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Research Article

Evaluation of the quality of dried fruits imported and consumed in Morocco (Case of apricots and raisins)

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Abstract

The dried fruit sector in Morocco can be divided into two categories: the cooperatives that focus on producing and marketing conventional dried fruits, and the newer industrial sector that is primarily involved in packaging and marketing imported dried fruits. The industrial sector is growing rapidly due to the expansion of retail networks. However, Morocco heavily relies on imported dried fruits, and there is a significant gap in domestic production. Limited information is available about the quality and conformity of these dried fruits. No specific study has been conducted on physicochemical, biochemical and microbiological quality. Therefore, it is crucial to assess the quality and conformity of these imported dried fruits, particularly apricots and raisins. To address this, a survey was conducted in the Fez-Meknes region of Morocco to understand consumer behavior towards dried fruits, resulting in 623 responses. Additionally, 60 random samples (500g per sample, 30 dried apricots and 30 dried raisins) were collected from the same region to assess their physicochemical, biochemical, and microbiological quality. The safety of these products for consumption was also evaluated through the identification of contaminants using Maldi-Tof-MS analysis. The main results show that 50% of apricots and 30% of raisins presented at least one non-conformity with respect to international standards, either in water content or residual SO₂ content, and the presence of Enterobacter in some samples further indicates a failure to adhere to proper handling, hygiene, and storage conditions for dried fruits.

Keywords

dried fruits, quality assessment, residual SO₂ content, microbiology, Maldi-Tof-Ms

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Introduction

The consumption of fresh and dried fruits has been related to a reduced risk of some chronic diseases like heart disease, cancer, and stroke, as indicated by various epidemiological studies (Campbell et al. 2013). However, fruits are perishable and seasonal, leading to limited availability throughout the year. To overcome this challenge, drying has been developed as a preservation method (Dai et al. 2015), which is the oldest and most effective technique for extending the life-time of fruits (Dai et al. 2015). There are two commonly used methods for dehydration: sun-drying and industrial drying. Sun-drying is widely practiced, especially in countries like Turkey, where it is used for producing dried fruits. However, sun-drying has drawbacks such as long drying times, potential contamination, and spoilage (Doymaz 2004; Omolola et al. 2017). On the other hand, industrial drying offers advantages such as reduced microbial contamination (since the product is protected from the open environment) and controlled drying parameters, including a known range of drying temperatures, relative moisture, and air velocity, which result in shorter drying times (Barbosa et al. 1996), making it a preferable option. However, both methods suffer from quality issues, primarily due to changes in fruit structure, which lead to decreased porosity, flavor alteration, uneven moisture distribution, and undesirable hardening (Link et al. 2017). Additionally, the heat sensitivity of pigments and nutrients results in damage to the nutritional and sensory properties of the dried fruit, causing significant losses in color and nutrients (Ochoa-Martínez et al. 2012).

The dried fruit sector in Morocco exhibits a lack of organization and can be classified into two types. The first type consists of long-established cooperatives that primarily produce and market conventional dried fruits such as figs, almonds, walnuts, and dates (Maniar et al. 2011). These cooperatives mainly use traditional sun-drying, sometimes combined with simple solar dryers or tunnel-type dryers to shorten drying time and reduce contamination risks. The second type is the industrial sector, which is relatively new and primarily engaged in the packaging and marketing of imported dried fruits such as apricots and golden sultana raisins. Some of these larger industrial units have begun experimenting with mechanical hot-air

drying, cabinet dryers, and, in a few cases, hybrid solar-electric systems to improve uniformity and color retention. This sector is growing rapidly due to the expansion of large and medium-sized retail networks. Despite these developments, Morocco still relies heavily on imported dried fruits, and domestic production of products such as apricots and golden raisins remains limited. and there is a significant gap in the domestic production of these products. There is limited information available about the quality and conformity of imported dried fruits, with only one study by Al Askari et al. (2012) examining the physicochemical parameters and microbiological aspects of "dried raisins," both locally produced and imported, and no specific study focusing on dried apricots. Therefore, it is crucial to assess the quality and conformity of these imported dried fruits, specifically apricots and raisins. To achieve this, a survey was conducted in the Fez-Meknes region of Morocco to understand consumer behavior towards dried fruits, resulting in 623 responses. After statistically analysing these data, an additional collection of 60 random samples (30 dried apricots and 30 dried raisins) from the same region was obtained for assessing their physicochemical, biochemical, and microbiological quality. Furthermore, the identification of contaminants was performed using Maldi-Tof-MS to evaluate the safety of these products for consumption.

Materials and Methods

Socio-economic investigation in the region of Fez-Meknes. The socio-economic investigation of dried fruit consumption in the Fez-Meknes region was carried out as part of an academic scientific research project over a period of six months. This survey was randomly distributed in the study area, with an explanation of the study's objectives. The survey was designed to be completed by the participants themselves and comprised three parts. The first part gathered information on participants' personal details, while the second part focused on their consumption of dried fruit, including types of fruit consumed, consumption rate, choice criteria and quality considerations. The third part focused specifically on dried apricots and raisins, covering aspects such as color preference, satisfaction with quality and estimated price per kg.

Quality assessment of selected samples from the region of Fez-Meknes

Chemicals used in this study. All the chemicals mentioned were of analytical grade and were sourced from Sigma Aldrich. The mediums used in the study were obtained from Biolife, located in Milano, Italy.

Sampling. A total of 500 g of dried raisins or dried apricots per sample were collected randomly from several high-traffic markets and sales outlets across

different localities of the Fez–Meknes region (Table 1). Sampling locations were selected based on market size and customer flow to ensure that sites with the highest circulation of imported dried fruits were represented. Each sample was placed in a sterile bag, kept at 0–4°C in a cooler, and transported to the laboratory within 24 h.

Physicochemical characteristic

Water content. According to the method described by AOAC (2000). Briefly, the samples were taken

Table 1. Geographic coordinates of samples collected from the region of Fez-Meknes

Sample number	Sample codes	Localization	Empla-cement
Sample 01	A-1; R1	33°52'05.4"N 5°32'58.0"W	Zitoune. Meknes
Sample 02	A-2; R-2	33°51'37.2"N 5°32'56.4"W	Marjane. Meknes
Sample 03	A-3; R-3	33°53'36.9"N 5°33'53.9"W	El hedime. Meknes
Sample 04	A-4; R-4	33°54'22.2"N 5°32'30.5"W	El hamria. Meknes
Sample 05	A-5; R-5	33°51'36.5"N 5°34'41.1"W	Marjane 2. Meknes
Sample 06	A-6; R-6	33°54'26.6"N 5°22'33.9"W	SabaâAïyoun
Sample 07	A-7; R-7	33°54'21.3"N 5°22'26.2"W	Swiktlakhmis
Sample 08	A-8; R-8	34°02'58.1"N 5°02'14.7"W	Medina. Fez
Sample 09	A-9; R-9	34°03'03.9"N 4°59'16.5"W	Barje. Fez
Sample 10	A-10; R-10	34°02'27.0"N 4°59'55.9"W	City center. Fez
Sample 11	A-11; R-11	34°02'14.2"N 4°59'20.1"W	Aljoulane. Fez
Sample 12	A-12; R-12	33°45'23.2"N 5°29'04.4"W	Boufekrane
Sample 13	A-13; R-13	33°45'17.8"N 5°28'56.5"W	Ichrak Boufekrane
Sample 14	A-14; R-14	33°49'41.3"N 5°25'22.9"W	El Haj Kaddour
Sample 15	A-15; R-15	33°49'44.1"N 5°25'27.7"W	El Haj Kaddour
Sample 16	A-16; R-16	33°55'55.5"N 5°22'06.9"W	Oued Jdida
Sample 17	A-17; R-17	33°55'56.0"N 5°22'07.0"W	Oued Jdida (2)
Sample 18	A-18; R-18	33°56'33.3"N 5°12'39.7"W	Ain Taoujdate
Sample 19	A-19; R-19	33°52'48.6"N 5°32'41.6"W	Agdal. Meknes
Sample 20	A-20; R-20	33°52'15.2"N 5°31'59.8"W	Zahwa. Meknes
Sample 21	A-21; R-21	33°49'52.9"N 4°50'15.9"W	Bab lamkan. Sefrou
Sample 22	A-22; R-22	33°49'31.0"N 4°50'12.2"W	City center. Sefrou
Sample 23	A-23; R-23	33°26'02.4"N 5°13'12.4"W	old town. Azrou
Sample 24	A-24; R-24	33°26'28.2"N 5°13'21.6"W	Mimosa. Azrou
Sample 25	A-25; R-25	33°31'15.1"N 5°07'08.6"W	Hay essalam Ifran
Sample 26	A-26; R-26	33°31'15.1"N 5°07'08.6"W	Quartier Atlas. Ifrane
Sample 27	A-27; R-27	33°31'33.9"N 5°06'57.5"W	Central Market. Ifrane
Sample 28	A-28; R-28	33°52'07.3"N 5°35'00.6"W	El Mensour; Meknes
Sample 29	A-29; R-29	33°51'52.1"N 5°34'03.9"W	Swika Marjane. Meknes
Sample 30	A-30; R-30	33°51'53.6"N 5°33'53.8"W	Sbata. Meknes

A: Apricots; R: raisins.

in a flat-bottom dish (pre-weighed) and kept overnight at 110 °C, in a Hygrometric enclosure HCP type 153 Memmert, Germany. The following formula was used to calculate the moisture content:

$$\text{Moisture \%} = \frac{(W_f - W_d)}{W_f} * 100 \quad (1)$$

Where:

W_f - weight of fresh samples;

W_d - weight of samples after drying

These results were confirmed with a Vibra MD Series Moisture Determination Balance MD83 model (Shinko Denshi Co., Ltd., Itabashi, Itabashi-ku Tokyo, Japan).

Water activity (a_w). The a_w was determined at 25 °C with an AquaLab CX-2 water activity meter (Decagon Devices, Inc. - METER Group, Inc., AQUALAB by Addium Inc., Pullman, WA, USA), previously controlled with saturated NaCl solution.

pH value. A quantity of 20 g of samples was homogenized for 5 min and filtered using a paper filter. The filtrate was analyzed to determine its pH value using a PC 7 Vio pH meter (XS Instruments brand, Giorgio Bormac S.r.l., Carpi, Modena, Italy) (Boudboud et al. 2023).

Total soluble content (°Brix). Total soluble solids were estimated as °Brix using a ATAGO Pocket Digital refractometer (Atago Co., Ltd., Minato-ku, Tokyo, Japan) at 25°C, the samples are homogenized and filtered before analysis (Boudboud et al. 2023).

Rehydration capacity. According to the method of (Singh et al. 2007) described by (Russo et al. 2013). Samples were totally immersed in distilled water at a ratio of 1:30 (1 part dried fruit to 30 parts water by weight). The experiments were performing with water at 20 °C. The weight of immersed samples was measured after 5 h. All rehydration experiments were performed in triplicate. The rehydration rate was calculated according to the following equation:

$$\text{Rehydration capacity} = \frac{(W_r - W_d)}{W_d} * 100 \quad (2)$$

Where:

W_r - weight of rehydrated samples;

W_d - weight of dried fruit

Chromatic characteristics

Instrumental color determination. Instrumental color of samples was analyzed with a light Konica Minolta Chroma Meter CR-5 benchtop reflectance and transmittance colorimeter (Konica Minolta, Inc., Ramsey, NJ, USA). Which had a viewing area of 30 mm diameter. Before use, the instrument was calibrated with a white tile. Measurements were noted in L^* (lightness), a^* (redness), and b^* (yellowness). Saturation (Chroma, C^*), hue value H^* , and yellow index were estimated from L^* , a^* and b^* using the subsequent equations (Ihns et al. 2011):

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \quad (3)$$

$$\text{Hue}^* = \tan^{-1} (b^*/a^*) \quad (4)$$

$$\text{Yellow index} = \frac{142,86 \times b^*}{L} \quad (5)$$

Browning index determination. Browning estimation was done according to the method described (Baisier and Labuza 1992) and (Peterson et al. 1994). Briefly, 5 g of dried sample was homogenized in 10 ml methanol. Then, centrifuged for 15 min at 15000 g. The supernatant was used to measure the absorbance at a wavelength of 420 nm. The intensification of the staining is considered as the browning index of the extracts.

Biochemical characteristics

Phenolic extract procedure. Polyphenols were extracted using the method described by (Dewanto, et al. 2002). 2 g of samples was homogenized with methanol (80%) for 30 min and centrifuged at 4500 min⁻¹.

Total phenols content. The supernatant was used to quantify a total phenolic compound according to the Folin-Ciocalteu method (de Moraes Barros et al. 2012). 250 µL of supernatant were added to 250 µL of Folin-Ciocalteu reagent and 500 µL of Na₂CO₃ (20%). The mixture was incubated in a water-bath for 30 min at 37 °C. The absorbance at 750 nm was measured by a V-630 UV-Vis Spectrophotometer (JASCO Corporation, JASCO Inc., Easton, MD, USA). The result was expressed as mg of gallic acid equivalent per 100g of dry weight (GAE). g⁻¹ DW.

Total flavonoids content (TFC). TFC were determined using the method explained by Dehpeur et al. (2009) 500 µl of the extract are added to 1500 µl of methanol (96%), 100 µl of 10% Aluminum

chloride (AlCl_3), 100 μl of sodium acetate (1M) and 2800 μl of distilled water. The mixture is stirred and incubated at room temperature in the dark for 30 min. The optical density is measured at 415 nm using a spectrophotometer. The TFC were presented in mg of quercetin equivalent.100g⁻¹ dry weight, referring to calibration curve of quercetin.

Total carotenoids content (TCC). According to the method of Drogoudi et al. (2008). One g of sample was homogenized in 30 ml of acetone: hexane (1:1, v/v) solution using an ultra-turrax for 2 min at 1000 min⁻¹. Then extracted on an IKA HS 260 basic reciprocal laboratory shaker (IKA-Werke GmbH & Co. KG, Staufen im Breisgau, Germany 260 basic) for 1 h at 270 min⁻¹. The extracts were filtered, and the supernatants were measured by V-630 UV-Vis Spectrophotometer (JASCO Corporation, JASCO Inc., Easton, MD, USA)

at 450 nm. The results were expressed as mg of β -carotene equivalent.100g⁻¹ DW.

SO₂ analysis. The SO₂ content of the dried samples was determined according to Monnier-William's distillation method (Türkyılmaz et al. 2014). The results were expressed as mg of SO₂ per kg of dried apricots.

Microbiological analyses and identification of strains by Maldi-Tof-MS

Microbiology quality assessment. Two samples (10 g of each) were aseptically placed in two separate sterile stomacher bags with a 1:9 (w/v) ratio. The first sample was diluted in peptone; the second was in Fraser broth base. Then both preparations were homogenized with a stomacher for 1 min at 230 min⁻¹. Each sample was used as described in the Table 2.

Table.2. Microbiological analyses applied to evaluate the quality of dried samples according to the international standards

Enumeration	Method (According to)	Mediums	Temperature and incubation time
The first aliquot			
The aerobic colonies	ISO 4833-1:2013	Plate Count Agar	30°C for 72 h.
<i>Enterobacteriaceae</i>	ISO 21528-2:2017	Violet Red Bile Glucose Agar	37°C for 24 h
<i>Clostridium</i> spp.	Nalbone et al. 2022	Tryptose Sulfite Cycloserine Agar.	37°C for 24 h under anaerobic conditions
Yeast and mould	ISO 21527-2:2008	Dichloran Glycerol (DG18) Agar	25°C for 5 d
<i>Bacillus</i> spp.	Fritze and Pukall 2011	- Mannitol egg-yolk polymyxin agar (MYP) - Polymyxin egg-yolk mannitol bromothymol blue agar (PEMBA)	37°C for 24 h
Coliforms	ISO 4832:2006	Violet Red Bile Agar	37°C for 24 h
<i>Escherichia coli</i>	ISO 16649-2:2010	Tryptone Bile X-GLUC agar (TBX)	44°C for 24 h
Lactic acid bacteria	ISO 15214:1998	M.R.S. Agar	30°C for 48 h
<i>Salmonella</i>	ISO 6579-1:2017	First step an enrichment in: - Mueller Kauffmann Tetrathionate Broth base - Rappaport Vassiliadis Soy Broth. Second step a smear on: - Plates of Chromogenic Salmonella Agar and Xylose Lysine Deoxycholate Agar.	37 ± 1°C for 24 h
The second aliquot			
<i>Listeria monocytogenes</i>	ISO 11290-1:2017	Agar Listeria according to Ottaviani and Agosti and Listeria Palcam Agar.	37 ± 1°C for 48 h

All the mediums used in this study were from Biolife, Milano, Italy

The identification using Matrix-Assisted Laser Desorption/ Ionization-Time of Flight (Maldi-Tof). The confirmation of a representative number of colonies from each medium was additionally validated using Mass Spectrometry (MS) with Maldi-Tof (Trabelsi et al. 2021). To do this, a portion of each colony or mycelium was placed on a VMS target slide, and 1 µl of 25% formic acid was used to lyse them. Once the samples were completely dried at room temperature, 1 µl of α -cyano-4-hydroxycinnamic acid matrix was applied to each spot. After drying all the spots, the target slide was inserted into the VMS, which operated with the following parameters: positive linear mode, laser frequency of 50 Hz, acceleration voltage of 20 kV, and extraction delay time of 200 ns. The mass spectra range was configured to detect values between 2000 and 20,000 Da. Maldi-Tof MS generated distinct mass spectra for each tested spot. These spectra were then imported into the SARAMIS software (Spectral Archive and Microbial Identification System, database version V4.12, software year 2013, bioMérieux, Firenze, Italy), where they were compared to the reference and super spectra databases to achieve identification at the genus and species levels. Only matches exceeding 70% similarity were deemed reliable.

Statistical analyses. The data underwent analysis using the SPSS software v23. As the samples were normally distributed, a one-way ANOVA was performed to determine statistical differences among means at a significance level of 0.05. Additionally, a principal component analysis (PCA) was carried out using factor analysis through the XLSTAT statistical software version 2016 to identify the key variables driving quality differences among samples and to support overall quality-control assessment of the imported dried fruits.

Results and Discussion

Socio-economic investigation in the region of Fez-Meknes. The socio-economic investigation of dried fruit consumption in the Fez-Meknes region was carried out as part of an academic scientific research project over a period of six months. A total of 623 participants were interviewed in this investigation. The participants belong to a different profession, and just 20 (participants) of them are jobless. The majority of participants (582) had an age between 18 and 40 years old, which is the

dynamic part of the population. 99.01 % of them confirm that, they consumed dried fruits. The rest who does not consume it, probably belong to a social group unable to obtain it because of their cost, which remains a little expensive. Furthermore, 53% (330 participants) confirmed a regular consumption of DF (Once or twice per week). According to the results the five most consumed dried fruits are: Dates (84.84%), Almonds (78.06%), Raisins (74.52%), Figs (58.55%), Apricots (49.84%). These fruits are divided into two distinct groups, a dominant classic range (Dates, Almonds, Figs and raisins) and an exotic range (Apricots, Dried bananas and dried pineapples) which are newly introduced in the Moroccan gastronomic culture. For the criteria used by participants to evaluate the quality were: Tasting (77.96%), color of the product (55.92%), and softness (49.59%). It is normal to had these responses because the most known manufacturing problems in the drying industry are: change of taste, color (Mcevely et al. 1992; Ruiz et al. 2005), and structure (Russo et al. 2013). These problems can be caused by the higher drying temperature, enzymatic reaction (Polyphenols oxidase) and non-enzymatic reaction (Maillard reaction), which together can darken the color, reduce natural fruit flavor, and alter texture, thereby diminishing the visual appeal and sensory quality of the dried fruits. For the color, preferences for dried apricot 72.94% of participants chose the orange color, and just 10.10% chose the brown color. For all participants the color orange it's a sign of higher quality. For dried raisins we note that the most requested colors are golden yellow (39.36%), brown (34.17%), black (6.53%) and indifferent (19.93%) respectively. It is normal because the drying of the raisins has been practicing for a long time in Morocco (Ater and Hmimsa 2013), and it is done by a traditional drying (Ater and Hmimsa 2013) (Huge loss of coloring due to browning phenomena). Consequently, consumers are habituated to products of this color.

Assessment of physicochemical and biochemical quality of collected samples

Physicochemical characterization. The assessment of physicochemical parameters is crucial for quality determination. Factors like water content, water activity, pH and the degree of brix are important because they react in different biochemical reaction that have a direct impact on

the quality of dried fruit. According to the statistical analyses (ANOVA) the factor region had a higher impact ($P < 0.005$) on all parameters analyzed in this study, except rehydration capacity of dried raisins (Table 3 and Table 4). The moisture content is a crucial characteristic that is typically assessed in various food items. Maintaining a low moisture content in food is essential for ensuring storage stability, improving processing conditions, and enhancing food quality (Hussain et al. 2015). The water contents and a_w values of dried raisins (Table 4) varied from 9.63 ± 0.45 (R-15) to 13.35 ± 0.34 (R-25), and from 0.348 ± 0.006 (R-20) to 0.514 ± 0.001 respectively. The water content of raisins never reaches the maximum value (18%) set by the UNECE Standard DDP-11 (2014). The water activity values of samples were less than 0.6. This mean lower potential for contamination by microorganisms, since a_w below 0.6 is widely recognized as the critical limit under which bacteria, yeasts, and molds cannot grow because the available free water is insufficient to support their metabolic and enzymatic activities. For apricots the water contents and a_w values varied from 16.60 ± 0.964 (A-7) to 31.23 ± 0.78 (A-18), and 0.60 ± 0.025 (A-7) to 0.79 ± 0.02 (A-17) respectively. According to the Fig. 1A, 15 samples were not in total compliance with the international standard UNECE Standard DDP-15 (2016), which specified a value not exceeding 25% of moisture. These results were much higher to those presented by (Hussain et al. 2011), who declare that moisture content of dried apricots ranged from 13.0 to 15.6 %. For the °brix, as shown in Table 3 the lowest value was $61.33 \pm 1.53\%$ (A20) and the highest was $82.33 \pm 1.53\%$ (A11) for apricot. For raisins (Table 4) the amount was ranging between $63.00 \pm 1.00\%$ (R1) and $87.33 \pm 1.53\%$ (R25). This result was near to those published by (Carranza et al. 2012) who mentioned an amount between 60% and 70%. According to these results, all samples had a good number of Total Soluble content (or °Brix), which mean a higher amount of sugar, organic acid and other soluble components. For the pH, which represent a limiting factor for bacterial growth and the development of enzymatic browning since most plant polyphenol oxidases shown maximum activity at neutral pH (Ümit Ünal et al. 2007) and this activity declined at acidic pH. As shown in Table 3 their significant difference between pH of apricots

and it was ranging from 4.33 ± 1.53 (A-01) to 4.57 ± 0.03 (A-29). For raisins (Table 4) it was ranging from 3.71 ± 0.58 (R-20) to 4.54 ± 0.12 (R-02). For raisins, the results of pH were the same as described by Al Askari et al. (2012) whom worked on different raisins imported to Morocco. For apricots the value of pH never exceeds the value of 4.5 for sulphured apricot mentioned by Inserra et al. (2017).

Rehydration capacity. Rehydration is a phenomenon influenced by many elements like pretreatments before drying, process, chemical composition and physical structure (Russo et al. 2013). In general, the higher the rehydration capacity, the better the dried fruit in terms of texture, taste and nutritional value (Horuz et al. 2017). Consequently, measuring this property is a significant indicator for assessing the quality of dried fruit and ensuring an optimal consumption experience. As shown in Table 3 and Table 4, the rehydration capacity for apricots and raisins ranged from $42.41 \pm 2.03\%$ (A-03) to $56.45 \pm 0.75\%$ (A-27) and from $10.86 \pm 1.93\%$ (R-24) to $69.24 \pm 0.93\%$ (R-29) respectively. As shown only 46% of apricots samples and only 30 % of raisins are able to regain more than 50 % of their initial weight on water. For the rest they had lower value, which refer to problem of manufacturing (non-Control of the process) and these samples cannot regain their soft appearance. For apricot the result of rehydration capacity was less than 60 to 80% published by Horuz et al. (2022), the lower rehydration capacity of both fruits can be explained by collapse of tissue and cell deformation caused by higher temperature of drying.

Biochemical characteristics

Total phenolics content and flavonoids content. Apricots and raisins are full of phenolic compounds, which are beneficial to human health. They possess potent antioxidant properties, which help protect cells from oxidative stress and decrease the risk of some chronic diseases. As shown in Table 3 and Table 4. There was a significant difference between the total phenolics content of all apricots and raisins. The total phenolic content (TPC) of dried apricots in this study ranged from 165.88 ± 1.93 mg GAE.100 g⁻¹ (A-7) to 177.55 ± 2.76 mg GAE.100 g⁻¹ (A-2), which falls within the values reported by Sakooei et al. (2020) ($120\text{--}160$ mg GAE.100 g⁻¹), but is lower than those reported by Sen et al. (2015)

Table 3. Physicochemical, chromatic and biochemical characteristics of dried apricots collected from fez-Meknes region

Samples	Physicochemical analyses			Chromatic Characteristics			Biochemical Characteristics				
	a _w	°Brix	pH	R.C	Chroma C*	Hue *	Yellow index	TPC	TFC	TCC	Browning
A- 01	0.67±0.02 ^{abc}	81.00±1.00 ^e	4.33±0.02 ^a	50.57±1.51 ^{abc}	36.62±1.92 ^b	62.96±3.15 ^a	109.59±2.12 ^b	172.20±0.79 ^b	47.46±0.67 ^k	36.15±0.68 ^b	1.24±0.006 ^a
A- 02	0.67±0.02 ^{abc}	69.00±1.00 ^a	4.40±0.02 ^a	52.02±1.43 ^{abc}	37.51±1.76 ^b	62.21±4.89 ^a	109.77±4.76 ^b	177.55±2.76 ^b	52.35±1.09 ^l	36.57±1.69 ^b	1.41±0.008 ^b
A- 03	0.66±0.02 ^{ab}	68.33±0.58 ^a	4.44±0.10 ^a	42.41±2.03 ^a	36.22±5.94 ^b	60.50±5.57 ^a	104.77±13.00 ^b	172.21±0.42 ^b	29.25±0.22 ^e	33.14±4.76 ^b	1.60±0.003 ^e
A- 04	0.68±0.02 ^{abc}	77.00±1.00 ^d	4.41±0.05 ^a	54.47±4.17 ^{abc}	41.45±2.08 ^b	67.25±4.66 ^a	117.30±5.96 ^b	176.74±2.45 ^b	21.39±0.71 ^c	37.91±1.76 ^b	0.99±0.003 ^a
A- 05	0.64±0.03 ^{ab}	70.67±1.15 ^a	4.47±0.03 ^b	47.57±2.23 ^{abc}	32.40±4.40 ^b	57.56±0.18 ^a	102.46±11.33 ^b	171.15±3.85 ^b	46.18±3.05 ^k	34.23±4.07 ^b	2.70±0.015 ⁱ
A- 06	0.73±0.02 ^{bcd}	72.33±1.15 ^a	4.42±0.05 ^a	49.11±1.36 ^{abc}	39.31±4.35 ^b	61.85±6.59 ^a	114.32±9.41 ^b	171.09±4.75 ^b	47.80±3.43 ^k	38.29±1.64 ^b	1.43±0.007 ^b
A- 07	0.60±0.02 ^a	62.33±1.53 ^a	4.55±0.03 ^e	51.55±1.58 ^{abc}	34.78±1.54 ^b	59.12±4.76 ^a	104.38±4.54 ^b	165.88±1.93 ^a	34.76±2.85 ^h	34.09±1.67 ^b	1.85±0.005 ^g
A- 08	0.77±0.02 ^{cd}	65.33±1.53 ^a	4.39±0.02 ^a	42.42±1.99 ^a	42.21±4.73 ^b	63.54±1.15 ^a	117.18±9.85 ^b	176.24±3.54 ^b	21.54±1.50 ^c	38.73±3.67 ^b	1.19±0.005 ^a
A- 09	0.73±0.02 ^{bcd}	71.33±0.58 ^a	4.44±0.04 ^a	49.50±1.13 ^{abc}	37.59±1.85 ^b	65.24±3.73 ^a	115.99±2.99 ^b	176.24±0.89 ^b	10.96±0.74 ^a	37.55±1.55 ^b	1.11±0.005 ^a
A- 10	0.64±0.02 ^{ab}	74.67±1.15 ^c	4.40±0.01 ^a	47.45±1.04 ^{abc}	33.52±4.32 ^b	59.46±3.25 ^a	103.91±11.80 ^b	172.79±0.84 ^b	30.92±2.01 ^f	34.12±4.79 ^b	1.70±0.006 ^f
A- 11	0.64±0.02 ^{ab}	82.33±1.53 ^f	4.41±0.02 ^a	48.38±2.23 ^{abc}	19.06±3.72 ^a	53.78±2.25 ^a	69.85±9.15 ^a	172.42±1.62 ^b	49.51±2.94 ^k	22.81±2.99 ^a	2.79±0.011 ⁱ
A- 12	0.70±0.07 ^{bcd}	72.33±1.15 ^a	4.36±0.02 ^a	49.84±4.31 ^{abc}	37.31±4.67 ^b	62.59±5.44 ^a	108.10±11.32 ^b	179.10±0.79 ^c	50.16±0.68 ^k	35.30±3.70 ^b	1.49±0.362 ^d
A- 13	0.67±0.02 ^{abc}	75.67±5.51 ^d	4.43±0.02 ^a	49.89±3.40 ^{abc}	38.13±6.80 ^b	61.44±4.37 ^a	109.46±11.11 ^b	184.45±2.76 ^f	55.05±1.09 ⁿ	35.75±3.63 ^b	1.65±0.016 ^f
A- 14	0.69±0.02 ^{abc}	75.67±6.66 ^d	4.47±0.10 ^b	47.98±5.15 ^{abc}	39.66±3.45 ^b	63.57±1.18 ^a	113.55±8.53 ^b	179.11±0.42 ^c	31.95±0.22 ^f	37.09±2.79 ^b	1.22±0.014 ^a
A- 15	0.67±0.02 ^{abc}	67.67±1.15 ^a	4.44±0.05 ^a	49.62±5.18 ^{abc}	35.79±1.88 ^b	65.39±3.69 ^a	110.83±4.95 ^b	183.64±2.45 ^e	24.09±0.71 ^c	36.20±1.62 ^b	1.15±0.014 ^a
A- 16	0.69±0.11 ^{abc}	70.67±5.51 ^a	4.50±0.03 ^d	50.49±1.17 ^{abc}	31.39±4.90 ^b	57.68±0.21 ^a	96.30±12.92 ^{ab}	179.28±2.12 ^c	49.14±2.68 ^k	31.12±4.54 ^a	2.74±0.041 ⁱ
A- 17	0.79±0.02 ^d	73.33±3.79 ^b	4.45±0.05 ^a	53.05±0.59 ^{abc}	32.89±2.08 ^b	59.52±4.53 ^a	100.51±1.06 ^b	181.69±4.75 ^d	51.30±3.43 ^k	33.69±0.35 ^b	2.57±0.010 ⁱ
A- 18	0.68±0.02 ^{abc}	70.67±1.53 ^a	4.58±0.03 ^g	51.50±1.80 ^{abc}	39.42±5.54 ^b	61.51±4.46 ^a	111.04±9.12 ^b	176.48±1.93 ^b	38.26±2.85 ⁱ	37.13±2.98 ^b	1.48±0.039 ^c
A- 19	0.71±0.04 ^{bcd}	67.67±5.86 ^a	4.42±0.02 ^a	49.86±2.30 ^{abc}	39.20±4.09 ^b	63.01±0.26 ^a	115.71±5.09 ^b	186.84±3.54 ^g	25.04±1.50 ^c	38.65±1.66 ^b	1.31±0.001 ^a
A- 20	0.69±0.03 ^{abc}	61.33±1.53 ^a	4.47±0.04 ^b	52.15±3.54 ^{abc}	36.38±1.92 ^b	63.46±6.11 ^a	111.04±4.95 ^b	186.84±0.89 ^g	14.46±0.74 ^b	37.13±1.62 ^b	1.21±0.016 ^a
A- 21	0.71±0.02 ^{bcd}	63.67±1.53 ^a	4.42±0.01 ^a	52.15±4.14 ^{abc}	37.35±7.84 ^b	65.58±7.32 ^a	108.86±17.40 ^b	184.62±1.88 ^f	33.87±1.54 ^g	36.41±5.68 ^b	1.11±0.014 ^a
A- 22	0.70±0.01 ^{bc}	68.67±4.16 ^a	4.43±0.02 ^a	50.09±4.10 ^{abc}	35.25±5.99 ^b	59.43±3.15 ^a	103.00±12.31 ^b	184.87±1.62 ^f	52.19±2.94 ^l	33.64±4.02 ^b	1.81±0.009 ^g
A- 23	0.65±0.03 ^{ab}	72.33±1.15 ^a	4.35±0.02 ^a	52.11±5.36 ^{abc}	37.93±6.26 ^b	59.16±5.88 ^a	112.13±9.91 ^b	184.65±0.79 ^f	50.14±0.68 ^k	36.62±3.24 ^b	2.32±0.559 ^h
A- 24	0.71±0.04 ^{bcd}	76.67±11.02 ^d	4.42±0.02 ^a	45.68±1.63 ^{bc}	31.83±9.88 ^b	58.34±6.47 ^a	95.80±22.12 ^{ab}	190.00±2.76 ^h	55.03±1.09 ⁿ	31.29±7.22 ^a	2.62±0.036 ⁱ
A- 25	0.71±0.02 ^{bcd}	66.67±4.04 ^a	4.46±0.10 ^a	44.59±4.08 ^{ab}	18.80±3.71 ^a	53.86±2.35 ^a	69.31±10.15 ^a	184.66±0.42 ^f	31.93±0.22 ^f	22.64±3.31 ^a	2.92±0.073 ^j
A- 26	0.73±0.05 ^{bcd}	71.67±2.89 ^a	4.43±0.05 ^a	45.79±1.00 ^{abc}	30.09±13.52 ^b	59.09±7.50 ^a	92.41±30.16 ^{ab}	192.41±2.45 ⁱ	28.29±0.71 ^d	30.18±9.85 ^a	1.88±0.020 ^g
A- 27	0.64±0.02 ^{ab}	76.33±5.77 ^d	4.49±0.03 ^c	56.45±0.75 ^c	38.62±3.83 ^b	60.32±6.98 ^a	110.50±7.30 ^b	186.82±3.85 ^g	53.08±3.05 ^m	36.09±2.38 ^b	1.84±0.023 ^g
A-28	0.64±0.02 ^{ab}	76.67±6.66 ^d	4.44±0.05 ^a	50.49±3.00 ^{abc}	35.00±4.26 ^b	64.69±1.92 ^a	103.13±13.00 ^b	186.76±4.75 ^g	54.70±3.43 ^o	33.68±4.25 ^b	1.19±0.009 ^a
A-29	0.66±0.03 ^{ab}	72.33±2.08 ^a	4.57±0.03 ^f	54.73±10.06 ^{bc}	40.27±3.28 ^b	64.28±7.52 ^a	113.50±6.03 ^b	181.55±1.93 ^d	41.66±2.85 ^j	37.07±1.97 ^b	1.20±0.029 ^a
A-30	0.76±0.02 ^{cd}	74.33±3.21 ^c	4.41±0.02 ^a	47.98±2.87 ^{abc}	31.03±8.90 ^b	59.33±4.17 ^a	94.76±20.50 ^{ab}	188.99±2.36 ^h	27.30±1.97 ^d	30.95±6.69 ^a	2.50±0.010 ^h
Sig	***	***	***	***	***	**	***	***	***	***	***
CV	7,259	8,223	1,463	8,705	19,682	8,175	14,421	3,845	34,215	14,713	35,147

A - Apricot sample; a_w - water activity; R.C - rehydration capacity; TPC - Total polyphenols content; TFC - Total flavonoids content; TCC - Total carotenoids content; Sig - Signification levels - *p<0.05; **p<0.01; ***p<0.001; n.s = Non-Significant p>0.05; CV - Coefficient of variation; Column with the same letter belong to the same group.

Table.4. Physicochemical, chromatic and biochemical characteristics of dried raisin collected from fez-Meknes region

Samples	Physicochemical characteristics				Chromatic characteristics				Biochemical characteristics		
	Water content, %	aw	°Brix	pH	R.C	Chroma C*	Hue H*	Yellow index	TPC	TFC	Browning
R- 01	11.19±0.75 ^d	0.45±0.04 ^a	63.00±1.00 ^a	4.23±0.10 ^a	26.75±0.98 ^a	29.36±1.11 ^q	66.93±0.90 ^l	93.38±0.25 ^o	101.90±1.37 ^h	33.50±1.21 ^k	2.98±0.17 ^a
R- 02	12.34±0.46 ^b	0.44±0.05 ^a	64.67±1.53 ^a	4.54±0.12 ^a	64.40±1.08 ^a	29.30±0.57 ^q	68.37±1.74 ^l	96.15±0.19 ^p	105.32±1.39 ⁱ	26.52±0.54 ^f	3.38±0.21 ^e
R- 03	11.87±0.12 ^f	0.45±0.03 ^a	76.00±1.00 ^d	4.17±0.04 ^a	36.60±1.11 ^a	13.14±0.26 ^j	48.80±0.83 ^g	54.42±1.08 ⁱ	106.38±1.40 ^j	36.46±2.54 ^m	4.63±0.31 ⁱ
R- 04	12.27±0.44 ^b	0.44±0.05 ^a	72.33±0.58 ^b	4.37±0.05 ^a	61.99±1.28 ^a	27.79±0.79 ^o	66.84±0.17 ^l	94.64±0.36 ^o	115.93±1.4 ¹	27.90±0.53 ^g	3.02±0.16 ^a
R- 05	13.21±0.09 ⁱ	0.44±0.08 ^a	71.33±1.53 ^b	4.33±0.04 ^b	35.95±1.29 ^a	17.08±0.73 ^k	58.56±0.30 ^k	68.38±2.00 ^k	81.88±1.39 ^f	23.34±0.39 ^e	3.37±0.53 ^d
R- 06	11.00±0.15 ^c	0.40±0.04 ^a	69.00±1.00 ^b	4.19±0.03 ^a	40.45±0.63 ^a	11.89±0.31 ⁱ	53.16±0.78 ^j	51.55±0.95 ^h	75.10±1.38 ^e	22.58±0.74 ^d	3.40±0.15 ^e
R- 07	12.12±0.20 ^g	0.49±0.01 ^a	72.33±1.53 ^b	4.13±0.08 ^e	38.73±1.02 ^a	16.46±0.33 ^k	57.68±1.08 ^k	64.39±1.28 ^j	91.27±1.40 ^g	25.55±1.33 ^f	3.00±0.16 ^a
R- 08	11.25±0.17 ^d	0.40±0.02 ^a	70.33±1.53 ^b	4.10±0.03 ^a	62.60±0.46 ^a	10.29±0.18 ^h	48.27±0.37 ^g	46.28±1.08 ^g	67.14±1.44 ^d	18.60±1.12 ^c	2.90±0.18 ^a
R- 09	9.76±0.20 ^a	0.41±0.05 ^a	81.00±1.00 ^e	4.45±0.10 ^a	50.43±0.52 ^a	26.27±0.55 ^m	68.29±0.28 ^l	89.08±0.98 ^m	140.17±1.45 ^q	30.58±0.74 ^h	4.23±0.18 ^h
R- 10	9.65±0.15 ^a	0.41±0.05 ^a	72.67±1.15 ^b	3.75±0.05 ^a	33.59±1.04 ^a	12.24±0.07 ⁱ	50.64±0.36 ⁱ	54.72±0.69 ^j	90.25±1.41 ^g	38.73±0.38 ⁿ	3.50±0.15 ^f
R- 11	10.29±0.20 ^a	0.41±0.05 ^a	82.67±1.53 ^e	4.02±0.03 ^a	39.54±0.81 ^a	16.48±0.30 ^k	59.38±1.50 ^k	67.91±0.72 ^k	117.06±1.37 ^l	31.70±0.17 ⁱ	3.65±0.21 ^g
R- 12	11.93±0.39 ^f	0.43±0.04 ^a	72.33±0.58 ^b	4.14±0.04 ^a	55.51±0.83 ^a	10.32±0.23 ^h	44.15±0.57 ^d	45.30±2.07 ^g	61.16±1.38 ^c	18.34±0.95 ^c	2.85±0.15 ^a
R- 13	11.04±0.05 ^c	0.41±0.05 ^a	80.67±0.58 ^e	3.86±0.06 ^a	26.30±1.06 ^a	30.37±0.15 ^r	67.84±0.20 ^l	98.73±1.02 ^q	134.11±1.36 ^p	34.88±0.75 ^l	2.81±0.18 ^a
R- 14	10.97±0.49 ^c	0.44±0.03 ^a	75.67±0.58 ^d	3.96±0.06 ^b	17.72±0.38 ^a	4.32±0.32 ^c	45.93±1.24 ^e	20.49±1.63 ^c	140.03±1.43 ^q	46.38±0.44 ^p	6.37±0.22 ^k
R- 15	9.63±0.32 ^a	0.41±0.05 ^a	81.67±1.15 ^e	4.06±0.04 ^a	46.61±1.09 ^a	1.82±0.06 ^{ab}	29.01±1.02 ^a	5.94±0.40 ^a	119.64±1.43 ^m	46.91±0.59 ^p	7.13±0.24 ^l
R- 16	10.45±0.42 ^a	0.41±0.05 ^a	84.00±1.73 ^e	3.76±0.08 ^d	52.18±1.87 ^a	27.15±0.36 ⁿ	70.19±0.10 ^l	91.51±0.87 ⁿ	132.86±1.45 ^p	41.49±0.18 ^o	3.54±0.20 ^f
R- 17	10.93±0.06 ^c	0.42±0.05 ^a	72.00±1.73 ^b	3.97±0.05 ^a	46.07±1.14 ^a	10.60±0.38 ^h	46.77±0.22 ^f	45.02±0.11 ^g	60.59±1.39 ^c	14.04±0.40 ^b	2.59±0.18 ^a
R- 18	11.35±0.45 ^e	0.41±0.05 ^a	74.33±0.58 ^c	3.87±0.05 ^g	47.74±2.86 ^a	11.42±0.16 ⁱ	52.97±1.09 ^j	49.93±0.79 ^h	59.79±1.40 ^c	21.11±0.59 ^d	3.32±0.20 ^c
R- 19	11.12±0.33 ^d	0.42±0.05 ^a	71.67±0.58 ^b	4.01±0.08 ^a	25.50±2.30 ^a	26.54±0.28 ^m	70.50±0.27 ^l	86.63±1.27 ^m	103.06±1.38 ^h	32.78±0.69 ^j	2.80±0.16 ^a
R- 20	10.03±0.05 ^a	0.39±0.07 ^a	85.67±2.52 ^f	3.71±0.58 ^b	21.70±0.76 ^a	2.29±0.17 ^b	44.97±2.25 ^d	10.54±1.13 ^b	154.06±1.37 ^r	62.29±0.88 ^r	8.59±0.18 ⁿ
R- 21	12.48±0.13 ^h	0.48±0.01 ^a	75.67±6.66 ^d	4.27±0.05 ^a	35.93±1.05 ^a	29.29±0.20 ^b	69.56±0.22 ^l	92.15±0.39 ⁿ	128.99±1.42 ^o	37.04±0.30 ^m	3.04±0.16 ^a
R- 22	11.97±0.78 ^f	0.48±0.01 ^a	83.00±1.00 ^e	4.46±0.04 ^a	57.65±1.19 ^a	7.93±0.04 ^f	40.37±0.31 ^c	31.67±0.29 ^e	81.93±1.40 ^f	29.85±0.38 ^h	3.37±0.17 ^d
R- 23	9.94±0.04 ^a	0.46±0.02 ^a	86.00±2.65 ^h	3.87±0.06 ^a	11.01±1.01 ^a	5.11±0.41 ^d	49.34±1.10 ^h	22.38±0.97 ^c	124.92±1.40 ⁿ	49.25±0.63 ^q	8.09±0.18 ^m
R- 24	11.12±0.25 ^d	0.48±0.01 ^a	84.00±1.00 ^e	3.98±0.02 ^a	10.86±1.93 ^a	6.15±0.33 ^e	47.25±1.31 ^f	28.53±1.46 ^d	122.77±1.38 ⁿ	37.04±0.66 ^m	5.91±0.17 ^j
R- 25	13.35±0.24 ⁱ	0.50±0.02 ^a	87.33±1.53 ⁱ	3.97±0.03 ^a	40.46±0.91 ^a	28.21±0.07 ^p	68.57±0.08 ^l	96.04±0.04 ^p	136.99±1.40 ^q	31.73±0.74 ⁱ	3.39±0.16 ^e
R- 26	12.51±0.46 ^h	0.49±0.01 ^a	69.33±0.58 ^b	3.94±0.06 ^a	32.13±0.17 ^a	17.86±0.11 ^l	59.16±0.04 ^k	71.96±0.34 ^l	74.85±1.40 ^e	21.46±0.14 ^d	2.76±0.17 ^a
R- 27	10.66±0.30 ^b	0.41±0.05 ^a	84.00±1.00 ^e	3.95±0.05 ^c	41.60±0.77 ^a	29.61±0.09 ^q	68.04±0.24 ^l	102.73±0.29 ^r	112.06±1.44 ^k	27.66±0.58 ^g	3.10±0.17 ^b
R-28	10.10±0.22 ^a	0.40±0.06 ^a	87.00±2.65 ⁱ	4.38±0.01 ^a	40.76±1.24 ^a	1.28±0.12 ^a	36.30±0.86 ^b	6.36±0.85 ^a	15.42±1.36 ^a	4.41±0.42 ^a	12.95±0.17 ^o
R-29	11.22±0.19 ^d	0.43±0.04 ^a	63.67±0.58 ^a	4.28±0.12 ^f	69.24±0.93 ^a	9.05±0.05 ^g	43.36±0.21 ^d	37.99±0.50 ^f	56.96±1.40 ^b	14.29±0.59 ^b	2.48±0.17 ^a
R-30	14.57±0.9 ^{lj}	0.51±0.03 ^a	65.33±2.08 ^a	4.30±0.10 ^a	51.91±1.91 ^a	13.83±1.24 ^j	42.43±5.97 ^c	46.85±8.03 ^g	56.21±4.88 ^b	13.57±0.70 ^b	2.47±0.17 ^a
Sig	***	*	***	***	n.s	***	***	***	***	***	***
CV	10,6660	11,2022	9,8915	5,9452	37,1668	60,1954	21,2917	50,7901	33,0155	40,4338	55,1895

R - raisin sample; a_w - water activity; R.C - rehydration capacity; TPC - Total polyphenols content; TFC - Total flavonoids content; TCC - Total carotenoids content; Sig - Signification levels - *p<0.05; **p<0.01; ***p<0.001; n.s = Non-Significant p>0.05; CV - Coefficient of variation; Column with the same letter belong to the same group.

(345.67–486.67 mg GAE.100 g⁻¹) and Boudboud et al. (2023a) (839–890 mg GAE.100 g⁻¹). For dried raisins (Table 4), TPC values ranged from 14.06 ± 2.34 mg GAE 100 g⁻¹ (R-28) to 152.69 ± 5.65 mg GAE.100 g⁻¹ (R-21). These variations may be explained by differences in growing conditions, climate, and cultivar (Dragović-Uzelac et al. 2007), as well as pretreatments and drying methods, which strongly influence phenolic retention (Deng et al. 2019; Boudboud et al. 2023b). Regarding total flavonoids, concentrations in apricots (Table 3) ranged from 10.96 ± 0.74 mg.100 g⁻¹ (A-9) to 52.35 ± 1.09 mg/100 g (A-2), while raisins (Table 4) ranged from 14.04 ± 1.42 mg.100 g⁻¹ (R-17) to 104.41 ± 1.45 mg.100 g⁻¹ (R-28). Significant differences ($p < 0.05$) were observed among all samples. For apricots, total flavonoid levels were lower than those reported by Sultana and Anwar (2008) (>78.48 mg.100 g⁻¹), whereas for raisins, the values were higher than those reported by Qin et al. (2020) (3,673–2,918 µg GE.g⁻¹) in their study of different drying methods for seedless raisins.

Overall, these results highlight the richness and diversity of phenolic and flavonoid profiles in dried apricots and raisins from the Fez–Meknes region, reflecting both natural and processing-related variability.

Carotenoids content in dried apricots.

Carotenoids helps to protect the body from harm caused by free radicals, which can lead to various diseases (Young et al. 2018). Measuring the beta-carotene content allows to assess the antioxidant potential of dried apricots and understand their significance in supporting overall health (Young et al. 2018). According to the Table 3 we detected a significant level of carotenoids in all dried apricots. The results ranged from 22.81±2.99 (A-11) to 38.65±1.66 mg Qeq.100 g⁻¹ (A-19). Therefore, the level of carotenoids had a strong (0.993) correlation with yellow index (Appendix 1), indicating that higher carotenoid content leads to a more intense yellow-orange color, which is a key indicator of product quality and consumer preference. The level of carotenoids in our samples was similar to those (22.38 mg/100 g DW) published by (Deng et al. 2022) and was within the range (12.2–51.2 mg.100 g⁻¹ DW) described by Sakooei et al. (2020) and Türkyılmaz et al. (2014) for dried apricots.

Sulfur dioxide content. Sulfur dioxide is commonly used as a preservative in dried fruits (Lou et al. 2017). However, excessive levels of residual SO₂ can have adverse health effects, particularly for individuals with sensitivities or allergies to sulfites (Lester 1995). Therefore, measuring the residual SO₂ content ensures compliance with regulatory limits and helps protect consumer health. According to the results shown in Fig. 1B, the amount of sulfur dioxide was ranging between 1690.54±95.34 (A-25) to 2147.05±145.03 mg SO₂.kg⁻¹ (A-04). According to the Codex Alimentarius (1981) we had 12 samples (A-01; A- 04; A- 08; A- 09; A- 12; A- 14; A- 15; A- 20; A- 21; A-28 and A-29) of dried apricots were not in conformity, because the use of SO₂ in food is strictly regulated and 2000 mg.kg⁻¹ have been established as the maximum threshold for dried fruits. Those results of SO₂ were higher to those published by Boudboud et al. (2023a), whom declared a value between (38.57 to 621.29 mg of SO₂.kg⁻¹ DF). For raisins the amount of SO₂ (Fig. 1C) was ranging from 502.39±32.39 (R-30) to 2139.52±2.76 (R-19). In these samples only 10 of them were not conform to the Codex Alimentarius (1981).

Correlation and analyses of principal components (PCA).

According to the results presented in the Appendix 1 and Appendix 2, for dried apricot or raisin samples, there is a strong correlation between the coloration components lightness (L^*), redness (a^*) and yellowness (b^*) with the values of chromaticity (C^*), yellow color index and hue angle (H^*), as these values are calculated from these basic components. Total carotenoid content in dried apricots was strongly and positively correlated with all color parameters, namely L^* (0.902), b^* (0.967), chromaticity C^* (0.970), hue H^* (0.814) and yellow color index (0.993). These results show that samples with higher chromaticity values have a greater level of total carotenoids, indicating less pigment degradation. Furthermore, total carotenoids show a positive correlation (0.804) with residual sulfur dioxide content and a negative correlation (-0.762) with browning. Additionally, the residual sulfur dioxide content of apricot samples is positively correlated with the color components L^* (0.845), b^* (0.858), chromaticity C^* (0.795), hue H^* (0.995) and yellow color index (0.818).

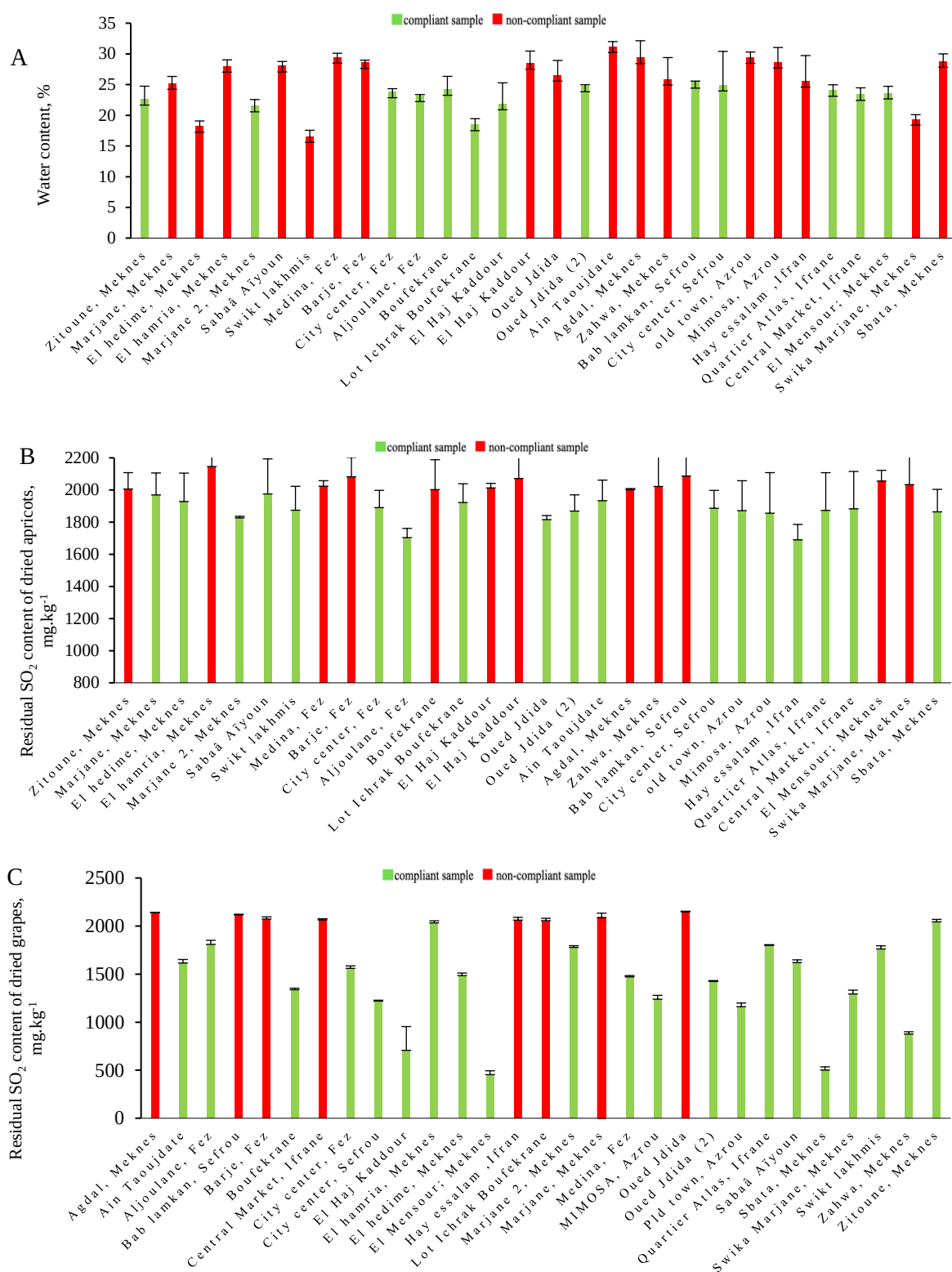


Figure 1. Presentation of non-conformity of samples regarding:
(A): water content for apricots; (B): residual SO₂ content for apricots; (C) residual SO₂ content for raisins

This can be explained by the fact that sulfur dioxide is an anti-browning agent widely used to preserve the color of dried fruit. It also has the advantage of preserving carotenoids against oxidation. These values are responsible for the yellow-orange coloration of dried apricots. However, residual sulfur dioxide content is negatively correlated with the degree of browning (-0.923), as SO_2 reacts with enzymatic browning reactions by inactivating the polyphenol oxidase enzymes responsible for browning, through reduction of their three-dimensional form or interaction with intermediate quinones to form a stable colorless compound (Iqbal et al. 2019). In addition, SO_2 can affect non-enzymatic browning reactions by interacting with reducing sugars to form highly stable products and limit the Maillard reaction (Guido 2016). For raisin samples, browning correlated negatively with the following color parameters: L^* (-0.513); a^* (-0.801); b^* (-0.530); chromaticity C^* (-0.585), H^* (-0.491) and the yellow color index (-0.653). This means that a decrease in the values of these components induces a fore discoloration of raisin samples. In the case of residual sulfur dioxide, a strong correlation was found with color parameters (same as apricot samples). In order to establish the relationships among samples (dried apricots and raisins), principal components analysis (PCA) was used. (PCA) was utilized to capture a substantial amount of variance and identify distinguishing characteristics with the fewest possible factors. Two factors (F1 and F2) were selected to elucidate the significant variability present (Fig. 2). More than 57% of the total variance was observed and explained the by factors F1 and F2 for Apricots samples (Fig. 2A), and more than 71% for dried raisins samples (Fig. 2B).

For apricots samples the first component F1 explained 43.81% of the total variability. It highlighted the presence of two groups, the first one hold samples with higher level of total carotenoids, which tend to have higher sulfur dioxide level and higher chromatic characteristics (chromaticity C^* , yellow index, hue value H^* , b^* and L^* component). The second one-hold samples with high browning index which present a higher degradation of color characteristics and less TCC and sulfur dioxide. The second axis F2 present also two groups. The first one was characterized by a higher total polyphenol content, along with higher levels of moisture and water activity, and tends to hold apricots with higher

weights. The second group hold apricots with higher flavonoids content (TFC) and a smaller number of fruits by kg of dried apricots, which mean apricot with less weight compared to the first group on the axis F2.

For raisins we observed the same behavior on the axis F1 (Fig. 2B) who explained 48,67% of total variability. Two groups were identified: the first was characterized by higher levels of residual sulfur dioxide and exhibited greater chromatic values (including Hue H^* , chromaticity C^* , yellow index, and L^* , a^* , b^* component), while the second group comprised raisins with a higher browning index, indicating greater color degradation. For the Axis F2 who explained 23.08% of variability also two major groups were detected, one with higher level of polyphenols (TPC, TFC) and higher degree of brix. The second one characterized by higher level of water content and water activity.

This data of ACP from Fig. 2A and Fig. 2B, testified on variability of dried samples (apricots and raisins) consumed in our local market. Therefore, it was essential to ensure their compliance with international standards.

Assessment of the microbial quality of dried samples and identification of species by Maldi-Tof-Ms. Although there has been thorough research into the processes of dehydration that cause microorganisms to become inactive or resilient during the drying process (Morgan et al. 2006), an increasing worry revolves around the existence of pathogens like *Salmonella* in dried food items. This concern was supported by the findings of Bourdoux et al. (2016). They offers a summary of studies investigating the occurrence of microorganisms such as *S. typhimurium*, *S. anatum*, coliforms, and so on, on different fruits, vegetables, herbs, and spices as a result of various drying methods. Results of the microbial analyses are presented in Table 5. The total viable counts were significantly higher ($p < 0.05$) in most raisins' samples than in the apricot samples, with a mean value of 4.43 ± 1.21 and 2.36 ± 0.37 Log CFU.g⁻¹, respectively. For the occurrence of *Enterobacteriaceae* only in one sample of dried apricots (A-11 from Aljoulane, Fez) against the four contaminated samples of raisins (G-5 from El Hamria, Meknes, G-9 from Barje, Fez, G-15 from El Haj Kaddour, G-24 from Mimosa, Azrou).

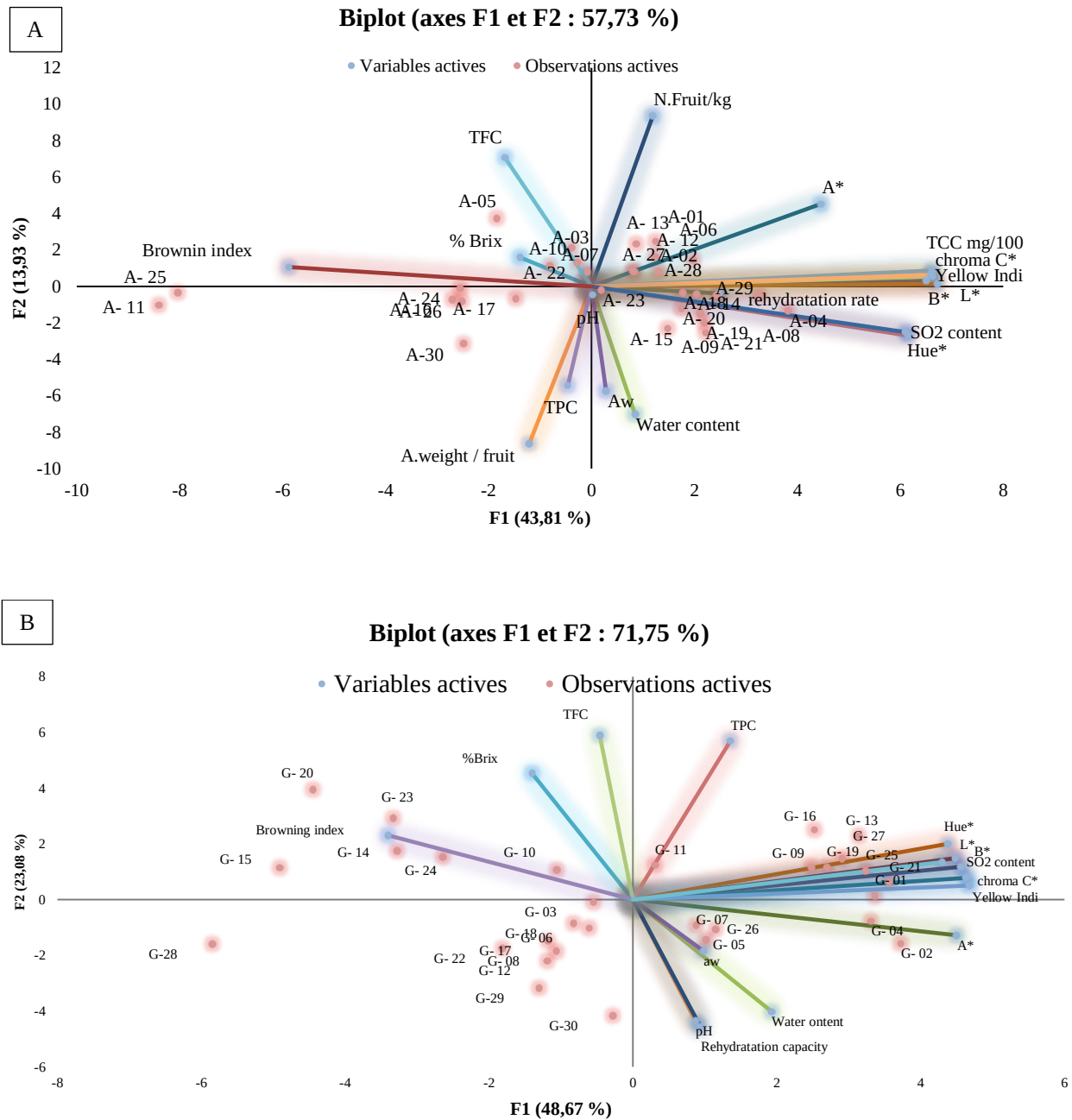


Figure 2. Principal component analysis of the samples: (A): Apricot samples; (B): raisin samples

However, in any case, loads of *Enterobacteriaceae* did not reach the limit of 10^2 CFU.g⁻¹ set by international standards (Clabots 2007). This contamination might be explained by the poor conditions of preparation, transport and exposure in the markets. The most frequently isolated strains were *Providencia stuartii* that is a Gram-negative opportunistic pathogen of the urinary tract (Urban 2013) and *Enterobacter cloacea*, species found in

commensal of the human gastrointestinal tract capable to shift into an opportunistic pathogen (Guérin 2015). Mean values of 1.58 ± 0.73 and 3.21 ± 0.66 Log CFU.g⁻¹ of *Bacillaceae* were detected in the samples of apricot and raisin, respectively. In the raisin samples, the loads were significantly higher ($p < 0.05$). These results highlighted that *Bacillaceae* represented the most abundant flora both in the apricot and raisin samples.

Table 5. Values of the loads (expressed as Log UFC/g and UFM/g) of different microbiological parameters detected in dried apricots and dried raisins

Sample ID	TVC	<i>Enterobacteriaceae</i>	Coliforms	<i>E. coli</i>	Lactic bacteria	<i>Bacillus</i> spp.	Yeasts	Molds	<i>Clostridium</i> spp.	<i>L. monocytogenes</i>	<i>Salmonella</i> spp.
A-01	1.48	< 10	< 10	< 10	< 10	1.90	< 100	< 100	< 10	Not detected	Not detected
A-02	1.85	< 10	< 10	< 10	< 10	1.70	< 100	< 100	< 10	Not detected	Not detected
A-03	2.36	< 10	< 10	< 10	< 10	2.04	< 100	< 100	< 10	Not detected	Not detected
A-04	2.15	< 10	< 10	< 10	< 10	2.18	< 100	< 100	< 10	Not detected	Not detected
A-05	3.21	< 10	< 10	< 10	< 10	2.04	< 100	2	< 10	Not detected	Not detected
A-06	2.57	< 10	< 10	< 10	< 10	<100	< 100	< 100	< 10	Not detected	Not detected
A-07	1.78	< 10	< 10	< 10	< 10	2.04	< 100	< 100	< 10	Not detected	Not detected
A-08	2.48	< 10	< 10	< 10	< 10	1.70	< 100	< 100	< 10	Not detected	Not detected
A-09	2.23	< 10	< 10	< 10	< 10	< 100	< 100	< 100	< 10	Not detected	Not detected
A-10	2.52	< 10	< 10	< 10	< 10	2.15	< 100	2	< 10	Not detected	Not detected
A-11	2.48	1.70	<10	< 10	< 10	1	< 100	2.85	< 10	Not detected	Not detected
A-12	1.48	< 10	< 10	< 10	< 10	1	< 100	2	< 10	Not detected	Not detected
A-13	2.49	< 10	< 10	< 10	< 10	1.95	< 100	2.48	< 10	Not detected	Not detected
A-14	2.49	< 10	< 10	< 10	< 10	1.48	< 100	< 100	< 10	Not detected	Not detected
A-15	2.49	< 10	< 10	< 10	< 10	2.23	< 100	2.48	< 10	Not detected	Not detected
A-16	2.60	< 10	< 10	< 10	< 10	<100	< 100	2.70	< 10	Not detected	Not detected
A-17	2.11	< 10	< 10	< 10	< 10	2.11	< 100	2	< 10	Not detected	Not detected
A-18	2.30	< 10	< 10	< 10	< 10	1.70	< 100	2.30	< 10	Not detected	Not detected
A-19	2.70	< 10	< 10	< 10	< 10	1.95	< 100	2.30	< 10	Not detected	Not detected
A-20	2.40	< 10	< 10	< 10	< 10	1.30	< 100	< 100	< 10	Not detected	Not detected
A-21	2.20	< 10	< 10	< 10	< 10	1	< 100	< 100	< 10	Not detected	Not detected
A-22	2.28	< 10	< 10	< 10	< 10	2.20	< 100	2.60	< 10	Not detected	Not detected
A-23	2.46	< 10	< 10	< 10	< 10	2.30	< 100	2.70	< 10	Not detected	Not detected
A-24	2.48	< 10	< 10	< 10	< 10	1.85	< 100	2.48	< 10	Not detected	Not detected
A-25	2.57	< 10	< 10	< 10	< 10	2	< 100	2.90	< 10	Not detected	Not detected
A-26	2.68	< 10	< 10	< 10	< 10	2.11	< 100	3.00	< 10	Not detected	Not detected
A-27	2.95	< 10	< 10	< 10	< 10	2.36	< 100	3.18	< 10	Not detected	Not detected
A-28	2.51	< 10	< 10	< 10	< 10	1.60	< 100	2.60	< 10	Not detected	Not detected
A-29	2.15	< 10	< 10	< 10	< 10	<100	< 100	2.48	< 10	Not detected	Not detected
A-30	2.49	< 10	< 10	< 10	< 10	1.48	< 100	< 100	< 10	Not detected	Not detected
R-1	5.08	< 10	< 10	< 10	< 10	3.30	2.48	3.11	< 10	Not detected	Not detected
R-2	5.55	< 10	< 10	< 10	< 10	2.49	< 100	2.48	< 10	Not detected	Not detected
R-3	5.87	< 10	< 10	< 10	< 10	2.46	< 100	2	< 10	Not detected	Not detected
R-4	5.55	< 10	< 10	< 10	< 10	4.04	< 100	2.60	< 10	Not detected	Not detected
R-5	5.73	1.60	< 10	< 10	< 10	2.73	< 100	< 100	< 10	Not detected	Not detected
R-6	5.22	< 10	< 10	< 10	< 10	3.30	< 100	2.48	< 10	Not detected	Not detected
R-7	5.70	< 10	< 10	< 10	< 10	2.51	< 100	< 100	< 10	Not detected	Not detected
R-8	3.02	< 10	< 10	< 10	< 10	3.60	< 100	3.11	< 10	Not detected	Not detected
R-9	4.28	1.70	< 10	< 10	< 10	2.78	< 100	3.08	< 10	Not detected	Not detected
R-10	5.89	< 10	< 10	< 10	< 10	3.30	2.48	< 100	< 10	Not detected	Not detected
R-11	5.51	< 10	< 10	< 10	< 10	3.30	2.30	2.30	< 10	Not detected	Not detected
R-12	5.68	< 10	< 10	< 10	< 10	3.48	2.48	3.08	< 10	Not detected	Not detected
R-13	2.49	< 10	< 10	< 10	< 10	3.48	< 100	2.48	< 10	Not detected	Not detected

Three species of the genus *Bacillus* were identified in both apricot and raisin samples. Two of them were common environmental contaminants, i.e., *Bacillus pumilus* and *Bacillus subtilis*. Instead, the

detection of *Bacillus cereus* in both apricot and raisin samples was of major concern since it could be responsible for toxic infections characterized by diarrheal symptoms, as well as intoxications

resulting in emetic symptoms. For the presence of yeasts, results show a contamination in only in seven samples of raisin (R1- R10- R11- R12- R14 - R23 and R24), with a load ranging from 2 to 3.61 Log CFU.g⁻¹. Elhalouat and Debevere (1997) observed similar results. They detected yeasts in raisins with a low count. The only species identified in our samples was *Saccharomyces cerevisiae*, which is ubiquitous in the environment, and often implicated in the spoilage of processed fruit products (Viljoen and Heard 1999). Molds were detected in eighteen samples of apricot with loads between 2 and 3.18 Log unit forming mycelium (UFM.g⁻¹ while they were detected in twenty-six raisin samples with loads between 2 to 3.18 Log UFM.g⁻¹ *Penicillium chrysogenum* and *Aspergillus tubingensis* were the two major species identified in our samples. Although the loads do not exceed the limit set by the regulations (Clabots 2007) of 10⁴ UFC.g⁻¹. The identification of molds species belonging to the *Penicillium* spp. and *Aspergillus* spp. genus raises concern about the potential production of mycotoxins during their proliferation in dried fruit (Zinedine et al. 2004). Two mycotoxins known to be produced by *Penicillium chrysogenum* are citrinin (Reiss 1977) and roquefortine C (García-Rico et al. 2008). Citrinin has been reported to be nephrotoxic and hepatotoxic to humans. The major target organ of this mycotoxin is kidney (Gil-Serna et al. 2014). Roquefortine C is a relatively weak neurotoxin (Abbas 2011) that has been widely studied in ruminants. The clinical symptoms include muscle weakness and lack of coordination (Abbas 2011). Based on (Medina et al. 2005) who studied the microbiota of Spanish raisins, they found that *Aspergillus tubingensis* could produce ochratoxin A (OTA), which is a naturally occurring mycotoxin. It has been widely detected across a diverse range of food products, including cereals, dried fruits, and meat products (Benford et al. 2001). OTA induces a variety of toxic effects, the most important being nephrotoxicity and nephrocarcinogenicity in rodents (Benford et al. 2001). Lactic acid bacteria were identified in only two raisin samples, whereas they were completely absent in the apricot samples. Furthermore, pathogens and indicator organisms - specifically. *Clostridium* spp., coliforms, *E. coli*, *L. monocytogenes* and *Salmonella* spp. we are not detected in any of the analyzed samples.

Conclusions

This study focused mainly on the quality of two dried fruits (apricots and raisins) and their conformity with international standards. Moreover, an evaluation of their microbial safety to understand the potential damage they can cause by the identification of strains with Maldi-Tof-Ms. Microbiological analysis indicated that all dried fruit samples collected from various retail outlets across the Fès-Meknès region complied with current regulatory limits. However, the detection of *Enterobacter* spp. in certain raisin and apricot samples highlights a deficiency in sanitary handling, hygiene, and storage conditions throughout the supply chain. Even when mold counts do not exceed established compliance thresholds, their presence may still pose a risk of mycotoxin contamination. Physicochemical and biochemical analyses revealed that half of the dried apricot samples exhibited at least one non-conformity, failing to meet requirements for either maximum water content or permissible sulfur dioxide levels. In contrast, all dried raisin samples complied with standard limits for maximum moisture content. However, several raisin samples displayed a low rehydration capacity, which compromised their biochemical quality and prevented them from restoring a soft texture. Furthermore, 33% of these samples exceeded the international regulatory threshold for sulfur dioxide.

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Author Contributions

Conceptualization, B.A.; methodology, B.A., H.H, M.H and L.N.; formal analysis, B.A. and L.N.; investigation, B.A. and L.N.; resources, B.A., H.H, M.H and L.N.; data curation, B.A.; writing – original draft preparation, B.A.; writing – review

and editing, B.A., L.N., H.H. and M.H.; visualization, B.A.; supervision, H.H. and M.H.; project administration, B.A., H.H. and M.H. All authors have read and agreed to the published version of the manuscript.

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Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The original contributions presented in this study are included in the article. Further inquiries can be directed to the corresponding authors.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Abbas A., Dobson A.D.W. Yeasts and Molds. *Penicillium roqueforti* In: *Encyclopedia of Dairy Sciences* (Second Edition) (J.W. Fuquay Ed.). Academic Press. 2011, pp. 772-775, ISBN: 978-0-12-374407-4, <https://doi.org/10.1016/B978-0-12-374407-4.00363-0>
- Al Askari G., Kahouadji A., Khedid K., Charof R., Mennane Z. Physicochemical and microbiological study of “raisin”, local and imported (Morocco). *Middle-East Journal of Scientific Research*, 2012, 11(1): 1-6. Available at: <https://www.idosi.org/mejsr/mejsr11%281%2912/1.pdf>
- AOAC Official Method 934.06 Moisture in Dried Fruits. 17th Edn. Washington, DC, USA, AOAC International, 2000.
- Ater M., Hmimsa Y. Agrodiversité des agroécosystèmes traditionnels du pays Jbala (Rif, Maroc) et produits de terroirs. In: *Indications Géographiques, dynamiques socio-économiques et patrimoine bio-culturel en Turquie et dans les pays méditerranéens* (H. Ilbert, Y. Tekelioglu, S. Çagatay, S. Tozanli Eds.). CIHEAM, Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 104. 2013, pp. 197-208, Available at: <https://om.ciheam.org/om/pdf/a104/00006851.pdf>
- Barbosa-Cánovas G.V., Vega-Mercado H. Introduction to Dehydration of Food. In: *Dehydration of Foods*, 1st Ed.(G.V. Barbosa-Cánovas, H. Vega-Mercado Eds.). Book Series: Food Engineering Series, Springer Science & Business Media. 1996, pp. 1-8, Print Hardcover ISBN: 978-0-412-06421-0, Print Softcover ISBN: 978-1-4419-4723-9, eBook ISBN: 978-1-4757-2456-1. <https://doi.org/10.1007/978-1-4757-2456-1>
- Baisier W.M., Labuza T.P. Maillard browning kinetics in a liquid model system. *Journal of Agricultural and Food Chemistry*, 1992,40(5): 707-713. <https://doi.org/10.1021/jf00017a001>
- Benford D., Boyle C., Dekant W., Fuchs R., Gaylor D.W., Hard G., McGregor D.B., Pitt J.I., Plestina R., Shephard G., Solfrizzo M., Verger P.J.P., Walker R. Ochratoxin A. In: *Safety Evaluation of Certain Mycotoxins in Food*, Book/Series: Safety Evaluation of Certain Mycotoxins in Food (Fifty-sixth meeting of the Joint FAO/WHO Expert Committee on Food Additives). FAO/WHO. *WHO Food Additives Series*, 2001, 47(74): 281-415.
- Bourdoux S., Li D., Rajkovic A., Devlieghere F., Uyttendaele M. Performance of drying technologies to ensure microbial safety of dried fruits and vegetables. *Comprehensive Reviews in Food Science and Food Safety*, 2016, 15(6): 1056-1066. <https://doi.org/10.1111/1541-4337.12224>
- Boudboud A., Aziz M.B., M'barek H.N., Hajjaj H., Hajji L., Hajji L., de Meulenaer B., Mazouz H. Effect of pretreatment and process parameters on the chemical and biochemical properties of moroccan apricots (*Prunus armeniaca* L. Var. Canino). *Journal of Food Chemistry & Nanotechnology*, 2023a, 9(3): 113-122. <https://doi.org/10.17756/jfcn.2023-157>
- Boudboud A., Aziz M.B., Hajjaj H., Hajji L., de Meulenaer B., Mazouz H. Impact of pretreatment and drying factors on chemical and biochemical attributes of Moroccan Thompson seedless grapes. *International Journal of Food Science*, 2023b, 2023(9): 4438353. <https://doi.org/10.1155/2023/4438353>
- Campbell O.E., Merwin I.A., Padilla-Zakour O.I. Characterization and the effect of maturity at harvest on the phenolic and carotenoid content of Northeast USA apricot (*Prunus armeniaca*) varieties. *Journal of Agricultural and Food Chemistry*, 2013, 61(51): 12700-12710. <https://doi.org/10.1021/jf403644r>
- Clabots F. Microbiological criteria for foodstuffs [In French]. National Health Laboratory, Foodstuff

- Control, Luxembourg. 2007, 30 p., Document Reference Code: [F-054 Rev01](#)
- Codex Alimentarius. International Food Standard. Codex Standard 130-1981 outlines the international requirements for dried apricots intended for direct human consumption or bulk repacking. Roma, Food and Agriculture Organization and the World Health Organization of the United Nations. (FAO/WHO), The Codex Alimentarius Commission (CAC). Adopted in 1981. Amended in 2019.
- Dai J.W., Rao J.Q., Wang D., Xie L., Xiao H.W., Liu Y.H., Gao Z.J. Process-based drying temperature and humidity integration control enhances drying kinetics of apricot halves. *Drying Technology*, 2015, 33(3): 365-376. <https://doi.org/10.1080/07373937.2014.954667>
- de Moraes Barros H.R., de Castro Ferreira T.A.P., Genovese M.I. Antioxidant capacity and mineral content of pulp and peel from commercial cultivars of citrus from Brazil. *Food Chemistry*, 2012, 134(4): 1892-1898. <https://doi.org/10.1016/j.foodchem.2012.03.090>
- Dehpour A.A., Ebrahimzadeh A.A., Fazel N.S., Nabavi S.M. Antioxidant activity of the methanol extract of *Ferula assafoetida* and its essential oil composition. *Grasas y Aceites*, 2009, 60(4): 405-412. <https://doi.org/10.3989/gya.010109>
- Deng L.Z., Pan Z., Mujumdar A.S., Zhao J.H., Zheng Z.A., Gao Z.J., Xiao H.W. High-humidity hot air impingement blanching (HHAIB) enhances drying quality of apricots by inactivating the enzymes, reducing drying time and altering cellular structure. *Food Control*, 2019, 96(2): 104-111. <https://doi.org/10.1016/j.foodcont.2018.09.008>
- Dewanto V., Wu X., Adom K.K., Liu R.H. Thermal processing enhances the nutritional value of tomatoes by increasing total antioxidant activity. *Journal of Agricultural and Food Chemistry*, 2002, 50(10): 3010-3014. <https://doi.org/10.1021/jf0115589>
- Doymaz İ. Effect of pre-treatments using potassium metabisulphide and alkaline ethyl oleate on the drying kinetics of apricots. *Biosystems Engineering*, 2004, 89(3): 281-287. <https://doi.org/10.1016/j.biosystemseng.2004.07.009>
- Dragović-Uzelac V., Levaj B., Bursać D., Pedisić S., Radojčić I., Biško A. Total phenolics and antioxidant capacity assays of selected fruits. *Agriculturae Conspectus Scientificus*, 2007, 72(4): 279-284. Available at: <https://hrcak.srce.hr/19384>
- Drogoudi P.D., Vemmos S., Pantelidis G., Petri E., Tzoutzoukou C., Karayiannis I. Physical characters and antioxidant, sugar, and mineral nutrient contents in fruit from 29 apricots (*Prunus armeniaca* L.) cultivars and hybrids. *Journal of Agricultural and Food Chemistry*, 2008, 56(22): 10754-10760. <https://doi.org/10.1021/jf801995x>
- Elhalouat A., Debevere J. Molds and yeasts isolated from hydrated prunes and raisins having different water. *Sciences des Aliments*, 1997, 17(5): 539-545.
- Fritze D., Pukall R. Culture Media for *Bacillus* spp. and Related Genera Relevant to Foods. In: *Handbook of Culture Media for Food and Water Microbiology*, 3rd ed. (J.E.L. Corry, G.D.W. Curtis, R.M. Baird, Eds.). Royal Society of Chemistry. 2011, pp. 90-114, ISBN: 978-1-84-755145-0, <http://doi.org/10.1039/9781847551450-00090>
- García-Rico R.O., Fierro F., Mauriz E., Gómez A., Fernández-Bodega M.Á., Martín J.F. The heterotrimeric Ga protein Pga1 regulates biosynthesis of penicillin, chrysogenin and roquefortine in *Penicillium chrysogenum*. *Microbiology*, 2008, 154(11): 3567-3578. <https://doi.org/10.1099/mic.0.2008/019091-0>
- Gil-Serna J., Vázquez C., González-Jaén M.T., Patiño B. Mycotoxins Toxicology. In: *Encyclopedia of Food Microbiology*, 2nd ed. (C.A. Batt, M.A. Tortorello Eds.). Academic Press. 2014, pp. 887-892, ISBN: 978-0-12-384730-0, <http://doi.org/10.1016/B978-0-12-384730-0.00234-2>
- Guérin, F. Infections à *Enterobacter cloacae* complex: résistance aux antibiotiques et traitement. *Journal des Anti-infectieux*, 2015, 17(3): 79-89. <https://doi.org/10.1016/j.antinf.2015.03.002>
- Guido L.F. Sulfites in beer: reviewing regulation, analysis and role. *Scientia Agricola*, 2016, 73(2): 189-197. <https://doi.org/10.1590/0103-9016-2015-0290>
- Horuz E., Bozkurt H., Karataş H., Maskan M. Comparison of quality, bioactive compounds, textural and sensorial properties of hybrid and convection-dried apricots. *Journal of Food Measurement and Characterization*, 2018, 12(9): 243-256. <https://doi.org/10.1007/s11694-017-9635-x>
- Hussain P.R., Meena R.S., Dar M.A., Wani A.M. Gamma irradiation of sun-dried apricots (*Prunus armeniaca* L.) for quality maintenance and quarantine purposes. *Radiation Physics and Chemistry*, 2011, 80(7): 817-827. <https://doi.org/10.1016/j.radphyschem.2011.02.029>
- Hussian N., Shahnawaz M., Abbas Y., Ali N., Abbas T., Ullah S., Ali A., Hussain A. Physio-chemical and sensorial quality evaluation of commercially available dried apricots of Gilgit Baltistan, Pakistan. *Journal of Food and Nutrition Sciences*, 2015, 3(6): 216-222. <https://doi.org/10.11648/j.jfns.20150306.13>
- Ihns R., Diamante L.M., Savage G.P., Vanhanen L., Effect of temperature on the drying characteristics, colour, antioxidant and beta-carotene contents of two apricot varieties. *International Journal of Food*

- Science & Technology, 2011, 46(2): 275-283.
<https://doi.org/10.1111/j.1365-2621.2010.02506.x>
- Inserra L., Cabaroğlu T., Şen K., Arena E., Ballistreri G., Fallico B. Effect of sulphuring on physicochemical characteristics and aroma of dried Alkaya apricot: a new Turkish variety. *Turkish Journal of Agriculture and Forestry*, 2017, 41(1): 59-68. <https://doi.org/10.3906/tar-1607-60>
- Iqbal A., Murtaza A., Hu W., Ahmad I., Ahmed A., Xu X. Activation and inactivation mechanisms of polyphenol oxidase during thermal and non-thermal methods of food processing. *Food and Bioprocess Processing*, 2019, 117(9): 170-182.
<https://doi.org/10.1016/j.fbp.2019.07.006>
- ISO 4833-1:2013 The aerobic colonies Plate Count Agar. Geneva, Switzerland: International Organization for Standardization (ISO), 2013.
- ISO 11290-1:2017. Microbiology of the Food Chain - Horizontal Method for the Detection and Enumeration of *Listeria monocytogenes* and of *Listeria* spp. - Part 1: Detection Method. Geneva, Switzerland: International Organization for Standardization (ISO), 2017.
- ISO 15214:1998; Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of mesophilic lactic acid bacteria - Colony-count technique at 30 degrees C. Geneva, Switzerland: International Organization for Standardization (ISO), 2003.
- ISO 16649-2:2010. Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of beta-glucuronidase- positive *Escherichia coli* - Part 2: Colony-count technique at 44 degrees C using 5-bromo-4-chloro-3-indolyl β -D-glucuronide. Geneva, Switzerland: International Organization for Standardization (ISO), 2003.
- ISO 21527-2:2008. Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of yeasts and molds - Part 2: Colony count technique in products with water activity less than or equal to 0.95. Geneva, Switzerland: International Organization for Standardization (ISO), 2003.
- ISO 21528-2:2017. Microbiology of the Food Chain - Horizontal Method for the Detection and Enumeration of *Enterobacteriaceae* - Part 2: Colony-Count Technique. Geneva, Switzerland: International Organization for Standardization (ISO), 2017.
- ISO 4832:2006. Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of Coliforms-Colony-count technique. Geneva, Switzerland: International Organization for Standardization (ISO), 2003.
- ISO 4833:2013. Microbiology of the Food Chain - Horizontal Method for the Enumeration of Microorganisms-Part 1: Colony Count at 30 °C by the Pour Plate Technique. Geneva, Switzerland: International Organization for Standardization (ISO), 2013.
- ISO 6579-1:2017. Microbiology of the Food Chain - Horizontal Method for the Detection, Enumeration and Serotyping of *Salmonella* - Part 1: Detection of *Salmonella* spp. Geneva, Switzerland: International Organization for Standardization (ISO), 2017.
- Lester M.R. Sulfite sensitivity: significance in human health. *Journal of the American College of Nutrition*, 1995, 14(3): 229-232.
<https://doi.org/10.1080/07315724.1995.10718500>
- Link J. V., Tribuzi G., Laurindo J.B. Improving quality of dried fruits: A comparison between conductive multi-flash and traditional drying methods. *LWT*, 2017, 84(10): 717-725.
<https://doi.org/10.1016/j.lwt.2017.06.045>
- Lou T., Huang W., Wu X., Wang M., Zhou L., Lu B., Zheng L., Hu Y. Monitoring, exposure and risk assessment of sulfur dioxide residues in fresh or dried fruits and vegetables in China. *Food Additives & Contaminants: Part A*, 2017, 34(6): 918-927.
<https://doi.org/10.1080/19440049.2017.1313458>
- Maniar S., El Ouali Lalami A. Qualité hygiénique des fruits secs au centre du Maroc. *Microbiologie - Hygiène - Alimentation (MHA)*, 2011,23(67): 9-15. [In France] Available at:
https://www.lissa.fr/rep/articles/PF_27392062
- McEvily A.J., Iyengar R., Otwell W.S. Inhibition of enzymatic browning in foods and beverages. *Critical Reviews in Food Science & Nutrition*, 1992, 32(3): 253-273.
<https://doi.org/10.1080/10408399209527599>
- Medina A., Mateo R., López-Ocana L., Valle-Algarra F.M., Jiménez M. Study of Spanish grape mycobiota and ochratoxin A production by isolates of *Aspergillus tubingensis* and other members of *Aspergillus* section Nigri. *Applied and Environmental Microbiology*, 2005, 71(8): 4696-4702. <https://doi.org/10.1128/AEM.71.8.4696-4702.2005>
- Morgan C.A., Herman N., White P.A., Vesey G. Preservation of micro-organisms by drying; a review. *Journal of Microbiological Methods*, 2006, 66(2), 183-193.
<https://doi.org/10.1016/j.mimet.2006.02.017>
- Nalbone L., Vallone L., Giarratana F., Virgone G., Lamberta F., Marotta S.M., Ziino G. Microbial risk assessment of industrial ice cream marketed in Italy. *Applied Sciences*, 2022, 12(4): 1988.
<https://doi.org/10.3390/app12041988>
- UNECE Standard DDP-11 (2014 Edition) concerning the marketing and commercial quality control of dried grapes. New York and Geneva, USA and Switzerland: United Nations, United Nations

- Economic Commission for Europe (UNECE), 2014. [In French]
UNECE Standard DDP-11 (2016 Edition) concerning the marketing and commercial quality control of dried apricots. New York and Geneva, USA and Switzerland: United Nations, United Nations Economic Commission for Europe (UNECE), 2016. [In French]
- Ochoa-Martínez C.I., Quintero P.T., Ayala A.A., Ortiz M.J. Drying characteristics of mango slices using the Refractance Window™ technique. *Journal of Food Engineering*, 2012, 109(1): 69-75.
<https://doi.org/10.1016/j.jfoodeng.2011.09.032>
- Omolola A.O., Jideani A.I., Kapila P.F. Quality properties of fruits as affected by drying operation. *Critical Reviews in Food Science and Nutrition*, 2017, 57(1): 95-108.
<https://doi.org/10.1080/10408398.2013.859563>
- Peterson B.I., Tong C.H., Ho C.T., Welt B.A. Effect of moisture content on Maillard browning kinetics of a model system during microwave heating. *Journal of Agricultural and Food Chemistry*, 1994, 42(9): 1884-1887. <https://doi.org/10.1021/jf00045a010>
- Qin L., Wang H., Zhang W., Pan M., Xie H., Guo X. Effects of different drying methods on phenolic substances and antioxidant activities of seedless raisins. *LWT*, (2020), 131(9): 109807.
<https://doi.org/10.1016/j.lwt.2020.109807>
- Reiss J. Mycotoxins in foodstuffs. X. Production of citrinin by *Penicillium chrysogenum* in bread. *Food and Cosmetics Toxicology*, 1977, 15(4): 303-307.
[https://doi.org/10.1016/S0015-6264\(77\)80201-0](https://doi.org/10.1016/S0015-6264(77)80201-0)
- Ruiz D., Egea J., Gil M.I., Tomás-Barberán F.A. Characterization and quantitation of phenolic compounds in new apricot (*Prunus armeniaca* L.) varieties. *Journal of Agricultural and Food Chemistry*, 2005, 53(24): 9544-9552.
<https://doi.org/10.1021/jf051539p>
- Russo P., Adiletta G., Di Matteo M. The influence of drying air temperature on the physical properties of dried and rehydrated eggplant. *Food and Bioprocess Processing*, 2013, 91(3): 249-256.
<https://doi.org/10.1016/j.fbp.2012.10.005>
- Sakooei-Vayghan R., Peighambaroust S.H., Hesari J., Peressini D. Effects of osmotic dehydration (with and without sonication) and pectin-based coating pretreatments on functional properties and color of hot-air dried apricot cubes. *Food Chemistry*, 2020, 311(5): 125978.
<https://doi.org/10.1016/j.foodchem.2019.125978>
- Sen F., Ozgen M., Asma B. M., Aksoy U. Quality and nutritional property changes in stored dried apricots fumigated by sulfur dioxide. *Horticulture, Environment, and Biotechnology*, 2015, 56(2): 200-206. <https://doi.org/10.1007/s13580-015-0041-1>
- Singh B., Panesar S.P., Nanda V. Rehydration kinetics of un-osmosed and pre-osmosed carrot cubes. *World Journal of Dairy & Food Sciences*, 2007, 2(1): 10-17. [In Fakhri]. Available at:
<https://sid.ir/paper/596762/en>
- Sultana B., Anwar F. Flavonols (kaempferol, quercetin, myricetin) contents of selected fruits, vegetables and medicinal plants. *Food Chemistry*, 2008, 108(3): 879-884.
<https://doi.org/10.1016/j.foodchem.2007.11.053>
- Trabelsi N., Nalbene L., Di Rosa A.R., Ed-Dra A., Nait-Mohamed S., Mhamdi R., Giuffrida A., Giarratana, F. Marinated anchovies (*Engraulis encrasicolus*) prepared with flavored olive oils (*Chétoui* cv.): Anisakicidal effect, microbiological, and sensory evaluation. *Sustainability*, (2021). 13(9), 5310.
<https://doi.org/10.3390/su13095310>
- Türkyılmaz M., Ozkan M., Güzel N. Loss of sulfur dioxide and changes in some chemical properties of Malatya apricots (*Prunus armeniaca* L.) during sulfuring and drying. *Journal of the Science of Food and Agriculture*, 2014, 94(12), 2488-2496.
<https://doi.org/10.1002/jsfa.6584>
- Ümit Ünal M., Şener A., Şen K. Characterization of Sultaniye grape (*Vitis vinifera* L. cv. Sultana) polyphenol oxidase. *International Journal of Food Science & Technology*, 2007, 42(9): 1123-1127.
<https://doi.org/10.1111/j.1365-2621.2006.01406.x>
- Urban S. Chapter 793 - Bacterial and Protozoan Rhomboid Proteases. In: *Handbook of Proteolytic Enzymes*. (Third Edition) (N.D. Rawlings, G. Salvesen Eds.). Academic Press. 2013, pp. 3581-3593, ISBN: 978-0-12-382219-2,
<https://doi.org/10.1016/C2009-1-60990-4>
- Viljoen B.C., Heard G.M. Saccharomyces/ *Saccharomyces cerevisiae*. In: *Encyclopedia of Food Microbiology*, Volume 2 (R.K. Robinson, C.A. Batt, P.D. Patel Eds.), Academic Press. 1999, pp. 1918-1925, ISBN: 978-0-12-227070-3,
<https://doi.org/10.1016/B978-012227070-3/50291-7>
- Young A.J., Lowe G.L. Carotenoids - antioxidant properties. *Antioxidants*, 2018, 7(2) : 28.
<https://doi.org/10.3390/antiox7020028>
- Zinedine A. Détermination des mycotoxines dans les aliments et étude de la réduction des aflatoxines par les bactéries lactiques isolées des ferments panaires traditionnels. PhD thesis by Université Sidi Mohammed Ben Abdellah, 2004, 162 p. [in French]

Appendix.1. Correlation matrix (Pearson) for dried apricots samples collected from Fez-Meknes region

Variables	Water content	Aw	% brix	A. weight	N. Fruit. kg ⁻¹	pH	R.C	L*	A*	B*	C*	Hue*	Y. ind	TPC	TFC	TCC	SO ₂	B. ind
Water content	1	0.525	-0.059	0.170	-0.204	-0.241	-0.019	0.063	-0.025	0.121	0.100	0.157	0.131	0.320	-0.255	0.165	0.160	-0.024
Aw	0.525	1	-0.125	-0.010	-0.063	-0.244	-0.261	0.054	-0.085	0.046	0.023	0.103	0.011	0.347	-0.252	0.043	0.101	0.040
% brix	-0.059	-0.125	1	0.169	-0.072	-0.310	0.110	-0.114	-0.121	-0.153	-0.155	-0.132	-0.186	-0.024	0.458	-0.211	-0.139	0.179
A. weight	0.170	-0.010	0.169	1	-0.957	0.225	0.213	-0.142	-0.222	-0.143	-0.160	-0.057	-0.156	0.111	-0.210	-0.185	-0.083	0.150
N. Fruit.kg⁻¹	-0.204	-0.063	-0.072	-0.957	1	-0.220	-0.166	0.133	0.241	0.144	0.164	0.042	0.166	-0.219	0.244	0.198	0.070	-0.134
pH	-0.241	-0.244	-0.310	0.225	-0.220	1	0.259	0.041	0.102	0.011	0.029	-0.062	-0.002	-0.075	-0.084	0.002	-0.106	0.042
R. Cap	-0.019	-0.261	0.110	0.213	-0.166	0.259	1	0.346	0.203	0.359	0.352	0.348	0.366	0.087	0.245	0.384	0.303	-0.238
L*	0.063	0.054	-0.114	-0.142	0.133	0.041	0.346	1	0.683	0.975	0.966	0.862	0.919	-0.005	-0.109	0.902	0.845	-0.805
A*	-0.025	-0.085	-0.121	-0.222	0.241	0.102	0.203	0.683	1	0.714	0.791	0.294	0.755	-0.183	0.174	0.749	0.278	-0.299
B*	0.121	0.046	-0.153	-0.143	0.144	0.011	0.359	0.975	0.714	1	0.993	0.871	0.979	-0.055	-0.192	0.967	0.858	-0.822
C*	0.100	0.023	-0.155	-0.160	0.164	0.029	0.352	0.966	0.791	0.993	1	0.809	0.981	-0.078	-0.137	0.970	0.795	-0.766
Hue*	0.157	0.103	-0.132	-0.057	0.042	-0.062	0.348	0.862	0.294	0.871	0.809	1	0.827	0.045	-0.372	0.814	0.995	-0.918
Y. in	0.131	0.011	-0.186	-0.156	0.166	-0.002	0.366	0.919	0.755	0.979	0.981	0.827	1	-0.112	-0.210	0.993	0.818	-0.774
TPC	0.320	0.347	-0.024	0.111	-0.219	-0.075	0.087	-0.005	-0.183	-0.055	-0.078	0.045	-0.112	1	0.023	-0.107	0.005	0.082
TFC	-0.255	-0.252	0.458	-0.210	0.244	-0.084	0.245	-0.109	0.174	-0.192	-0.137	-0.372	-0.210	0.023	1	-0.194	-0.390	0.397
TCC	0.165	0.043	-0.211	-0.185	0.198	0.002	0.384	0.902	0.749	0.967	0.970	0.814	0.993	-0.107	-0.194	1	0.804	-0.762
SO₂	0.160	0.101	-0.139	-0.083	0.070	-0.106	0.303	0.845	0.278	0.858	0.795	0.995	0.818	0.005	-0.390	0.804	1	-0.923
B. ind	-0.024	0.040	0.179	0.150	-0.134	0.042	-0.238	-0.805	-0.299	-0.822	-0.766	-0.918	-0.774	0.082	0.397	-0.762	-0.923	1

R.C - Rehydrationcapacity, %; C* - Chromaticity C*; Y. ind - Yellow index; TPC - Total polyphenols content, mg Geq.100g⁻¹ DW); TFC - Total flavonoids content, mg Qrc.100g⁻¹ Dw; SO₂ - Residualsulfurdioxide, mg.kg⁻¹ DF; B. ind - Browning index; ; Values in bold are significantly different from 0 at a significance level of $\alpha = 0.05$.

Appendix.2. Correlation matrix of dried raisins samples collected from Fez-Meknes region

Variables	Water content	a _w	% Brix	pH	R.C	L*	a*	b*	C*	H*	Y. ind	TPC	TFC	B. ind	SO ₂
Water content	1	0.722	-0.430	0.397	0.251	0.254	0.500	0.251	0.299	0.180	0.312	-0.221	-0.398	-0.484	0.135
a_w	0.722	1	-0.121	0.248	-0.115	0.141	0.258	0.098	0.128	0.060	0.119	0.026	-0.073	-0.227	0.005
% brix	-0.430	-0.121	1	-0.357	-0.351	-0.124	-0.407	-0.122	-0.171	-0.075	-0.205	0.438	0.442	0.576	-0.149
pH	0.397	0.248	-0.357	1	0.525	0.125	0.216	0.133	0.152	-0.001	0.120	-0.323	-0.495	-0.079	0.007
R.C	0.251	-0.115	-0.351	0.525	1	0.053	0.278	0.112	0.146	-0.043	0.167	-0.423	-0.560	-0.382	0.076
L*	0.254	0.141	-0.124	0.125	0.053	1	0.829	0.985	0.979	0.940	0.944	0.449	0.092	-0.513	0.851
a*	0.500	0.258	-0.407	0.216	0.278	0.829	1	0.863	0.902	0.796	0.934	0.106	-0.251	-0.801	0.805
b*	0.251	0.098	-0.122	0.133	0.112	0.985	0.863	1	0.997	0.947	0.976	0.386	0.007	-0.530	0.881
Chroma C*	0.299	0.128	-0.171	0.152	0.146	0.979	0.902	0.997	1	0.938	0.986	0.347	-0.036	-0.585	0.881
Hue H*	0.180	0.060	-0.075	-0.001	-0.043	0.940	0.796	0.947	0.938	1	0.943	0.446	0.089	-0.491	0.937
Y. ind	0.312	0.119	-0.205	0.120	0.167	0.944	0.934	0.976	0.986	0.943	1	0.298	-0.088	-0.653	0.921
TPC	-0.221	0.026	0.438	-0.323	-0.423	0.449	0.106	0.386	0.347	0.446	0.298	1	0.858	0.019	0.347
TFC	-0.398	-0.073	0.442	-0.495	-0.560	0.092	-0.251	0.007	-0.036	0.089	-0.088	0.858	1	0.254	0.018
B. ind	-0.484	-0.227	0.576	-0.079	-0.382	-0.513	-0.801	-0.530	-0.585	-0.491	-0.653	0.019	0.254	1	-0.631
SO₂	0.135	0.005	-0.149	0.007	0.076	0.851	0.805	0.881	0.881	0.937	0.921	0.347	0.018	-0.631	1

R.C - Rehydration capacity, %; C* - Chromaticity C*; Y. ind - Yellow index; TPC - Total polyphenols content, mg Geq.100g⁻¹ DW); TFC - Total flavonoids content, mg Qrc.100g⁻¹ Dw; SO₂ - Residual sulfur dioxide, mg.kg⁻¹ DF; B. ind - Browning index; Values in bold are significantly different from 0 at a significance level of $\alpha = 0.05$.