of acetonitrile as the mobile phase. By using an ultrasonic bath the solution was degassed. A 0.5  $\mu\text{m}$  nylon membrane filter was used for filtrating the solutions before analysis by HPLC, and the mobile phase solvent was degassed. To achieve the maximum performance, all of the components' conditions, such as equilibration and mobile phase flow rate, were standardized according to the method used before starting the analysis.

#### **Orange Juice Samples Analysis by HPLC**

Using a homogenizer at the highest speed, all samples were homogenized for 3-5 min. The filtrate (12.5 ml) was then diluted into 50 mL using a 1:1 diluent combination of acetonitrile and distilled water. The newly diluted orange juice was filtered using the C18 Sep-Pak cartridge. Total sugars from freshly squeezed fruit juices were in the eluate. The eluate was filtered via a 0.45  $\mu\text{m}$  nylon filter before HPLC analysis.

The standard solutions and juice samples were assessed in the same approach. The retention times of standard solutions were compared to the chromatographic peaks for each measured juice sample. To collect the information and perform the calculations, the Shimadzu LC solution program was employed. The calculation's outcome was represented as the percent of specific sugars in distinct juices. The calibration curve was developed by utilizing the peak areas to obtain the quantification values.

#### **Determination of organic acids (ascorbic acid, acetic acid and citric acid) using (HPLC)**

##### **Standard Solutions**

The stock standard solutions of ascorbic acid (1 mg ml<sup>-1</sup>), citric acid (10 mg ml<sup>-1</sup>), and acetic acid (10 mg ml<sup>-1</sup>) were prepared. The stock solutions were kept in the dark at 4°C until they were analyzed. The diluted solution in the mobile phase range of 150 to 1000  $\mu\text{g ml}^{-1}$  for acetic acid, 100 to 1000  $\mu\text{g ml}^{-1}$  for citric acid and 2.0 to 100  $\mu\text{g ml}^{-1}$  for ascorbic acid were used to construct the calibration curve.

**Preparation of Orange Juice Samples:**

For 15 minutes, the total orange juice was centrifuged at 13200 rpm. For the measurement of organic acids, the supernatant was diluted with a mobile phase at a ratio of 1:10 and 1:5. Before injection, the diluted solutions were filtrated with the membrane (0.45 µM).

**Sensory Evaluation:**

A sensory evaluation of all mixed juice samples was conducted by a taste testing panel. The panel consisted of ten test panelists who were chosen from food science and quality control department at University of Sulaimani in Sulaimani city and were informed before assessing the sensory quality of the juice samples. On a numeric rating scale, the panelists were required to rate the color, flavor, sweetness, and overall acceptability as sensory evaluation parameters, which are commonly used for evaluating food and beverage products. The scale was set up as follows: 9 = extremely like, 8 = very much like, 7 = moderately like, 6 = slightly like, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely. The analysis of variance (ANOVA) and Duncan multiple comparison test were used for analysis of the data (AOAC, 2005).

**Experimental Design and Multivariate Analysis:**

Analysis of variance (ANOVA) was performed to evaluate the chemical composition of the orange juice content. The set of data were statistically evaluated using ANOVA method as a general test of the treatments, and the reversed least significant difference test (Duncan at  $P < 0.05$ ) was used for mean comparisons. The hierarchical cluster analysis as one of the common multivariate analysis parameter was also utilized to determine the degree of similarity between the various types and our homemade orange juice samples.

**RESULTS AND DISCUSSION****Physicochemical properties of the orange juice**

The orange juice physicochemical parameters are presented in Table 1. Juice with a pH of 3 to 4 may have a high ability to suppress the growth of harmful microorganisms. Citrus juices include flavonoids (particularly in the pulp), which may be beneficial to health. Orange juice also contains the antioxidant hesperidin. Orange juice is acidic due to the citric acid component, with a usual pH of roughly 3.5. Citric acid is the primary acid in orange juice, according to Kareem & Adebawale (2007). Edible acid influences the primary microbial community in food and, to a considerable extent, affect the juice's storage durability (Ezeama, 2007). The higher acidity of the juice, the less sensitive it is to bacteria, but the higher acidity, the more susceptible it is to yeast and mould (Jay, 2000). Furthermore, Anvoh *et al.* (2009) revealed that fruit acids influence the color, flavor, and taste of juice products. The results in table 1 revealed that the pH of fresh extracted orange juice is lower than that of commercial samples, which is most likely owing to their naturalness since they are prepared only from their fruit and contain no water or other additives that may cause a change in the pH value. Another explanation for the discrepancy might be connected to the shelf life and storage of commercial samples, which normally influence the majority of the parameters in food and drink samples.

Brix value, total acidity, and the Brix-acidity ratio are all quality measurement indicators for determining the sweetness, tartness, and degree of ripeness of the fruits used to prepare the juice. Brix levels must be at least 11 and the ratio (Brix: acid) must be between 12.5- 20.5 (Gbarakoro *et al.*, 2020). A high Brix value suggests a high quantity of sugar as well as amino acids, minerals, organic acids, and other water-soluble components, whereas a high titratable acidity indicates a high level of organic acid. According to Codex Stan 45-1981, standards for preservation of orange juice abundantly by physical means, when the Brix-acidity ratio indicated as citric acid is excess of 15, the word "sweetened" could be used on the label to indicate that the product has been artificially sweetened. The Brix-acidity ratio of fresh extracted orange juice samples varied from 13.52 to 13.71, according to the results in Table 1. This indicates that the freshly extracted samples aggregated with Codex Stan 45-1981, however, all commercial samples have a ratio larger than 15%. (16.36 to 25.52 percent) This reveals that all of these packed orange juices might have been modified or contained extra ingredients such as sweeteners (Utama *et al.*, 2015).



Moisture is a key component in the quality of food, conservation, and deterioration resistance. When it comes to moisture content, the results reveal that it ranged from 87.267% in freshly prepared orange juice to 90.493% in an IT commercial orange juice sample. The current study's findings indicate that there are no significant differences between all types of orange juice from different types ( $P < 0.05$ ). However, none of the samples agreed with the USDA Nutrient Database's claimed 86.75% (Galaverna, & Dall'Asta, 2014). Because of its high moisture content, orange juice is thought to be an excellent supply of water in the body, especially during seasons of decreased appetite when water consumption is no longer desirable (Baturh & Olutola, 2016).

Also, the results of total solid were similar to that of the TSS, the highest value return to fresh juice2 (12.733%), and the lowest value was the (IT) brand juice (9.507%), the result was agreed to the result found by (Ndife *et al.*, 2013),

Total (soluble and insoluble) solids are utilized to determine the fruit juice content. The characterization of the quality of juice and other beverage products can be evaluated by total solids and total soluble solids content (Egbekun and Akubor, 2007; Adubofuor *et al.*, 2010). The findings reveal that there is no considerable difference in total solid content between homemade and commercial orange juice (Table 1) (Agbaje *et al.*, 2020).

The inorganic residue left behind after the ignition or full oxidation of organic materials in a food is referred to as ash. The ash content was determined using the weight reduction method (AOAC, 2010). The ash content in foodstuffs shows the entire mineral content. Determining the ash content may be necessary for a variety of reasons. It is a component of proximate analysis for nutritional assessment. The ash content of foods, which is an inorganic component of foods, reflects the diversity of mineral elements found in dietary products. Fruits, fruit juice, and melons have 0.2–0.6% ash, but dried fruits have higher ash content (2.4–3.5%) (Nielsen, 2009). The ash content ranged from (0.447%) fresh juice 1 to (0.110%) (IS) orange juice type, although the ash value of fresh juice is superior to that of processed juice (0.447 and 0.340%) individually, there is a significant difference between them ( $p < 0.05$ ). The ash content of fresh juices was below those stated by Onibon *et al.* (2007) but agreed with those reported by Idah *et al.* (2010).

**Table (1) Physicochemical properties in two fresh juices and five commercial packaged fruit**

Samples	Physicochemical properties								
	pH	TSS °Brix	Moisture %	Total solid %	Ash content %	Total Acidity (TA) %	Fixed Acidity (FA) %	Volatile Acidity (VA) %	The ratio of TSS:TA%
Fresh1	4.360 <sup>a</sup>	12 <sup>bc</sup>	88.333 <sup>bcd</sup>	11.667 <sup>abc</sup>	0.447 <sup>a</sup>	0.875 <sup>b</sup>	0.789 <sup>b</sup>	0.095 <sup>d</sup>	13.71
Fresh2	4.420 <sup>a</sup>	14 <sup>a</sup>	87.267 <sup>cd</sup>	12.733 <sup>ab</sup>	0.340 <sup>a</sup>	1.035 <sup>a</sup>	0.896 <sup>a</sup>	0.141 <sup>c</sup>	13.526
ER	5.293 <sup>a</sup>	13 <sup>ab</sup>	86.855 <sup>d</sup>	13.145 <sup>a</sup>	0.200 <sup>b</sup>	0.536 <sup>c</sup>	0.363 <sup>e</sup>	0.394 <sup>b</sup>	24.25
FN	5.970 <sup>a</sup>	12.5 <sup>abc</sup>	88.80 <sup>bc</sup>	11.196 <sup>bc</sup>	0.327 <sup>a</sup>	0.491 <sup>f</sup>	0.448 <sup>d</sup>	0.011 <sup>e</sup>	25.45
TA	5.163 <sup>a</sup>	12.5 <sup>abc</sup>	89.119 <sup>ab</sup>	11.881 <sup>abc</sup>	0.113 <sup>bc</sup>	0.747 <sup>c</sup>	0.619 <sup>c</sup>	0.128 <sup>c</sup>	16.73
IT	5.177 <sup>a</sup>	11 <sup>c</sup>	90.493 <sup>a</sup>	9.507 <sup>d</sup>	0.000 <sup>c</sup>	0.431 <sup>g</sup>	0.331 <sup>e</sup>	0.097 <sup>d</sup>	25.52
IS	5.880 <sup>a</sup>	11 <sup>c</sup>	89.227 <sup>ab</sup>	10.773 <sup>cd</sup>	0.110 <sup>bc</sup>	0.672 <sup>d</sup>	0.609 <sup>c</sup>	0.501 <sup>a</sup>	16.36

Volatile acidity is a assess of the low molar mass (or steam distillability) of fatty acids in drinks, and it is popularly known as the vinegar odor, which may be unpleasant at high levels. The Volatile Acidity values of various orange juice types range between 0.011% and 0.501%. The fixed acidity results show that fresh1 and fresh2 have the highest values (0.789 and 0.869)% and IT type juice had the lowest value (0.331%), according to Perestrelo *et al.* (2019), orange juice contains volatile compounds (acetic acid, hexanoic acid, and octanoic acid)

## Sugar content

The amount of sugar of fruits indicates their sweetness, which affects significantly to the overall nutritional quality of fruit juices. It's crucial to determine if juices labelled "no sugar added" accurately reflect the sugar level of juice removed from the appropriate fresh fruit. Customers might consider consuming commercial juices when the sugar level of bottled fruit juice with the "no added sugar" label is superior to that of freshly extracted fruit juice. Fructose level in fruit juice is high, one of the most abundant sugars. Some people feel it is healthier than sucrose; however, it can be just as harmful. Sucrose, commonly known as table sugar, it is consisting of glucose and fructose. Broadly, the amount of sugar in a fruit juice is proportional to that of the fruit itself. (Serpen, 2012) Citrus juice is mostly composed of sugars and soluble solids, and the sweetness of orange juice is inherent in its sugar content. Orange juice contains a significant amount of sucrose (table sugar). As shown in figure 1 and table 2, the total sugar levels in all juice samples ranged from 12.158 to 7.58 present for the Fresh2 and IT juices, respectively, with no significant difference ( $p < 0.05$ ) in all industrial and fresh juices. This is comparable with Chanson-Rolle *et al.* (2016) (8.61-10.32.%s percent) and Ndife *et al.* (2013) (9.15.%s–14.25 percent) ranges for different types of orange juice. The major variances in total sugars among fruits of the same or different species might be attributable mostly to variations in the enzymatic activity of fruits, which have been proven to alter sweetness. Many factors can influence the sugar content, concentration, and ratios in orange fruit, including citrus cultivars, fruit ripeness, climate, juice processing, juice storage conditions, and significant exposure to sunlight.

Fructose, glucose, and sucrose were found as the three major sugar molecules in orange juice, with sucrose contributing the most (46%), followed by fructose (31%), and glucose (23%), virtually equating to a 2:1:1 ratio. Whereas the glucose-to-fructose ratio is approximately constant, it should not exceed 1.00 and is usually greater than 0.85. The ratio of glucose-to-fructose was suggested as being a useful way to investigate potential orange juice adulteration (Zhang & Ritenour, 2016), (Niu *et al.*, 2008).

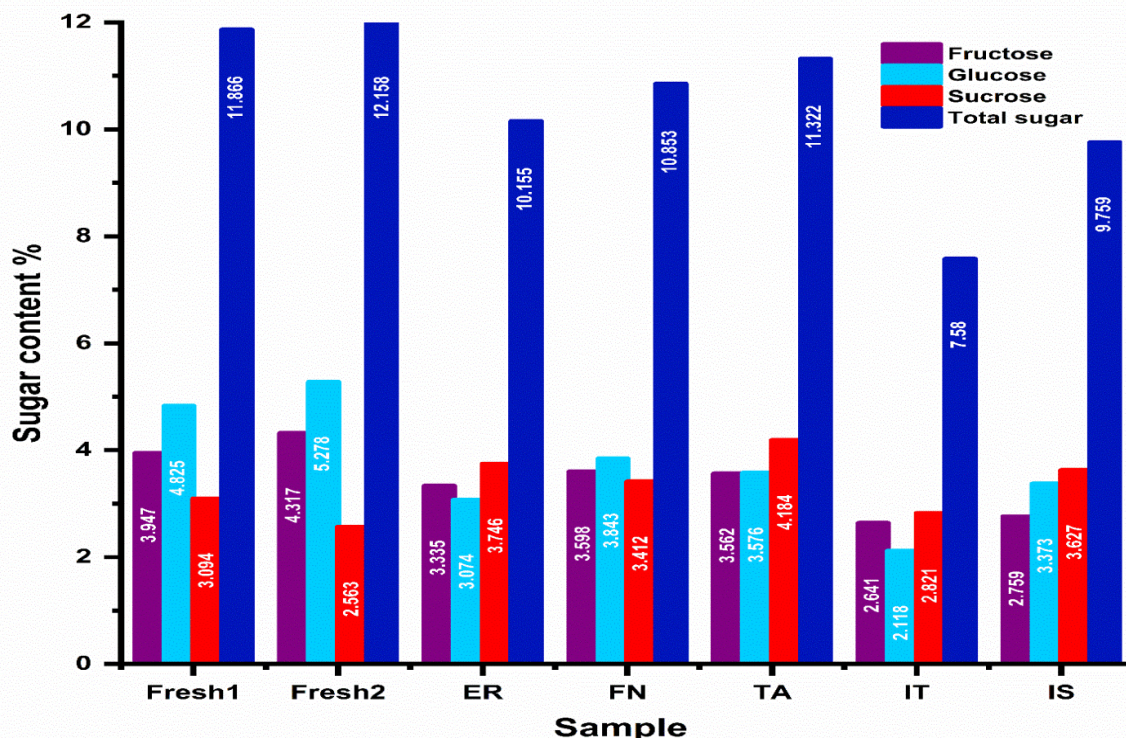


Figure (1) Sugar content (fructose, glucose, sucrose) in the different orange juice.

Results of packed and fresh juices for all three simple sugars indicates a significant difference between them is shown in figure 1. The highest amount of fructose sugar was 4.317g/100 ml in Fresh2, while the lowest amount was 2.641g/100ml in IT, respectively. Fresh2 contained the highest amount of glucose which was 5.278g/100ml, whereas the lowest amount was

2.118 g/100ml in IT. Furthermore, the highest amount of sucrose was 4.184g/100 ml in TA, while the lowest amount was 2.563g/100ml in Fresh2. The results that were reported by Rodrigues *et al.* (2021) for the evaluation of fructose, glucose, and sucrose in orange juice were (4.835, 3.390, and 4.365 g/100ml), respectively. As demonstrated in table 2, the glucose: fructose ratio and the glucose: fructose: sucrose ratio are significantly different from those previously published, (Zhang & Ritenour, 2016) (Niu, *et al.*, 2008), and this is mostly owing to inappropriate adulteration of the fruit samples used to prepare the orange juice. For any orange juices, the authenticity of sweetness and quality of juice depends on the amount and concentration of specific sugars.

**Table (2) Content of Total sugar, Fructose, Glucose and Sucrose in five commercial packaged fruit aid in two fresh juices**

Orange juice	Sugar content (%)					
	Total sugar %	Fructose (mg/100ml)	Glucose (mg/100ml)	Sucrose (mg/100ml)	Glucose: Fructose	Glucose: fructose: Sucrose Ratio
Fresh1	11.866 <sup>a</sup>	3.947 <sup>a</sup>	4.825 <sup>ab</sup>	3.094 <sup>a</sup>	1.2	1:0.8:0.6
Fresh2	12.158 <sup>a</sup>	4.317 <sup>a</sup>	5.278 <sup>a</sup>	2.563 <sup>a</sup>	1.2	1:0.8:0.5
ER	10.155 <sup>a</sup>	3.335 <sup>a</sup>	3.074 <sup>bc</sup>	3.746 <sup>a</sup>	0.9	1:1.1:1.2
FN	10.853 <sup>a</sup>	3.598 <sup>a</sup>	3.843 <sup>abc</sup>	3.412 <sup>a</sup>	1.1	1:0.9:0.9
TA	11.322 <sup>a</sup>	3.562 <sup>a</sup>	3.576 <sup>abc</sup>	4.184 <sup>a</sup>	1.0	1:1:1.2
IT	7.58 <sup>a</sup>	2.641 <sup>a</sup>	2.118 <sup>c</sup>	2.821 <sup>a</sup>	0.8	1:1.2:1.3
IS	9.759 <sup>a</sup>	2.759 <sup>a</sup>	3.373 <sup>abc</sup>	3.627 <sup>a</sup>	1.2	1:0.8:1.1

Values in the same column with different letters are statistically different ( $p < 0.05$ )

### Organic acids content

Citrus fruits are rich in organic acids, which are used as a main indicator of maturation and one of the primary analytical evaluations of flavor quality when combined with sugar content. The organic acid content of fruits is especially interesting since it has a considerable influence on the sensory aspects of fruit juices, according to previous paper (Kelebek & Selli, 2011). In fresh and type orange juices, three organic acids (citric, ascorbic and acetic acid) were isolated and identified. Vitamin C (ascorbic acid) is an important ingredient in the diet, but it is quickly depleted or destroyed by heat and oxygen during food processing, packing, and storage. The Vitamin C level of products must be indicated on the nutrition label, according to the US Food and Drug Administration. Since vitamin C is unstable, it is more difficult to guarantee that the vitamin C amount on a nutrition label is accurate. Oranges contain a large amount of citric acid, which has been used as a natural preservative in fruit drinks and other fruit products (Nielsen, 2017). Phosphoric acid and citric acid are the primary causes of dental erosion from beverages; both are triprotic acids with three accessible hydrogen ions, allowing proton-promoted breakdown. Table 3 displays the organic acid findings. Although ascorbic acid is present in all fresh and packed samples except the (IT) sample, fresh juice has more ascorbic acid than packaged orange juice. Orange juice quality is also determined by ascorbic acids, which are powerful antioxidants (Kelebek & Selli, 2011). The outcomes were comparable to those achieved by (Büyüktuncel *et al.*, 2017). Since of its ease of degradation, ascorbic acid is used as a reference in several industrial processes because its presence assures that the end product has a satisfactory nutritional quality (Klimczak *et al.*, 2007). Sanchez-moreno *et al.* (2006) found that these quality criteria are linked to the stability of bioactive chemicals in fruit products.

Acetic acid was identified in all types of orange juice except the IT sample, in the range of 1.307 to 5.760 mg/100 ml, with the greatest value being (5.760 mg/100ml) which belong to fresh 1 sample and the lowest value being (1.307mg/100 ml) in the (TA) orange juice sample. According to Perestrelo *et al.* (2019), orange juice contains volatile chemicals such as acetic acid.

When the quantities of citric acid were investigated, it was determined that they were present in all of the samples examined. In terms of citric acid, there were no major variations across any orange



juice types. Regarding to concentration, there is a range of 311 to 411.3 mg/100 ml (table 3). The detection and quantification criteria were exceeded by all of the samples. Citric acid is present in all samples, indicating that it is used by industry as a preservative and acidulant, as Kelebek (2010), and colleagues argue (kelebek *et al.*, 2009).

**Table (3) organic acid content in two fresh juices and five commercial packaged fruit**

Orange juice	Organic acid content (mg/100 ml)		
	Ascorbic acid	Acetic acid	Citric acid
<b>Fresh1</b>	43.981 <sup>a</sup>	5.760 <sup>a</sup>	318.000 <sup>a</sup>
<b>Fresh2</b>	40.981 <sup>b</sup>	1.367 <sup>bc</sup>	311.000 <sup>a</sup>
<b>ER</b>	27.967 <sup>c</sup>	2.010 <sup>b</sup>	398.000 <sup>a</sup>
<b>FN</b>	25.170 <sup>c</sup>	1.830 <sup>b</sup>	323.000 <sup>a</sup>
<b>TA</b>	27.000 <sup>c</sup>	1.307 <sup>bc</sup>	383.333 <sup>a</sup>
<b>IT</b>	N.D	N.D	409.000 <sup>a</sup>
<b>IS</b>	26.323 <sup>c</sup>	1.597 <sup>b</sup>	411.333 <sup>a</sup>

### Sensory evaluation

The evaluated findings of the several sensory characteristics, namely color, flavor, sweetness, bitterness, and taste, for the orange juices, are revealed in Figure 2 and table 4. When compared to other treatments, the findings demonstrate that there were no significant variations in the color of the treatment (fresh1) and the sample (fresh2), and that the treatments (fresh1) and (fresh2) had the best color and sensory attributes. The (IT) and (ER) treatments, on the other hand, had the lowest color scores. The color of orange juice can be changed by non-enzymatic browning events that arise during juice processing or storage (Dauda & Adegoke, 2014).

For flavor characteristics, the findings of figure 2 revealed a significant difference between the treatments (Fresh1) and (ER, TA, IT, IS), but no significant difference between the treatments (Fresh1) and (Fresh2, FN). Furthermore, the treatment (Fresh1) had a much greater taste value, which indicated (7.000), and the (IT) treatment had the lowest taste value of (3.571), possibly due to the orange juice losing part of its fresh flavor during storage due to decreasing amounts of volatile flavor ingredients, thereby forming a stable flavor (Mashonas & Shaw, 2000).

Taste assessment is an admirable characteristic. Figure 2 demonstrates that the treatment (IT) had a higher score when compared to the other treatments. There were insignificant difference between the treatments (Fresh1 and Fresh2) compared to the majority of commercials (FN, TA, IS), however, there was a major difference between the treatments (Fresh1, Fresh2) and the (ER, IT). The organic acid–sugar content balance of the fruit determines taste primarily, and these substances serve as unambiguous markers for sensory attribute evaluation and genetic characterisation (Melgarejo *et al.*, 2000; Poyrazoğlu *et al.*, 2002).

The sweetness of orange juice is determined by the amount of sugar in it, which includes sucrose, glucose, and fructose. So, for the sweetness characteristic, the results showed that the treatments (IT, IS) had a higher sweetness score and there was no significant difference between them and the treatments (Fresh1, ER, TA), but there was a significant difference between the treatments (Fresh2, FN) and the treatments (Fresh1, ER, TA) (Fresh1, ER, TA, IT, IS).

The chemical limonin, which causes the bitterness in orange juice, may be detected in the seeds and skins of all citrus fruits (Mozaffar *et al.*, 2000; Hasegawa *et al.*, 2000). So, for bitterness, the results revealed that the treatments (Fresh2 and Fresh1) had greater bitterness values (5.250, 4.571) compared to other treatments, whereas the treatments (IT, IS) had lower bitterness values (3.000) accordingly. And there was a significant difference between the treatment (Fresh2) and the treatments (ER, TA, IT, IS), respectively, but not between the treatments (Fresh1, ER, FN, and TA)



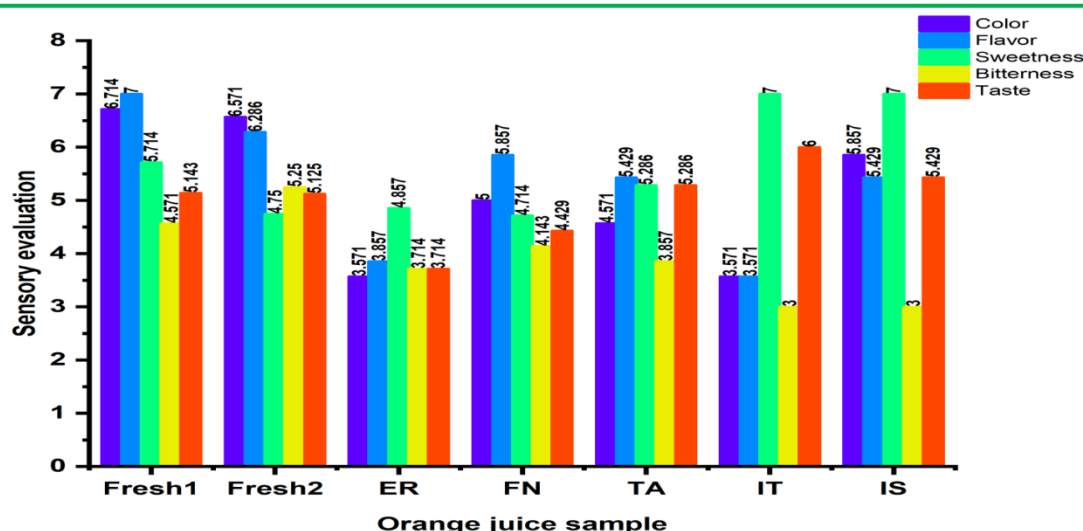


Figure (2) Sensory evaluation for all types of commercial and homemade organic juice

Table (4) Sensory evaluation in two fresh juices and five commercial packaged fruit

Orange juice	Sensory evaluation				
	color	Flavor	sweetness	bitterness	taste
Fresh1	6.714 <sup>a</sup>	7.000 <sup>a</sup>	5.714 <sup>ab</sup>	4.571 <sup>ab</sup>	5.143 <sup>ab</sup>
Fresh2	6.571 <sup>a</sup>	6.286 <sup>ab</sup>	4.750 <sup>b</sup>	5.250 <sup>a</sup>	5.125 <sup>ab</sup>
ER	3.571 <sup>c</sup>	3.857 <sup>c</sup>	4.857 <sup>ab</sup>	3.714 <sup>bc</sup>	3.714 <sup>b</sup>
FN	5.000 <sup>abc</sup>	5.857 <sup>ab</sup>	4.714 <sup>b</sup>	4.143 <sup>abc</sup>	4.429 <sup>ab</sup>
TA	4.571 <sup>bc</sup>	5.429 <sup>b</sup>	5.286 <sup>ab</sup>	3.857 <sup>bc</sup>	5.286 <sup>ab</sup>
IT	3.571 <sup>c</sup>	3.571 <sup>c</sup>	7.000 <sup>a</sup>	3.000 <sup>c</sup>	6.000 <sup>a</sup>
IS	5.857 <sup>ab</sup>	5.429 <sup>b</sup>	7.000 <sup>a</sup>	3.000 <sup>c</sup>	5.429 <sup>ab</sup>

### HIERARCHICAL CLUSTER ANALYSIS (HCA)

To categorize all samples tested, hierarchical cluster analysis (HCA) was used using all measured parameters as variables. Ward's method was used for classification, which connects cases to reduce variance within a cluster. The samples investigated may be categorized into two principal groups based on the dendrogram (Fig. 3), namely Cluster 1 (Fresh1, Fresh2, and FN) and Cluster 2. (which contains all the other samples analyzed). The dendrogram reveals that the lowest distance is less than 10 between the two local preparation samples, while the dissimilarity between the two main groups is roughly 85. These results demonstrate that the physicochemical parameters and sensory evaluation of fresh and commercial orange juice samples differ significantly.

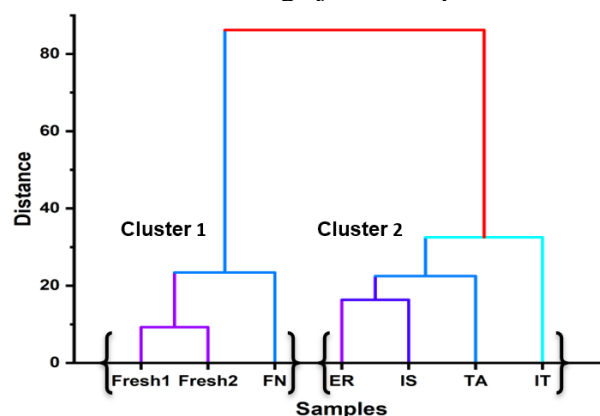


Figure (3) Dendrogram of hierarchical cluster analysis for clustering samples in main different clusters

### CONCLUSION

In this study, the nutritional content and sensory assessment of two sets of orange juice samples, five commercial and two local preparation, were investigated. One of the 100 % fruit juices had been pasteurized, whereas the other had not. Commercial samples include more sugar

than handmade samples, according to experimental results and the Brix to acid ratio. Commercial orange juice, for example, has lower vitamin C (ascorbic acid) levels than household orange juice. Because of the vitamin breakdown that can occur during industrial processes like pasteurization and storage packaged orange juice. Acetic acid has the highest value in fresh orange juice that has not been pasteurized, but it has the lowest value in the other orange juice due to acetic acid evaporation during heat treatment. All sensory characteristics change considerably between homemade and commercial orange juice samples, depending on the sensory evaluation, which is connected to the content of sugar, organic acid, the phenol component, and carotenoids in orange juice. According to the hierarchical cluster analysis, two primary groups belong to all of the samples investigated, with the smallest distance between two fresh samples and the greatest distance between the homemade and commercial samples. Consequently, the experimental results, multivariate analysis, and statistical analysis show that there are considerable differences in the composition and sensory evaluation of homemade and packaged orange samples. These findings serve to clarify consumer misconceptions about commercial orange juice and aid in the decision to consume fresh orange juice rather than commercial orange juice more frequently.

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## دراسة مقارنة للخصائص الفيزيائية والكيميائية والتقييم الحسي لعصير البرتقال التجاري المباع في سوق السليمانية مع عصير البرتقال محلي الصنع

شيلان محمد عبدالله<sup>1</sup> ازين بختيار محمود<sup>2</sup> سوکار کمال محمود<sup>1</sup> ساکار کمال حمه صالح<sup>1</sup>

1- قسم علوم الأغذية، كلية علوم الهندسة الزراعية، جامعة السليمانية، السليمانية، العراق

2- الهيئة الكوردستانية للدراسات الاستراتيجية والبحوث العلمية السليمانية، العراق

### الخلاصة

يعد عصير البرتقال من العصائر المتداولة في السوق. معظم مشروبات الفاكهة التي يمكن الوصول إليها مصنوعة من مواد اصطناعية وقد تحتوي على المواد السامة و التي تضر بصحة المستهلكين. تقارن هذه الدراسة المعاملات الفيزيائية والكيميائية ومحتوى السكر والأحماض العضوية والتقييم الحسي لعينات عصير البرتقال التجاري والطازج. تمت معالجة ثمار البرتقال لإنتاج عصير طازج يحتوي على نسبة 100% من الفاكهة ولا يحتوي على سكريات أو سوائل مخففة. تم الحصول على عينات العصير المعبأة من متجر محلي، وتم الانتهاء من جميع الاختبارات قبل انتهاء العمر الافتراضي للعصير. كانت المواد الصلبة الكلية ومحتوى الرماد والأس الهيدروجيني من بين الخواص الفيزيائية والكيميائية التي تم فحصها، إذ تراوحت القيم من (9.507-13.145% و 0.110-0.447% و 4.360-5.970 على التوالي. لوحظ أن محتوى السكر يتراوح بين 2,118-5,278 و 4,317-2,641 و 4.184-2.563 جم / 100 مل للجلوكوز والفركتوز والسكروز كل على حدة. تم العثور على الأحماض العضوية (حمض الأسكوربيك والأسيتيك والستريك) بتركيز تتراوح من 25.170-43.981، 1.307-5.760، و 311-411.33 مجم / 100 مل بشكل منفصل. أظهر التقييم الحسي وجود فرق معنوي ( $P < 0.05$ ) بين عينات البرتقال محلية الصنع وعينات البرتقال التجارية. وفقاً للنتائج التي تم الحصول عليها والتحليل العنقودي، هناك فرق كبير بين معايير العصير المصنوعة يدوياً والعصائر التجارية. تحتوي العناصر التجارية سكرًا أكثر من العينات الطازجة. تساهم نتائج هذه الدراسة في فهمنا للتغذية و جودة عينات عصير البرتقال التجارية أو المحلية الصنع. لا يُنصح بتناول العينات التجارية بكثرة نظرًا للاختلافات الكبيرة بين عينات عصير البرتقال الاصطناعي وعصير البرتقال الطازج.

### الكلمات المفتاحية:

عصير برتقال، تحليل فيزيو كيميائي، سكر و احماض عضوية، تقييم حسي، تحليل الكتلة الهرمي متعدد المتغيرات