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# Valorization of Moroccan dried Fig fruit of low market: Physico-chemical, organoleptic and microbiological study of syrup

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**Abstract:** This study was undertaken in the perspective of the valorization of low grade quality of dried figs by trying to develop syrup that meets a high quality. We used 2 different conditions for our extractions (T=80°C, t=90mn) and (T=90°C, t=60mn) used in literature to optimize the syrup extraction process and we compared results with the syrup obtained from high grade quality of dried figs. Beforehand we undertook physic-chemical analyzes (titrable acidity, density at 20 ° C, pH, total dry residue, and water content), microbiological analyzes (Total Aerobic Mesophilic Flora "FMAT"), and organoleptic analyzes were evaluated. Also by doing a second extraction of the residue obtained from the first extraction for two qualities to maximize this valorization. The obtained results show that all the analyzed syrups contain very similar values for density, pH, titratable acidity, and dry matter for both qualities and for each extraction. Regarding microbiological analysis results obtained show an average FMAT for both qualities below standard, and after sensorial test we found encouraging results from consumers for both qualities. The valorization of these dried figs by producting syrup proved to be feasible and it would be highly recommended to think about a strategy to using it in industry.

**Keywords:** Environment, Moroccan dried fig, quality, syrup, valorization.

## I. INTRODUCTION

The fig is the fruit of a tree called Ficuscarica, belonging to the Moraceae family, which is existing in the Mediterranean basin where it has been cultivated for thousands of years [1] [2]. The fig tree is probably originates from the Mediterranean basin and Western Asia region [3], some have linked its origin to southern Arabia where wild fig trees still exist [4]. This species has been cultivated by Phoenicians, Syrians, Egyptians, and Greeks throughout the Mediterranean basin to the extent that it is thought to be native to these environments. There are over 800 different varieties of the genus Ficuscarica, mostly grown in hot and dry climates, such as the Middle East and the Mediterranean region [5], [6]. In 2011, one million tons of figs were produced worldwide, while 76% of the total crop came from the Mediterranean region. Turkey contributed 20-30% of the global production, followed by Egypt, Morocco, Iran, Algeria, and Greece [7], [8].

In Morocco, the cultivation of the fig tree is very old. In 2011, it occupies an area of about 47,300 ha and produces an estimated 74,300 t of figs (fresh and dried). The fruits are mainly sun-dried in the traditional way. A small part is used for fresh consumption and a very small quantity is used for jam, marmalade, and brandy production. The fig tree is among the fruit species of major economic importance, especially in the northern regions of Morocco (Taounate, Chaouen, Al Hoceima, Ouezzane, and Tetouan). It is also cultivated in other regions such as Taza, Nador, Essaouira, El Jadida and Safi [9]. In addition, there are a large number of varieties with a lot of synonymy of the appellation. Twenty-four commercially grown varieties have been identified in the Rif. Among these varieties, six are grown on a large scale: El Messari or Homrame or Johri, Lembdar Labiad, Lembdar Lakhal, Rhouddane, El Koté, and Aounq Hmam [10].

Taking into consideration the current situation of the sector of the fig tree in Morocco, of which one recalls:

- The fruit of the fig tree is sensitive and very fragile.
- The socio-economic reality of production areas (infrastructure, level of education, organization of the profession, know-how ...).
- Enclosure of the production areas.

So, the most convenient way of processing figs is the conservation by drying. Which activity requires the organization of the transport circuit of the raw material, the multiplication of collection centers and the creation of other drying units. The technique of drying figs, especially the drying known as "Traditional", is known since the antiquity. The figs are spread out under the sun, on the ground in beaten earth, on the terraces of the buildings or on areas of the hard ground in cement, either on the trays or braided mats and put on the ground or on the terraces. This method is not expensive, but results in a finished product of poor hygienic and nutritive quality because the figs are exposed to dust, insects, mites, pests, dirt, with the possibility of fermentation, as well as other various contaminations thus favoring enormous losses in production. It does not allow any control of the drying parameters and lengthens the period of the operation. This method is therefore not recommended from an economic point of view, but above all from a public health point of view (the products obtained constitute a real danger to the health of the consumer). While, the modern drying techniques use solar dryers with a closed drying chamber allowing to optimizing the energy, to control the drying parameters and to ensure the product the required safety and quality standards.

Additionally, the dried fruits will constitute a raw material for other uses and for other subsequent industrial activities. The fig is a seasonal fruit that can be harvested twice a year, either in spring and summer or in early and late summer, depending on the cultivar [11]. Its color varies from dark purple to green [6]. It can be eaten fresh, also peeled or not, dried, as jam, and as juice. The industry currently attaches great importance to the fruit of the fig tree for its various uses. It can be dried and/or transformed in several ways [5], [12], [13]: Production of jam; Production of brandies; Ingredient to the cooked dishes; Ingredient of the pastry; Ingredient of salads....

Fresh and dried figs are an important element in the human diet because of their high content of assimilable carbohydrates (fructose and glucose), responsible for most of its energy intake (75 Kcal/100g of fresh fruit and 250 Kcal/100g of dried fruit), also an important sources of trace elements (iron, calcium, potassium) and vitamins (thiamine and riboflavin), which contain > 17 types of amino acids. Figs are sodium-free, fat-free, and cholesterol-free, while they are rich in fiber and antioxidant compounds. The nutritional values of fresh and dried figs are summarized in Table1 [6], [11], [14], [15].

**Table 1:** Nutrient content of fresh and dried figs.

| Dietary component | Value/100 g fresh | Value/100 g dried |
|---|---|---|
| **Water (g)** | 79.11 | 30.05 |
| **Total Calories (kcal)** | 74.0 | 249.0 |
| **Protein (g)** | 0.75 | 3.30 |
| **Total fat (g)** | 0.30 | 0.93 |
| **Saturated fat (g)** | 0.06 | 0.93 |
| **Fiber (g)** | 2.9 | 9.8 |
| **Sugars (g)** | 16.26 | 47.92 |
| **Cholesterol (mg)** | 0.0 | 0.0 |
| **Calcium (mg)** | 35.0 | 162 |
| **Iron (mg)** | 0.37 | 2.03 |
| **Magnesium (mg)** | 17.0 | 68.0 |
| **Phosphorus (mg)** | 14 | 67 |
| **Potassium (mg)** | 232 | 680 |
| **Sodium (mg)** | 1 | 10 |
| **Zinc (mg)** | 0.15 | 0.55 |
| **Vitamin A (IU)** | 142 | 10 |
| **Vitamin C(mg)** | 2 | 1.2 |
| **Thiamin (mg)** | 0.06 | 0.085 |
| **Riboflavin (mg)** | 0.05 | 0.082 |

**Source:** Data from the USDA National Nutrient Database for Standard References (2018).

The antioxidant compounds such as phenolic compounds, organic acids, vitamin E, and carotenoids are healthy compounds that are found in different fruits and vegetables and they are also available in figs. These compounds can prevent the formation of free radicals by reducing or donating hydrogen to other compounds. Among them, phenolic compounds are the most popular because of their well-known antioxidant abilities, while there are also major constituents of color, flavor, and aroma. Two major categories of phenolic compounds are phenolic acids and flavonoids [16], [17].

Finally, according to the literature, there is a lack of research on valorization of dried figs. Therefore, in the present study, to valorize poorly tradable dried figs, we were focused on quality of syrups extracted from two different qualities of dried figs high and low grade. This quality was assessed by determining the physicochemical, microbiological and organoleptic parameters; followed by a comparison between the two types of syrups.

## II. MATERIAL AND METHODS

**Raw Materials:** The variety of dried fig selected in this study is the variety "ficuscarica"which is a very common variety in the Moroccan fig tree, especially in the north of the country.
The plant material contains two different qualities of dried figs, the low grade quality that we want to valorize and the high grade quality to compare results with it.

**Extraction of dried figs syrup:** The syrup will extracted using the protocol below,

- **Reception and Cleaning:** The dry figs of two qualities (high and low grade) are cleaned to remove the dust that sometimes remains on the fruit.
- **Drying:** After cleaning, the purpose of this step is to eliminate the water through contact with the ambient air (natural drying).
- **Cutting:** At this point, the dried figs are cut into small pieces (3 mm of wide), to facilitate the work, using a sharp object with oil, so that the material does not stick to the tool.
- **First Extraction:** At this stage, we take 30g of dried figs (high and low grade quality), and a determined volume of water V = 60ml, in a beaker under the following conditions:
  - 1st condition: T = 80 ° C, t = 1h30 min for the two qualities.
  - 2nd condition: T = 90 ° C, t = 1h for the two qualities.

We are looking for the best extraction conditions. From this step we obtain a raw sugar juice totally in the liquid phase and which contains the extreme amount of sugar possible.

- **Filtration:** After juice extraction, the juice and the residue are separated by a filter, to obtain the raw juice.
- **Concentration:** By evaporating the water from the juice using the water bath, we obtain the syrup.
- **Conservation:** The syrup obtained is kept in a small box in the refrigerator for analysis. And the residue is kept in aluminum foil also in the refrigerator for the 2nd extraction.

- **Second Extraction:** At this step the residue obtained from the filtration was extracted again to obtain the maximum valorization, same conditions are applied to obtained syrup 2 of second extraction and wastes (table 2).

**Table 2:** Extraction of dried fig syrup

| | **High grade Quality** | | | | **Low grade Quality** | | | |
|---|---|---|---|---|---|---|---|---|
| | **extraction1** | | **extraction1** | | **extraction1** | | **extraction1** | |
| **Type** | Juice | Syrup | Juice | Syrup | Juice | Syrup | Juice | Syrup |
| **Temperature°C** | 80 | 80 | 90 | 90 | 80 | 80 | 90 | 90 |
| **Time min** | 90 | 10 | 60 | 5 | 90 | 10 | 60 | 5 |
| | **extraction2** | | **extraction2** | | **extraction2** | | **extraction2** | |
| **Type** | Juice | Syrup | Juice | Syrup | Juice | Syrup | Juice | Syrup |
| **Temperature°C** | 80 | 80 | 90 | 90 | 80 | 80 | 90 | 90 |
| **Time min** | 90 | 80 | 60 | 60 | 90 | 90 | 60 | 60 |

**Chemical analysis of concentrated dried fig syrup**

- **Determination of density:** Eating energy-dense foods is therefore an effective strategy for maintaining or achieving a healthy weight. The more nutritionally dense a food is, the more vitamins and minerals it contains for a given number of calories. Nutrient-dense foods contain a large number of protective micronutrients expressed on per weight, per volume, or per-serving basis. A "nutrient-dense" food is one that provides the best ratio of calories to nutrients that benefit the body. In short, the fewest calories for the greatest concentration of nutrients. The density of the product is defined from the measurement of its mass and volume [18].
- **Determination of the water content:** The dry matter or dry residue is the part of a plant product that remains after the water has been completely removed. It is determined by drying the sample in a ventilated oven. The determination of the moisture content of a product consists in principle of removing all the water without entraining the volatile substances initially present or formed during the drying process by the degradation of labile compounds. The mass of dry matter is measured after removing samples from the oven (temperature T=105°C for t=3h) [19].
- **Determination of pH:** The hydrogen potential (pH) is one of the variables used to characterize the properties of environments. Relatively easy to measure, the pH is used in many fields as an operating variable, characterization of the finished product or for quality control purposes. Many studies have correlated its value to reaction kinetics, organoleptic qualities of products or enzymatic activities [20]. The pH is determined by direct reading on the pH meter, taking care that the electrode is completely immersed in the solution.
- **Determination of titratable acidity:** Titratable acidity is an important parameter in determining fruit maturity and an acid taste in citrus fruits. Fruit maturity is one of the most important factors in determining fruit taste and storage conditions. For some fruits, government quality standards (based on titratable acidity or on the ratio of total soluble solids are in place to protect consumers. The acidity value provides information on all substances of an acidic nature in the product, including free hydrogen ions, organic acids, and salts of acids. The titratable acidity is expressed in g/100 ml of the predominant acid. The predominant acids in fruit depend on the type of syrup being analyzed and include citric acid, tartaric acid, and malic acid. It represents the sum of the free acids. The colorimetric method was used. It is a titration with sodium hydroxide in the presence of the colored indicator, which is phenolphthalein. One takes 2g of syrup, and one adds to it a volume of 22,5 ml of distilled water, in the presence of a few drops of phenolphthalein, and one titrates with the sodium hydroxide solution until the color change of the colored indicator to pink, results explained on mg of citric acid per 100ml of product [21].

**Microbiological analysis of concentrated dried figs syrup:** Fruits present a great variability of bacterial flora. In our study we will be interested in the determination of the total flora on PCA medium.

- **Preparation:** In a bottle we put 500ml of distilled water, 10.25g of PCA culture medium and 7g of agar-agar. We shake the whole solution, and then we introduce the bottle in the water bath under a temperature of 80°C during 20min. After gelling of the solution, we put the gel in the petri dishes to take its shape, sterilize the working medium by the benzene burner and the disinfectants, and then make the seeding by syrup drafts on the culture medium; finally we introduce the dishes in the oven under a temperature of 30°C during 72 hours [22].

**Sensory evaluation:** To ensure consumer satisfaction the sensory characteristics of dried figs syrups were conducted to determine the acceptability of the product. Syrup samples were evaluated using a 6-point organoleptic test for taste, odor, residual taste, color and viscosity. A numerical basis evaluation where zero indicates the absence of intensity and five corresponds to an extreme intensity [23].
The sensory analyzes were studied by a panel of 20 students from the student community of the Higher School of Technology of the second year of DUT (University Diploma in Technology) training; sectors: agro-industry and process engineering. The panelists underwent a preliminary training which lasted 2 hours, before determining the organoleptic parameters of the studied dried fig syrups.

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## III. RESULTS AND DISCUSSIONS

Within the framework of the valorization of low-grad quality of dried figs and the improvement of its quality, samples were subjected to a physico-chemical analysis (pH, acidity, density, and dry matter), a microbiological analysis (search for the total aerobic mesophilic flora), and a sensory analysis. Then, a comparison with those of high grad quality was maed to give a value to this low-grad quality.

Tables3 present the summary of the conditions used for the extractions of samples and the results obtained for the masses of juice, syrup, and residues.

**Tables 3:** The summary of extraction of dried fig syrup

| | **High Quality** | | **LowQuality** | | **High Quality** | | **LowQuality** | |
|---|---|---|---|---|---|---|---|---|
| **Ex1** | juice: | T=80°C, t=1h30min | juice: | T=80°C, t=1h30min | juice: | T=90°C , t=1h | juice: | T=90°C, t=1h |
| | W0=30g | V0=60ml | W0=30,03g | V0=60ml | W0=30g | V0=60ml | W0=30g | V0=60ml |
| | W j=31,362g | W r1=29,49g | W j =38,73g | W r11=29,71g | W j =61,36g | W r1=23,10g | W j =40g | W r1=29,60g |
| | syrup: | T=80°C, t=10min | syrup: | T=80°C, t=15min | syrup: | T=90°C, t=5min | syrup: | T=90°C, t=6min |
| | W s=30g | | W s =31,80g | | W s =33,14g | | W s =39g | |
| **EX2** | juice: | T=80°C, t=1h30 | juice: | T=80°C, t=1h30 | juice: | T=90°C, t=1h | juice: | T=90°C, t=1h |
| | W r1=29,49 | v0=60ml | W r1=29,71g | v0=59ml | W r1=23,10g | v=46ml | W r1=29g | v0=60ml |
| | W j =69,73g | W r2=17,38g | W j =44,37 | W r2=24,046g | W j =26,97g r2=18,18g | W | W j =26,97g | W r2=19,43g |
| | syrup: | T=80°C, t=1h30min | syrup: | T=80°C, t=1h30min | syrup: | T=90°C, t=1h | syrup: | T=90°C, t=1h |
| | W s =58,628g | | W s =36,023g | | W s =22g | | W s =60,39g | |

W0: weight of dried fig prepared to the extraction
W j1: weight of juice after first extraction
W r2: weight of residue after first extraction
W s: weight of syrup
W r2: weight of residue after second extraction

**Table 4:** Results of physico-chemical analyzes of high and low grade quality of dried figs

| | **Condition 1 : T=80°C, t=1h30** | | | | **Condition 2 : T=90°C, t=1h** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Q 1 EX 1** | **Q 1 EX 2** | **Q 2 EX 1** | **Q 2 EX 2** | **Q 1 EX 1** | **Q 1 EX 2** | **Q 2 EX 1** | **Q 2 EX 2** |
| **Density (g/cm3)** | 1.068±0.08 | 0.921±0.07 | 1.05±0.09 | 0.879±0.08 | 1.11±0.1 | 0.97±0.08 | 1.29±0.09 | 0.86±0.07 |
| **pH** | 4.56±0.01 | 4.99±0.01 | 4.66±0.01 | 5.12±0.025 | 4.56±0.1 | 5.15±0.015 | 4.77±0.01 | 5.16±0.015 |
| **Titratable acidity (mg/100ml)** | 2.68 ±0.11 | 1.48±0.07 | 2.15±0.2 | 1.4±0.06 | 2.52±0.12 | 0.94±0.04 | 2.4±0.12 | 1.09±0.09 |
| **The dry matter (%)** | 78 ±0.5 | 20 ±0.01 | 69 ±0.5 | 20 ±0.01 | 89 ±0.7 | 22 ±0.01 | 84 ±0.6 | 21 ±0.01 |

Q 1 EX 1: First extraction for high quality dried figs

Q 2 EX 1: First extraction for low quality dried figs

Analysis of the results obtained show a very high density of the syrups of the first extraction compared to the syrups of the second extraction. We notice that the first extraction gives us values around 1.05 and 1.29 g/cm3 otherwise the second extraction gives us values between 0.86 and 0.97 1.29 g/cm3.

The syrup of dry figs of low quality had the highest value 1.29 g/cm$^3$. These levels are close to those reported by date syrups by Mimouni, [24] and Belguedj [25].

The density of the syrup is very high due to the rate of soluble solids existing in this product; this character allows their storage for a long period [26].

The determination of pH and acidity is essential to determine whether or not there is microbial activity [27]. The pH may vary depending on the physiological state of the fruit, so depending on climatic and storage conditions [28]. The pH and titratable acidity values show a slight difference between the syrups of two qualities of dried figs studied (Table 4). Samples show an acidic pH between 4.56 and 5.16, and a titratable acidity between 0.94 and 2.68.

First extraction give us close results for both high and low grade qualities of dried figs and for both conditions, other way we mentioned that second extraction had the high values of pH and low values of titratable acidity for both qualities, which confirms the tangy taste for the syrup obtained from first extraction. Results are accordance with the standards of the Codex Alimentarius (2001). These results close to those of Mimouni [24] who found a pH of syrup of dates, between 5.25 and 5.

The percentages of the dry matter (table 4) of the analyzed syrups vary between 69% and 89% for first extraction and between 20% and 22% for the second extraction. High values obtained by extraction1 conditions 2 for high and low grade qualities dried figs 89% and 84% respectively. These levels close to those found by Mimouni [24] Ibrahim and Khallil [29].

**Table 5:** Results of microbiological analysis of high and low grade quality of dried figs

| | **High quality** | **Low quality** | **Standards** | **Reference** |
|---|---|---|---|---|
| **Total Aerobic Mesophilic Flora FMAT** | $0.7.10^5$ UFC/ml | $1.4.10^5$ UFC/ml | $<10^6$ UFC/ml | [19] |

The presence of FMAT colonies in the syrup is an indicator of the presence of germs. More specifically, the presence of coliforms is a good indicator of hygiene and contamination, and does not present a danger to human health. The obtained results show an average FMAT of high quality and low quality dried fig respectively $0.7.10^5$ CFU/ml, and $1.4.10^5$ UFC/ml (<106 CFU/ml according to international standards [22].

Sensory evaluation is a key indicator of potential consumer preferences. The data indicate that in general we have good results for both qualities intensities for all 6 points are high between 3 and 4 (Figure1and 2). The panelists show same intensity for overall acceptance, and taste for both dried figs qualities. And a small differences in color, smell, and viscosity. Finally, even if there is a huge difference between the two qualities of dried figs before valorizing them, we found almost the same quality for their syrups.

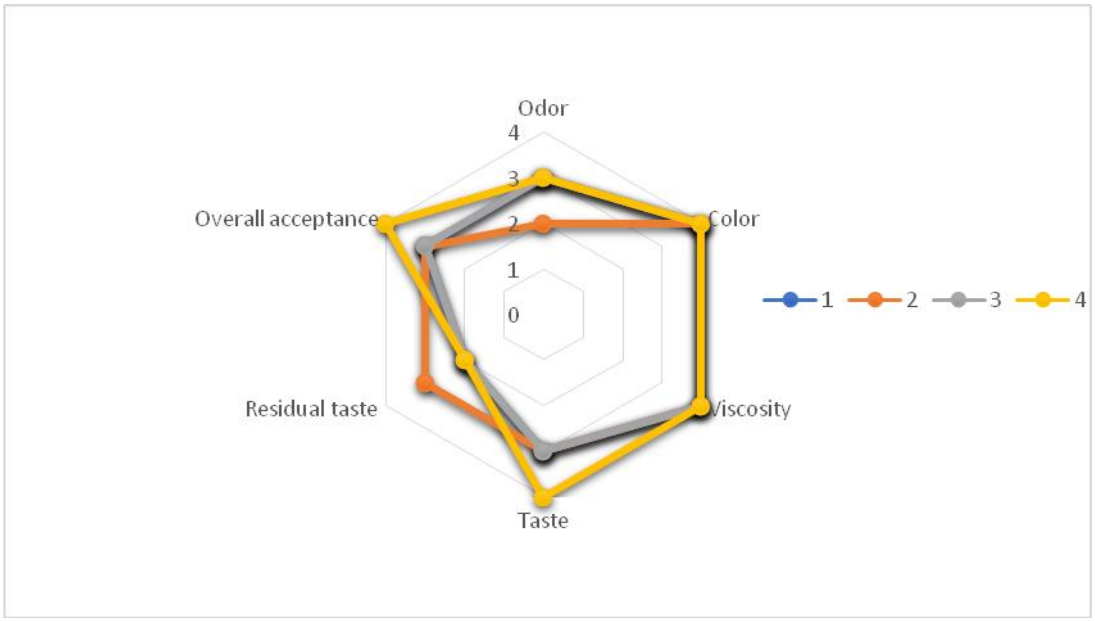


**Figure1:** Organoleptic test results for the first extraction of high grade quality of dried figs

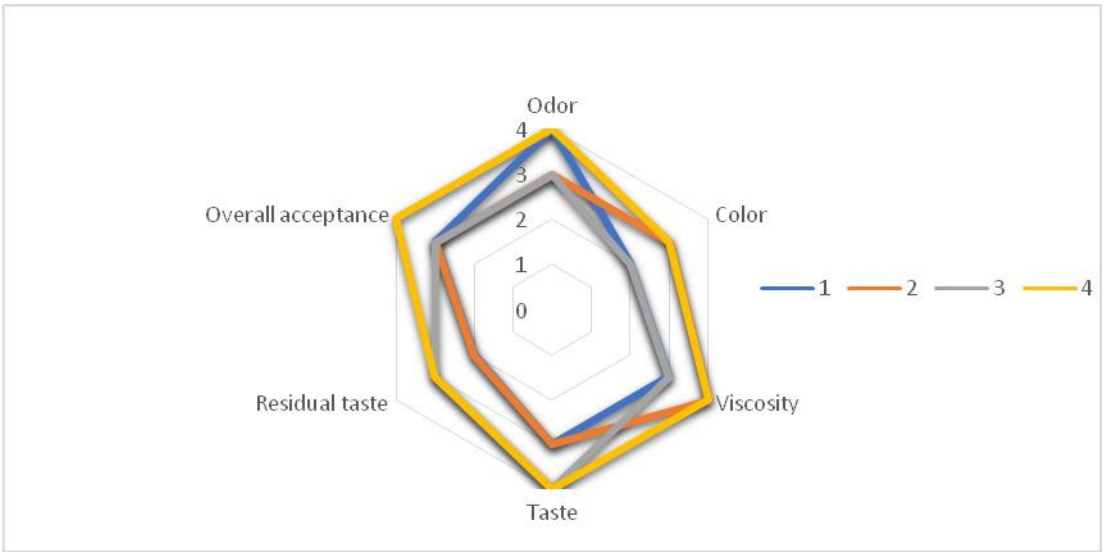


**Figure2:** Organoleptic test results for the first extraction of low grade quality of dried figs

Concerning second extraction (Figure 3 and 4), in general each figure shows that's intensities are between 2 and 3. That is normal because we already extracted the majority of competent of dried figs. But we still can use it in some consumed product it much better than manufactured and chemical flavors.

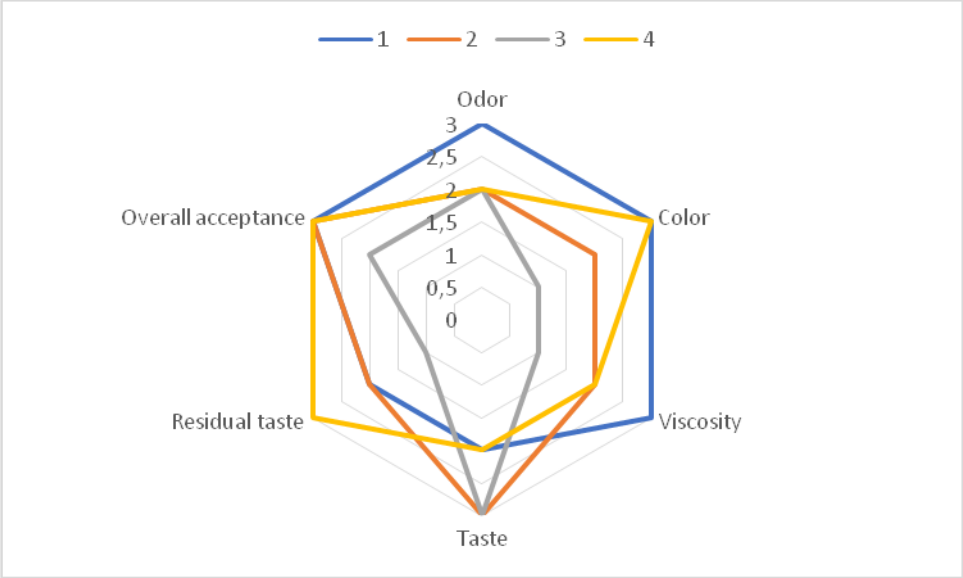


**Figure3:** Organoleptic test results for the second extraction of low grade quality of dried figs

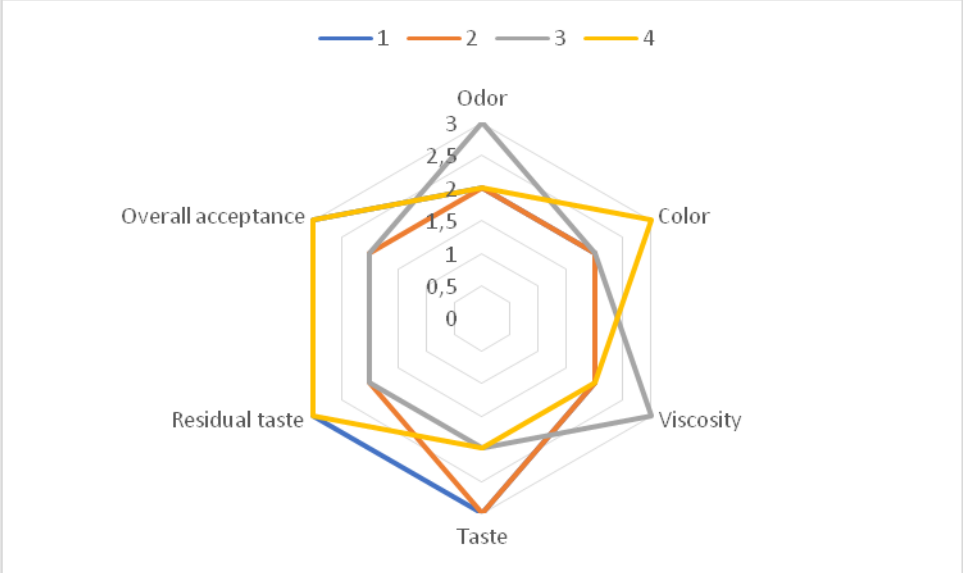


**Figure4:** Organoleptic test results for the second extraction of low grade quality of dried figs

We mentioned that there isn't a huge difference between both qualities, after valorization we can replace high quality dried figs with low quality in industry and having same results.

## IV. CONCLUSION

In conclusion, Despite the big difference in the quality of the dried figs used, all studied dried figs syrups have physicochemical and microbiological characteristics relatively close, and sensorial test are encouraging from consumers.

In general, the expertise regarding the valorization of dried figs among the Mediterranean countries remains scientifically low despite their cultural and economic values. Therefore, this knowledge deserves special attention for a sustainable and integrated development based on the use of local resources in Morocco.

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