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Characterization of Algerian turmeric and ginger based on their physicochemical, functional and biological properties

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Abstract

The purpose of the study was to characterize (physicochemical properties, functional properties, antioxidant contents and biological activities) of two Algerian spices, turmeric and ginger. The results showed the richness of both spices in phytochemicals especially in polyphenols. Compared to ginger, which showed greater affinity for oil, turmeric powder had more affinity for water. In addition, turmeric swelled more (14.17 ml g^{-1}) than ginger powder (8.33 ml g^{-1}). The methanolic extract showed the highest total antioxidant activities of 470.72 ± 3.13 and 228.73 ± 42.19 AAE 100 g^{-1} for turmeric and ginger respectively. The aqueous extracts didn't show anticoagulant activity while, the methanolic and acetonic extracts showed anticoagulant activity in a dose – dependent manner. As the butanolic extracts prevented the blood clot from forming, it could be used for medical application in future. Therefore, turmeric and ginger are a rich source of bioactive molecules and have functional and biological properties to be exploited in the food and pharmaceutical industry.

Keywords: *Curcuma longa, Zingiber officinale,* biological activity, bioactive compounds, functional properties

Introduction

Spice is an "aromatic vegetable substance in the whole, broken, or ground form, the significant function of which in food is seasoning rather than nutrition" and from which "no portion of any volatile oil or other flavoring principle has been removed." (Przygodzka *et al.* 2016). Among these spices, turmeric and ginger, members of the Zingiberaceae family, have been used for centuries in traditional cuisine as a coloring agent and in traditional medicine as a remedy. Ginger (*Zingiber officinale*) rhizome, very rich in starch (60%), contains proteins, fats of the oleic and linolenic acid type (10 %), essential oil (in an amount of 10 to 25 ml

kg^{-1} rhizome), an oleoresin complex and an enzyme, zingibain (Gigon, 2012). This plant of exceptional composition shows anti-tumor, antioxidant, anti-inflammatory, anti-infective, cytoprotective (skin and liver) properties, anti-ulcer, anti-diabetic and lipid-lowering, immunomodulatory and antithrombotic activity. However, the best documented property is undoubtedly its antiemetic property. Turmeric (*Curcuma longa*), is widely grown in India, China, Pakistan, Ghana, Kenya, and Nigeria (Kieliszek *et al.* 2020). Ibáñez & Blázquez (2021) reported some therapeutic properties of turmeric rhizome, including antioxidant, antibacterial, antifungal and herbicidal activity. These therapeutic properties are related to the phytochemical content particularly curcumin. In Algeria, especially in recent years, these two spices are used much more in the form of powders for culinary and therapeutic purposes. Indeed, according to the quantitative ethnopharmacology analysis of Taïbi *et al.* (2020), it was found that turmeric among the most commonly reported plant species for the management of cancer in Algeria. According to Bouzabata & Boukhari (2014), the local knowledge of turmeric in Algeria is mainly linked to the traditional use of turmeric in Ayruvedic herbal medicine. Ginger is used in Algeria to treat respiratory diseases like cough, flu, allergies etc. (Benarba, 2016). Despite the use of these two spices in Algeria, little is known about their characteristics, in particular their techno functional properties. Thereby, a detailed investigation regarding functional properties, phytochemicals and biological activities was carried out in the current study.

Materials and methods

Plant material

Turmeric and ginger were purchased directly in powder form (as used by the Algerian consumer) from herbalist in El-Tarf (Northeastern of Algeria). According to the seller, the spices are originating from the region of "Oued-Souf" (Southern Algeria). The powders were sieved several times in order to eliminate any impurities. The powders obtained, having a maximum particle size of 500 µm, were stored, for few days, in airtight bags at 4^0C until analysis.

Spice powders characterization

Proximate physicochemical composition of turmeric and ginger powders

The spice powders were analyzed for their physicochemical characteristics according to protocols described in our previous work (Benmeziane – Derradji *et al.* 2020). The powder was examined for pH (pH-meter benchtop brand Hanna Instruments), water content by drying in an oven at 103°C ± 2°C for 4 hours; the color index, which is expressed as the absorbance value at 420 nm, and the absorbance at 280 nm of the spice powders suspension was also evaluated by spectrophotometry (UV mini 1240, Uv-Vis spectrophotometer-Shimadzu); Brix and refractive index (measured with a benchtop refractometer, WYA Abbe Refractometer) and the conductivity were also determined with a conductivity meter benchtop (Adwa 3000).

Functional properties of spice powders

In order to find a possible food application of turmeric and ginger powders, functional properties were determined as described in our previous work (Benmeziane–Derradji *et al*. 2020). The method defined in the work of Martínez *et al.* (2019) was used to evaluate the clarity of gel. Finally, the Hausner report and the compressibility index (CI) were measured according to the protocol of WHO (2012).

Phytochemical screening

Tests were performed on turmeric and ginger powders for preliminary determination of the various secondary metabolites. It is a qualitative analysis based on staining and/or precipitation reactions. The analysis was carried out on a

diluted powder solution and on the powder itself. The classes of metabolites sought were: total tannins, anthocyanins, starches, mucilages, iridoids, alkaloids, terpenoids and reducing compounds.

Bioactive molecules determination

Preparation of extracts

To prepare polyphenol extracts, 200 mg of each spice powder was mixed with 10 mL of 80% of methanol, acetone and butanol. Aqueous extracts were also prepared following the same procedure. After 30 min of stirring, the mixture was filtered and the extracts obtained were stored at -10 °C until analysis.

Estimation of phenolic compounds

Total polyphenols were measured following the Folin-Ciocalteu colorimetric assay and the absorbance was measured at 765 nm using gallic acid as a standard. Total flavonoid content was evaluated by colorimetry and absorbance measurement at 510 nm using catechin as a standard. The content of condensed tannins was determined by heating the extract at 95 °C for 15 min in the presence of iron sulfate and absorbance measurement at 530 nm using cyanidin as a standard (Benmeziane-Derradji *et al.* 2020).

Pigments determination in spice powders

The protocol of Arkoub-Djermoune *et al.* (2019) was followed to assess the anthocyanins (absorbance read at 530 nm using a molar extinction coefficient (ε) of 29000 L x mol^{-1} x cm^{-1} recorded from a pure sample of delphinidin-3-rutinoside), flavonols (absorbance read at 630 nm using a molar extinction coefficient (ε) of 20000 L x mol^{-1} x cm^{-1} recorded from a pure sample of quercetin 3-glucoside), the carotenoids and lycopene contents (using hexane as solvent extraction and absorbance measurements at 420 nm for total carotenoids using as μg β-carotene as standard; and at 472 nm for lycopene using lycopene as standard). Finally, the method of Gharajeh *et al.* (2020) by extraction with acetone and absorbance measurements at 645 nm and 662 nm was followed to determine the content of chlorophyll a, b and total chlorophyll in spices.

Biological activities

Total antioxidant activity

The estimation of the total antioxidant capacity was performed by adopting the phosphomolybdenum method described by Prieto *et al.* (1999). Results were expressed as mg of ascorbic acid equivalent per 100 g of powder (mg AAE 100 g^{-1}).

Anticoagulant activities

The effect of the various extracts of turmeric and ginger on blood coagulation was evaluated *in vitro* by coagulation test for the two coagulation pathways (the endogenous and the exogenous pathway) on a pool of normal platelet-free plasmas and using two global chronometric tests, the kaolin cephalin time test and the quick time test. Three volumes of different spice extracts were tested (10, 20 and 30 μL) (Boukeria *et al.* 2019).

Statistical analyses

Analysis was performed in triplicate and results were displayed as mean ± standard deviation. The analysis of variance (ANOVA) was carried out using Minitab version 17 Software (Minitab Inc., State College, PA, United States) to compare means and to detect significant differences between spice powders. Differences at a *p*-value of 0.05 by Tukey's test were considered statistically significant.

Results and discussion

Physicochemical characteristics

The proximate composition results of spice powders are presented in Table 1. Among all the analyzed parameters, moisture, Brix and the conductivity did not differ significantly

(p>0.05). The results showed that ginger and turmeric powders were slightly acidic with pH of 6.12 and 6.42 respectively. This relatively low pH recorded denotes more stability of spice against microbial spoilage. It has been stated that at 3.5 > pH > 6.5 protein molecules have net positive or negative charges; similarly, water molecule interacts with protein charges. Net charges and charge repulsion contribute to greater protein solubility (Sarker *et al.* 2021). These values were higher when compared to those of ginger powder obtained using different drying techniques (4.82–4.98) and turmeric powder (6.246) (Sarker *et al.* 2021). However, the turmeric pH was in the range (6.10-6.80) of that noted by Emelike (2020). In contrast, an opposite trend was noted for acidity where ginger had the highest acidity of 5.76% compared to the 3.84% observed for turmeric. Our findings were far from those recorded by Sarker *et al.* (2021) on ginger powder as they recorded values between 0.36% and 0.51% and those reported by Emelike *et al.* (2020) as the total acidity found in the turmeric powders (from different processing methods) ranged from 0.31-1.61%. The acidity could be due to organic acids naturally occurring in the spices.

Turmeric and ginger moisture were close with values of 11.13% and 11.87% respectively. The moisture content of turmeric was close to 11.19% recorded by Mushtaq *et al.* (2019), while that of ginger was far from the 30.21% reported by the same authors. It is known that more the solution is concentrated in sugar, the greater the refraction of light and therefore the values of the refractive index and Brix are high. The respective Brix and refractive index rates were 2.23% and 1.336 for turmeric and 1.90% and 1.338 for ginger. These results indicate that these two spices are lower in sugar. As for absorbances at 280 and 420 nm they varied significantly being 0.305 and 0.844 for turmeric and 0.246 (p>0.05) and 0.820 for ginger, respectively. It was observed that absorbances at 420 nm were higher than those at 280 nm. The electrical conductivity of both spices (turmeric and ginger with values of 1326.7 μS cm^{-1} and 1348 μS cm^{-1}, respectively) were low with no significant differences (p>0.05). Coradi *et al.* (2018) pointed out that electrical conductivity test is a suitable method for quality control of aromatic plants in essential oil extraction industries to monitor the yield and quality of the essential oils extracted from the aromatic plants after drying and storage. The proximate composition of turmeric and ginger varies depending on their harvesting and growing condition (Mushtaq *et al.* 2019).

Functional properties of spices powders

No significant differences (p>0.05) were found between the solubility of spices, with the results being 25.28% and 24.95% for turmeric and ginger, respectively. The low solubility value observed in turmeric reported in this study, was also supported by Emelike (2020), who reported less solubility (25%) in oven-dried turmeric powder. There are no results in the literature on the solubility of ginger powder. The low hygroscopicity found in the studied powders makes them stable during storage. Indeed, respective values of 1.06% and 0.57% were recorded on turmeric and ginger with no significant differences (p>0.05). (Table 1). The bulk density (BD) of ginger powder (0.66) was significantly higher than that of turmeric powder (0.62). A bulk density of 0.67 g ml^{-1} was indicated by Emelike (2020) on cooked/oven dried turmeric powder. It has been pointed out that higher dispersibility has been linked to better reconstitution properties to give a fine and coherent dough. Values of 8% and 10% of D were observed on turmeric and ginger powders respectively (Table 1). The high dispersibility of ginger denotes better reconstitution properties compared to turmeric. Emelike (2020) reported that the dispersibility ranged from 17% in oven dried sample to 51% in sun dried sample of turmeric and the sun-dried turmeric powder showed better reconstitution properties. The amount of water/oil that can be absorbed per gram of sample refers to water/oil holding

capacities (WAC/OAC). These two parameters play a major role in food preparation due to their influence on other functional and sensory properties. Compared to ginger powder (126.5%), turmeric had a significantly higher WAC (295.16%) (Table 1), making it a useful functional ingredient in products where good viscosity is required, such as soups, sauces, dairy products (yoghurts and cheeses). The results of the current study were far from the WAC (30.84–51.2%) reported by Oladimeji *et al.* (2019) on unpeeled and peeled turmeric powder. Sarker *et al.* (2021) have pointed out that all dried ginger powders (prepared using different drying techniques) had a poor WAC as results were below 2 g g^{-1}. Authors have linked this low WAC to less protein, polysaccharide and starch ginger content. The WAC of Nigerian turmeric powder from different processing methods ranged from 2.05 to 6.90 mL g^{-1}. As for OAC, no significant differences ($p>0.05$) have been marked between both spice powders. Oil absorption is a substantial criterion in food formulation since fat contributes to the organoleptic properties, acting as flavor trap, improves the softness of food and the mouthfeel. Our outcomes were in the range of those reported by Emelike (2020) on turmeric and ginger from the study of Marak *et al.* (2019). The OAC is explained mainly by the presence of hydrophobic amino acids of the constituent proteins of the product.

The hydrophily/lipophyly ratio (HLR) was calculated for the first time in these powders in order to evaluate their affinity for water / oil. The ratio indicates the balance between lipid and water binding where a perfect balance is highly desirable. The HLR higher than 1.5 is the sign of a greater ability to fix water than oil as found for turmeric (1.64) which differ significantly ($p>0.05$) from that of ginger having more affinity for oil than water as the HLR value was of 0.76. This difference in powder HLR ratios could be explained by the amino acid composition of the powders where a high content of hydrophobic amino acids in the proteins increases the OAC thus decreasing the HLR ratio (Klang *et al.* 2019). Both whole milk absorption capacity (WMAC) and skim milk absorption capacity (SMAC) functionalities are reported for the first time in these spices powder. Like WACs, significant differences ($p>0.05$) were observed between the WMACs where turmeric exhibited a higher absorption capacity (174%) than ginger (91.33%). Whereas, the SMACs did not differ significantly ($p>0.05$) and the respective values recorded were 196.67% and 106.67% for turmeric and ginger. The higher WMAC noted in the turmeric may be a result of the powder's high absorption to water more than that of ginger in addition to that of oil. The same tendencies were observed in the study conducted by Benmeziane-Derradji *et al.* (2020) on roasted and unroasted lentil flours. The emulsifying properties are summarized in the emulsifying activity (EA) and emulsions stability (ES). No significant differences ($p>0.05$) were recorded between the emulsifying properties of the both spices (Table 1). Whereas, emulsions were highly stable with respective ESs results of 79.69% and 76.09% for turmeric and ginger.

The swelling capacity (SC) designates the water holding capacity of the starch. Swelling behavior below 16 gm g^{-1} is taken into account as extremely restricted. The restricted swelling behavior of the starch samples means its stability against shearing action once subjected to heat (Sathya Moorthy *et al.* 2020). Ginger powder showed significantly ($p>0.05$) lower SC (8.33 ml g^{-1}) than turmeric powder (14.17 ml g^{-1}). Sarker *et al.* (2021) pointed out that swelling capacity has a correlation with amylose content and that lower swelling power denotes the presence of lower amount amylose content and hydrophilic groups in product. Least gelation concentration (LGC) is a very important functional property in food processing such as puddings, jellies, and in many dessert and meat applications as stated by Boye *et al.* (2010). Gelation occurs when proteins and starches form a three-dimensional network that resists

Table 1. Physicochemical characteristics and functional properties of turmeric and ginger spice powders

	Turmeric powder	Ginger powder
pH	6.42±0.02 [a]	6.12±0.02[b]
Acidity (%)	3.84±0.00 [b]	5.76±0.00 [a]
Moisture (%)	11.13±0.23 [a]	11.87±0.46 [a]
TSS (°Brix) (%)	2.23±0.25[a]	1.90±0.10 [a]
Refractive index	1.336±0.001 [b]	1.338±0.001 [a]
A420	0.844±0.006 [a]	0.820±0.005 [b]
A280	0.305±0.00 [a]	0.246±0.009 [b]
Conductivity µS/cm	1326.7±1.53 [a]	1348±13.89 [a]
Solubility (%)	25.28±0.5 [a]	24.95±0.25 [a]
Hygroscopicity (%)	1.06±0.43 [a]	0.57±0.02 [a]
Bulk density	0.62±0.00 [b]	0.66±0.00[a]
Dispersibility (%)	8±0.00 [b]	10±0.00 [a]
Water absorption capacity (%)	296.5±0.71 [a]	126.5±0.71 [b]
Oil absorption capacity (%)	173.33±8.33 [a]	174.67±7.57 [a]
Hydrophilic / Lipophilic ratio (%)	1.64±0.004 [a]	0.76±0.003 [b]
Whole milk absorption capacity (%)	174±4.58[a]	91.33±9.61 [b]
Skim milk absorption capacity (%)	196,67±11.55[a]	106.67±11.55[a]
Emulsifying activity (%)	47.82±3.34 [a]	49.07±2.10 [a]
Emulsifying stability (%)	79,69±2.38[a]	76.09±5.49 [a]
Swelling capacity (mL g^{-1})	14.17±1.44[a]	8.33±2.89 [b]
Least gelation concentration (%)	14	14
Clarity of powder (%)	1.17±0.15[a]	0.47±0.06 [b]
Hausner ratio	1.10±0.05 [a]	1.12±0.02 [a]
Compressibility index (%)	8.88±3.85 [a]	11.11±1.92 [a]

Each value in the Table is the mean ± standard deviation (n = 3); Values in the same column sharing different letters are significantly different ($p < 0.05$). Results are ranked in descending order: a > b.

flowing under pressure. As it can be seen in Table 1, LGC of 14% has been observed on both spices. This result can be considered relatively high meaning that both spice powders have an increased ability to provide the structural matrix to retain water, flavors, sugars and food ingredients, a function of practical importance (Odimegwu *et al.* 2019).

The turmeric gel clarity (1.17%) was significantly ($p>0.05$) higher than that of ginger (0.47%) (Table 1). Alcázaray & Meireles (2015) have explained the low clarity in common cereals (non-waxy) by the presence of traces of swollen starch granules and amylose-lipid complexes and they stated that clarity in starch suspensions is modified during storage, decreasing due to amylose and/or amylopectin molecule. Martínez *et al.* (2019) explained the high gel transmittance (650 nm) of the potato starches by the high content of phosphate monoesters content. Flowability an important indicator of the powder system, which is characterized by the compressibility index (CI) and the *Hausner* ratio (HR). According to the obtained results, irrespective of the composition of the spice powders, no significant differences ($p>0.05$) were observed regarding their flowability properties. The respective calculated HR and CI were 1.10-8.80% for turmeric powder and 1.12–11.11% for the ginger (Table 1). Turmeric and ginger spice powders may be classified as a material with a very good flowability, as indicated by the calculated HR value below 1.2 and the CI inferior to 18%. In general, powders with smaller particle size has poor flowing properties (Tze *et al.* 2012).

Phytochemical screening

Our phytochemical screening tests revealed the presence of starch, glucosides, mucilages and terpenoids in both powders, in addition to iridoids detected only in ginger (Table 2). The presence of these phytochemicals confers the health-promoting effects of turmeric and ginger. For instance, mucilages act as a potential nutraceutical and exhibits a prebiotic activity

Table 2. Phytochemical screening of turmeric and ginger powders

	Turmeric powder	Ginger powder
Tannins	-	-
Anthocyanins	-	-
Starch	+	+
Glucosides	+	+
Mucilage	+	+
Iridoids	-	+
Alkaloids	-	-
Terpenoids	+	+
Reducing compounds	-	-

(+) presence; (-) absence

and can lowers cholesterol level (Dybka-Stepien *et al.* 2021). Cör *et al.* (2018) indicated several biological activities of terpenoids such as antitumour, antimicrobial, antioxidant and antiacetylcholinesterase. The presence of these constituents and others makes turmeric and ginger spice powders a functional food.

Phenolic Compound estimation (polyphenols, flavonoids and condensed tannins contents)

A comparison of the total polyphenols, flavonoids and condensed tannins contents as influenced by different extraction solvent (ethanol, methanol, butanol and water) is presented in Table 3. Different solvents used in the literature to extract phytochemicals from various plant matrices differ in their polarity; hence, they have different influences on the potential extraction of phytochemicals. The efficient solvent for polyphenols extraction (mg EAG $100g^{-1}$) was methanol (1488.73) followed by acetone (1013.31) and butanol (910.08) with no significant differences ($p>0.05$) and finally water (580.00) for turmeric. In ginger, methanol and acetone solvents gave high polyphenol levels of 907.36 and 1013.31 and significantly ($p>0.05$) lower levels were depicted in aqueous

Table 3. Quantification of total phenolic compounds, total flavonoids and tannins in spices of various extracts.

	Methanolic extract		Acetonic extract		Ageous extract		Butanolic extract	
	Turmeric	Ginger	Turmeric	Ginger	Turmeric	Ginger	Turmeric	Ginger
Total Polyphenols (mg EAG $100g^{-1}$)	1488.73±117.07^{a,A}	907.36±69.31^{b,A}	1013.31±6.22^{a,B},	829.65±9.18^{b,A}	580.00±12.45^{a,C}	550.12±4.07^{b,B}	910.08±16.97^{a,B}	558.27±4.7^{b,B}
Total flavonoids (mg EC 100 g^{-1})	171.11±25.46^{a,C}	105.00±4.41^{b,C}	498.89±16.36^{a,A}	129.45±3.47^{b,B}	107.78±7.52^{a,D}	84.44±6.74^{b,D}	374.44±12.06^{a,B}	190.56±3.47^{b,A}
Total condensed tannins (µg EC 100 g^{-1})	540.82±37.33^{a,A}	383.54±37.33^{b,B}	524.26±74.19^{a,A}	342.15±84.96^{b,B}	725.69±108.04^{a,A}	557.37±31.34^{a,A}	593.24±103.50^{a,A}	640.16±55.11^{a,A}

Each value in the table is the mean ± standard deviation (n = 3); Values in the same row sharing different letters (lowercase / uppercase) are significantly different by the Tukey test at a 5% significance level; Results are ranked in descending order: a > b / A > B > C > D (a, b: differences between the contents of the spices of the same extract; A, B, C, D: differences between the contents of the same spice of the different extracts).

and butanolic extract with corresponding values of 580.00 and 558.27. Irrespective of the solvent, turmeric showed significantly ($p>0.05$) high levels of polyphenols, flavonoids and condensed tannins. Similar trends were observed with respect to polyphenol and flavonoids contents of turmeric (Mushtaq *et al.*, 2019). As for flavonoids, it seems that acetone and water yielded the highest and the lowest flavonoid contents in turmeric with 498.89 and 107.78 mg EC 100 g^{-1}, respectively. Our results are supported by Sepahpour *et al.* (2020) who found that the highest and lowest flavonoid content value belong to turmeric, at 549.2 mg QE g^{-1} of freeze-dried crude extract for 80% acetone extraction and 0.6 mg QE g^{-1} freeze-dried crude extract for water extraction, respectively. Total condensed tannins were extracted in close amounts with no significant differences ($p>0.05$) for all solvents tested, except for methanolic and acetonic extracts, which gave the lowest amounts in ginger, with corresponding levels, expressed in µg EC 100 g^{-1}, of 383.54 and 342.15. A high content of condensed tannins (0.02 mg CE g^{-1}) was noted in the ethanolic extract of ginger by Chou *et al.* (2021).

Table 4. Pigment content of turmeric and ginger spice powders

	Turmeric	Ginger
Anthocyanins (mg ED 100 g^{-1})	3.1±1.21[b]	11.12±2.98[a]
Flavonols (mg EQ 100 g^{-1})	285.30±33.90[a]	34.75±1.58[b]
Carotenoids (mg βCE 100 g^{-1})	29.77±2.30[a]	8.75±1.73[b]
Lycopene (mg LE 100 g^{-1})	11.48±1.91[a]	4.37±0.88[b]
Chlorophyll a (mg 100 g^{-1})	0.81±0.22[a]	0.58±0.02[a]
Chlorophyll b (mg 100 g^{-1})	1.20±0.09[a]	1.02±0.03[b]
Total chlorophyll (mg 100 g^{-1})	2.01±0.15[a]	1.59 ± 0.03[b]

Each value in the table is the mean ± standard deviation (n = 3); Identical lowercase letters in the same row do not differ significantly by the Tukey test at a 5% significance level; Results are ranked in descending order: a > b.

Pigment contents assessment in turmeric and ginger

Pigment contents (anthocyanins, flavonoids, carotenoids, lycopene, chlorophyll a, b and total) were determined on the spice powders and the results are shown in Table 4. All pigments were present in small amounts in both spices, except for the flavonols in turmeric, the content being 285.30 mg EQ 100 g^{-1}, which can explain in part, the yellow color of the spice. Flavonol intake has been found to be linked to a variety of health benefits, including antioxidant potential and a reduced risk of cardiovascular diseases. Likewise, the content of quantified pigments in turmeric was significantly ($p>0.05$) higher compared to ginger, with the exception of anthocyanins, where surprisingly, ginger had a higher content of 11.12 mg ED100 g^{-1}. The carotenoid content of turmeric in the current study was lower than the combined α and β-carotene contents reported by Britto *et al.* (2017) on four brands of turmeric powder. Ghafoor *et al.* (2020) recorded carotenoid levels, in fresh and dried ginger using different techniques lower than that found in the present study.

According to Britto *et al.* (2017), several factors can impact carotenoids content such as the stage of rhizome maturation, processing procedures, exposure to high temperatures or sunlight and storage conditions. Lycopene, plant carotenoid is considered as an effective scavenger of singlet oxygen and free radicals in the body, but it has no vitamin A activity. Lycopene content of turmeric (11.48 mg LE 100 g^{-1}) was significantly ($p>0.05$) higher than that in ginger (4.37 mg LE 100 g-1). As for chlorophyll a, the content in turmeric did not differ significantly

(p>0.05) from that observed in ginger. While, the chlorophyll b content differs significantly (p>0.05) between both spices, where turmeric had recorded higher level of 1.20 mg 100 g^{-1}. The same trend was noted for total chlorophyll. To best of our knowledge, these results are the first to be reported for Algerian turmeric and ginger.

Biological activities

Total antioxidant activity (TAA)

Antioxidant potency results are expressed as reducing capacity ($RC_{0.5}$) (Table 5), which represents the concentration of the sample that reduces 50% of the ammonium phosphomolybdate reagent. A low $RC_{0.5}$ corresponds to a high antioxidant capacity. Results showed no significant differences between the $RC_{0.5}$ of both spices in different (p>0.05) solvent, except the acetonic extract where ginger exhibited a high $RC_{0.5}$ of 34.03 mg ml^{-1}, which means lower antioxidant power compared to turmeric which exhibited a $RC_{0.5}$ of 22.83 mg ml^{-1}. Moreover, turmeric had the highest TAA as compared to ginger, except in the acetonic extract where no significant differences (p>0.05) were detected between both spices. These results were not comparable to those of Barbosa and Minguillan (2021) who reported that the TAA of fresh and cured turmeric rhizome were 28.18 and 37.66 mg AAE g^{-1} sample, respectively. While a low antioxidant capacity was noticed in the study of Chou *et al.* (2021) on culinary spices, who found that ginger yielded 0.73 mg AAE g^{-1}. These differences can be related to differences in cultivars and/or geographical origin, as well as to the extraction method (solvent, time and temperature).

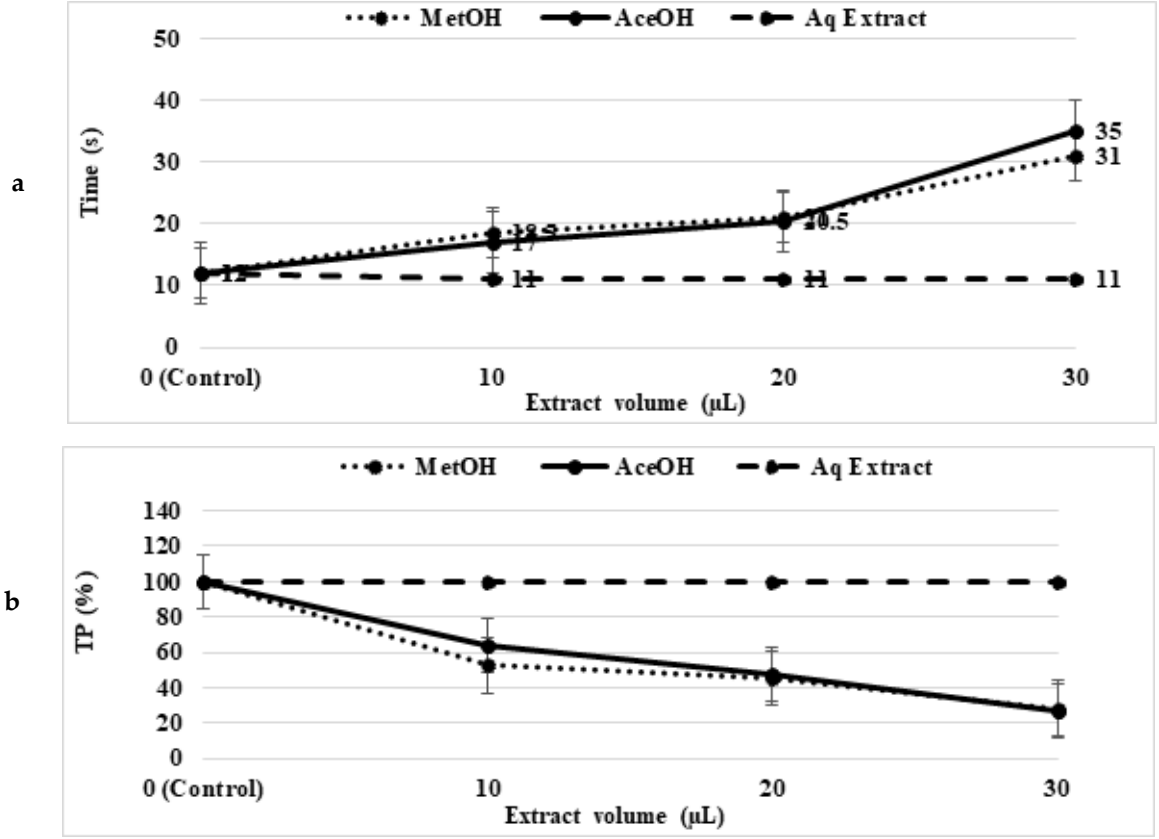

Fig. 1. Anticoagulant activity of turmeric extracts with respect to the exogenous pathway, a): coagulation time; b) prothrombin level

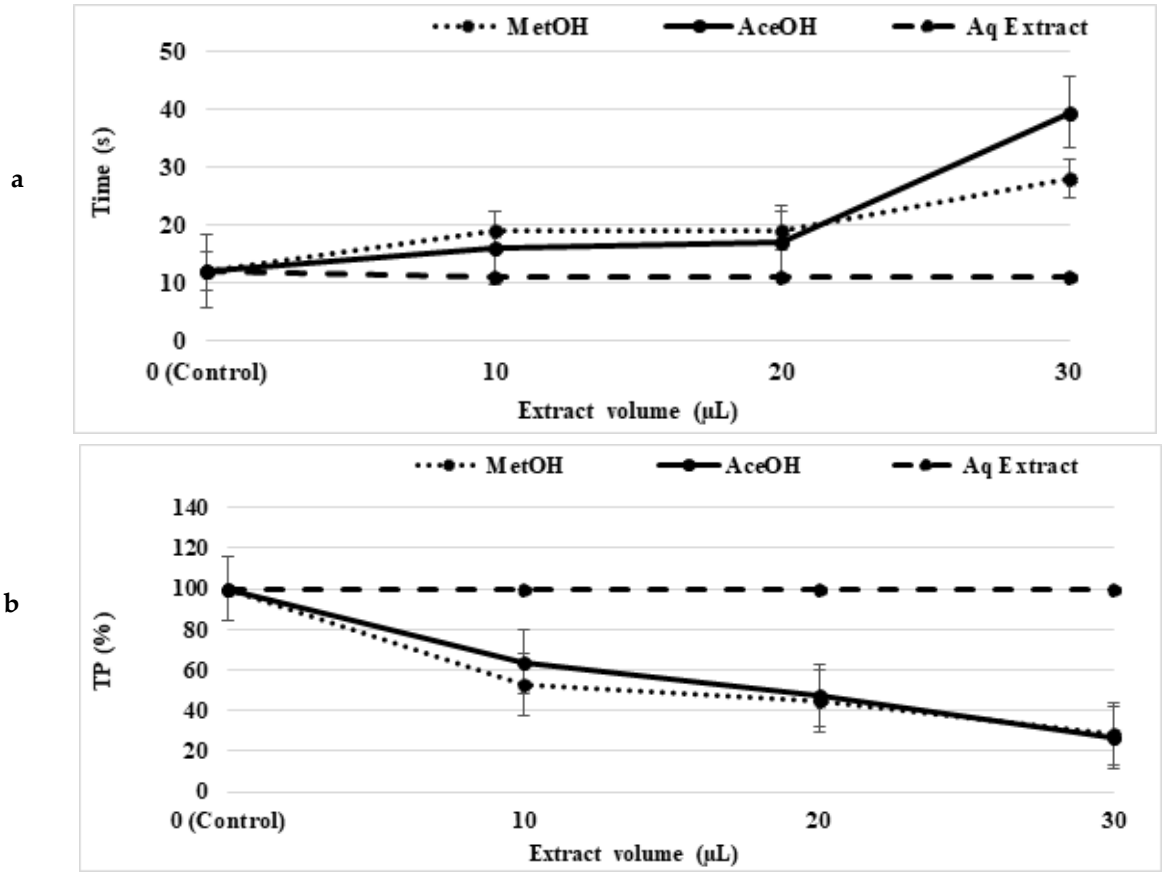

Fig. 2. Anticoagulant activity of ginger extracts with respect to the exogenous pathway, a): coagulation time; b) prothrombin level

Anticoagulant activity

Results showed that times of coagulation obtained on normal plasma in the presence of methanolic and acetonic extracts indicated that they carry an anticoagulant effect on the two coagulation pathways with highly marked effect on the exogenous pathway. In fact, it was observed that the blood clot formation times were lengthened significantly ($p>0.05$) in the presence of methanolic and acetonic extracts compared to the control (without addition of extract). It was also noticed that the clotting time lengthened as the extract volume increased (dose-dependent). In fact, the clotting time increased, respectively, from 18.5 to 31 s and from 17.15 to 35 s from the 10 to 30 µL volume extracts for the methanolic and acetonic extracts for turmeric (Fig. 1). For ginger, the times increased from 19 to 28 s and from 16 to 39.5 s as the volumes tested increased from 10 to 30 µL for the methanolic and acetonic extracts, respectively (Fig. 2). Based on the obtained results, it can be suggested that both turmeric and ginger possess antithrombotic activities, Kim *et al.* (2012) observed that turmeric prevents platelet aggregation and clot formation and stimulates blood circulation. They also reported that curcumin (main compound of turmeric polyphenols) significantly prolonged the activated partial thromboplastin time and prothrombin time and inhibits thrombin and activated factor X activities (which converts prothrombin to active thrombin). In the presence of the aqueous extract, the clotting time and the prothrombin level percentage were identical to those obtained for the control (12.3 sec and the prothrombin level of 100% depending on the reagent used) which indicates no anticoagulant effect. Nevertheless, no blood clot formation

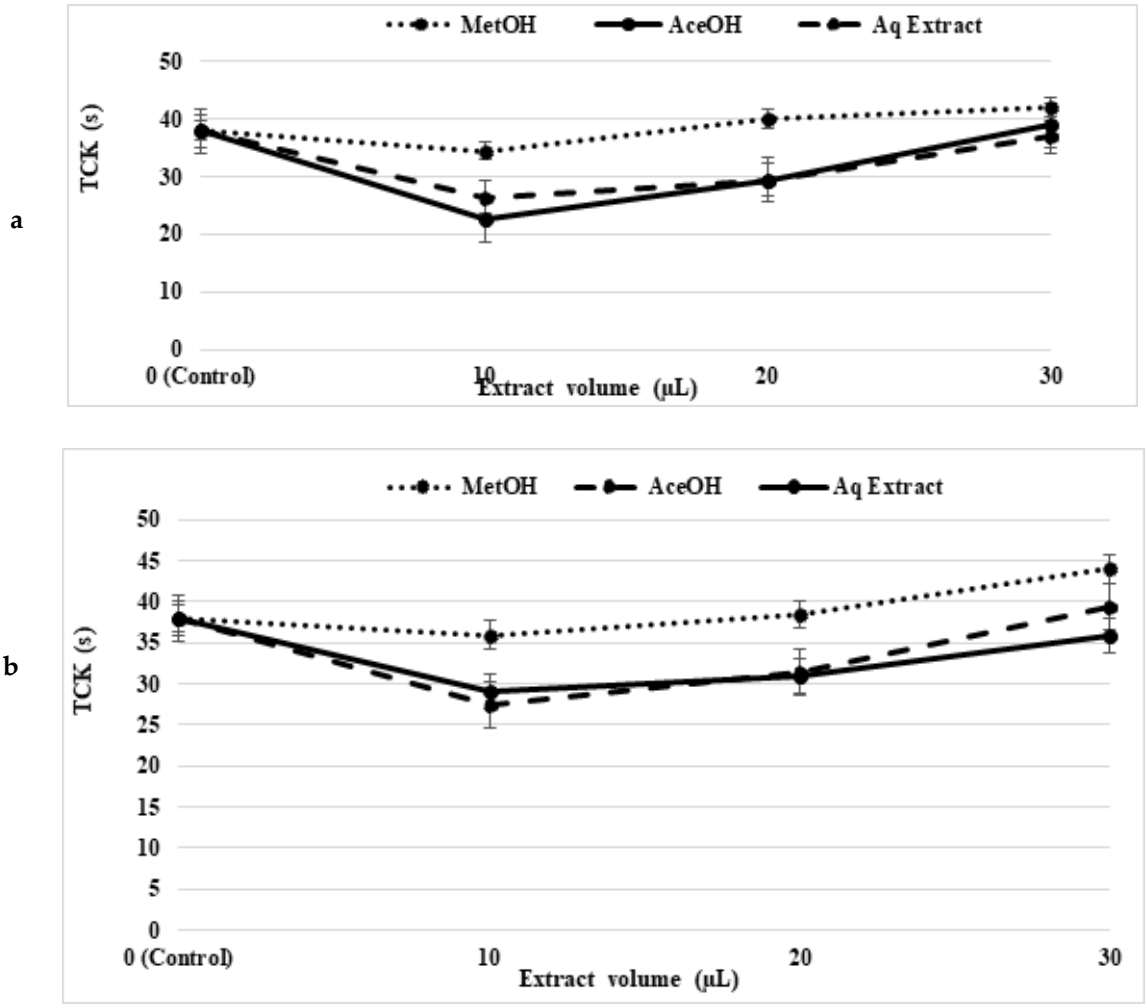

Fig. 3. Anticoagulant activity of turmeric (a) and ginger (b) extracts against the endogenous pathway

occurred in the presence of the butanol extract, confirming that the compounds extracted with butanol are effective anticoagulants that can be used as a blood anticoagulant. The data from the present study clearly showed that all turmeric and ginger extracts significantly increased the clotting time of normal human plasma. These results are consistent with previous reports on the anticoagulant effects of plant extracts (El-Hameid *et al.*, 2020).

As for the anticoagulant activity against the endogenous coagulation pathway (Fig. 3), the results showed that the aqueous extracts of both spices had no anticoagulant effect as the clotting time for all volumes tested was lower than that of the TCK control of 38 sec (the normal TCK ranges from 23 to 38 sec depending on the reagent). The methanolic extract exhibited an anticoagulant activity for high volumes (20 and 30 µL) as the clotting time was long compared to that of control, whereas, the volume of 10 µL did not show any anticoagulant activity. The same trend was observed for the acetonic extract for volume of 30 µL which showed a slight anticoagulant activity. Otherwise, the 10 and 20 µL volumes had no anticoagulant activity as the time was shorter than that recorded for the control. In the presence of the butanolic extract, the serum tested was non-coagulable, which confirms its considerable anticoagulant potent.

Our results are comparable to those of Boukeria *et al.* (2019) who found that turmeric extracts exert anticoagulant activity against both endogenous and exogenous pathways of coagulation. Furthermore, Ajala *et al.* (2017) have found that the ginger rhizome methanolic extract has an anticoagulant effect as prothrombin time, activated partial thromboplastin time and thrombin time were significantly prolonged compared to the control.

Conclusion

Results from the current study showed that turmeric powder possess a higher swelling capacity, absorption capacities in terms of water and oil, than ginger powder. These functional characteristics make turmeric useful in products that require hydration to prevent syneresis, improve yield, stabilize emulsions and high-fat food products, and modify texture and viscosity. All solvents tested were able to extract polyphenols, flavonoids and proanthocyanidins, however, methanol extracted the high polyphenols, whereas, the acetone extracted the high rate of flavonoids. Nevertheless, the condensed tannins contents were present at low concentrations in all tested solvents. In addition, the high contents of polyphenols and flavonoids indicated the antioxidant potential of both spices. Furthermore, this study showed that both turmeric and ginger have shown capability of improving anticoagulant activity by inhibiting significantly the extrinsic pathway of blood coagulation and lengthen the clotting time.

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