

Microbiological Status and Nutritional Composition of Spices Used in Food Preparation

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Abstract

The present study showed significant initial microbial load, as well nutritional value of ten spices used widely across the world in food preparation. The microbiological tests demonstrated that sumac and cloves had the highest antimicrobial activity with respect to total plate counting and spore forming count. Results showed that chemical composition of the spices and herbs varied significantly. Dry matter content ranged between 83.6% and 92.4%. The highest ash content 10.4% was found in sweet cumin, protein 21.2% in cumin, fat 19.7% in sumac, fiber 59.2% in turmeric and carbohydrates 27.3% in sumac. These spices were also differing in their minerals content. Substantial amounts of Ca, Na, K and Mg were found, while Cu, Fe, P, Mn and Zn were present in trace amounts in all investigated spices.

Keywords

Microbial Status, Minerals, Proximate Chemical Composition, Spices

1. Introduction

The role of plants in human health has extensively revealed due to the emergence of numerous advancements in the medicine and nutrition disciplines. The awareness of the benefits of plants in food as wealthy additives poses researchers to pursue for discovering the influence of such ingredients to the health of the human beings [1] [2].

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Spices and herbs are well known food ingredients, which enhances the flavor and aroma of the supplemented foods. Botanically, spices are one class of the aromatic plants; they are mainly present in the tropical provinces. Generally, spices could be either as seeds, flowers or leaves [3]. On the other hand, herbs are fragrant and non-woody plants in which they are used in flavoring food dishes; the herbs could be leaves, stems or seeds. Nutritionally, the spices and herbs are significant in reducing the peroxidation of lipids, which are the changes (off-flavor) in the nature and the chemical composition of lipids during the processing, preservation and the final preparation of foods [4]. Generally, spices and herbs prevent the lipid oxidation process due to the presence of natural antioxidants [5]-[7]. Spices and herbs have also antimicrobial properties that can help in the preservation of foods and more recently in animal feed. Nowadays, there is more pressure by consumers in food and feed industry in replacing synthetic preservatives by natural preservatives [8] [9]. Antimicrobial compounds in food, whether or not processed, can increase the shelf life by reducing the growth of microorganisms or by reducing their viability [10]-[12]. The exact chemical composition of herbs and spices have been reported to be greatly influenced by many factors such as part of the plant used, its vegetative state, environmental conditions, harvesting technique, etc. [13]. Recent review reported the variation in approximate composition of the essential oils in spices [8], however and to best of our knowledge, no study reported the variation in mineral and chemical composition of herbs and spices marketed in Jordan. The main objective of this research was to characterize the chemical and minerals composition and antimicrobial and anti fungal activities of the mostly used spices and herbs present in Jordanian market.

2. Materials and Methods

About 500 g of the investigated spices and herbs (**Table 1**) were purchased from the local markets, mainly in Irbid governorate in Jordan. All the spices were purchased on two different occasions within a two months period. All the purchased spices were ground to a fine powder using a laboratory mill to pass a 0.5 mm sieve and kept at 4°C in Ziploc plastic bags until analyzed. All spices were identified according to the label of the container.

Proximate Analysis: Moisture, ash, proteins, fat and crude fiber contents were determined according to the standard procedures outlined in Williams [14]. Total carbohydrate was calculated by difference according to Williams [14] procedure.

Minerals Analysis: The spice samples were ashed and the residue was dissolved in hydrochloric acid and quantitatively transferred into a volumetric flask. The volume was made up to 50 ml using distilled deionized water. The concentration of the mineral elements (Ca, Na, K, Cu, Fe, Mg, Mn and Zn) was determined using atomic absorption spectrophotometer according to the method outlined by the Williams [14]. Phosphorous was determined according to the procedure reported by Fiske and Subbarow [15]. The averages were recorded and computed on dry weight basis.

Microbiological Analysis: All investigated spices were tested for total plate count, aerobic spore forming count and enumeration of yeast and mold according to the procedure described by Cousin [16] and Andrews [17].

Table 1. The investigated spices marketed in Jordan.

Plant family	Scientific name	English name
Myrtaceae	<i>Syzygium aromaticum</i> L.	Cloves
Apiaceae	<i>Coriandrum sativum</i> L.	Coriander
Apiaceae	<i>Cuminum cyminum</i> L.	Cumin
Zingiberaceae	<i>Zingiber officinale</i> Rosc.	Ginger
Zingiberaceae	<i>Elettaria cardamomum</i>	Green Cardamom
Zingiberaceae	<i>Curcuma longa</i> L.	Turmeric
Anacardiaceae	<i>Rhus coriaria</i> L.	Sumac
Lauraceae	<i>Cinnamomum zeylanicum</i> Blume	Cinnamon
Apiaceae	<i>Foeniculum vulgare</i> Mill	Sweet Cumin, Fennel
Lauraceae	<i>Laurus nobilis</i> L.	Sweet Laurel, Sweet Bay leaf

Statistical Analysis: The collected data were statistically analyzed using analysis of variance (ANOVA), using the general linear model procedure of SAS institute (2004). Data for each test were analyzed as a Completely Randomized Design (CRD). Differences among treatment means were separated using the Least Significant Differences (LSD) at $P \leq 0.05$.

3. Results and Discussion

3.1. Chemical Composition

Data on the dry matter, ash, fat, protein, fiber and carbohydrates constituents in the investigated spices are shown in **Table 2**. Dry matter varied significantly among the spices, and ranged from 83.6% (cloves) and 92.4% (sumac). The ash contents were varied significantly among all the investigated spices, and ranged between 4.5% (cinnamon) and 10.4% (sweet cumin). Cloves and coriander were not varied significantly and the ash values were 7.8% and 7.3%, respectively. The dry matter and ash content of these spices were found to agree with data reported previously [3].

The fat contents varied significantly among the spices. Cinnamon, turmeric and green cardamom showed significantly the lowest values for the fat contents (1.7%, 2.9%, and 3.2% respectively), while the fat content for the sumac, cumin, sweet cumin and coriander had significantly the highest values (19.7%, 15.5%, 13.7% and 11.6% respectively). These results are comparable with those reported by Kirk and Sawyer [3].

Protein levels of spices showed that all spices were significantly different. The protein values ranged between 2.9% for sumac and 21.2% for cumin and these results were similar to values reported by Tashtush [18]. Furthermore, the protein contents for cloves, ginger, sweet laurel and green cardamom they were almost similar (9.3%, 9.4%, 9.7% and 9.9% respectively). Fiber contents also varied significantly among the spices and ranged between 25.78% (cumin) and 59.29% (turmeric). In general, the outer protective coatings of many foods contain considerably more fiber than the softer [3]. As the fiber content increases with plants age, the fiber may be of value in assessing the maturity of legumes.

Carbohydrate levels were significantly different in the spices, the content ranged between 4.55% and 31%. Cloves, sumac, cinnamon and green cardamom had significantly the highest values (31.0%, 27.25%, 24.49% and 21.10%, respectively). While the sweet cumin, coriander, turmeric and sweet laurel had significantly the lowest values (4.55%, 9.9%, 11.11% and 12.1%, respectively).

Among all nutrient composition, fat contents in the current study had the highest variation (CV = 57.09%) while dry matter content had the lowest variation (CV = 3.12%). The variation in fat content suggests high variation in the essential oil content. Within same spices type, huge variations in essential oils have been reported to

Table 2. Gross chemical composition of spices marketed in Jordan.

Spices	DM (%)	Ash (%)	Fat (%)	Protein (%)	Fiber (%)	Carbohydrate (%)
Cloves	83.6 ^e	7.8 ^{bc}	4.3 ^f	9.3 ^{de}	31.2 ^{ef}	31 ^a
Coriander	90.8 ^{ab}	7.3 ^{cd}	11.6 ^d	14.9 ^c	47.1 ^d	9.9 ^h
Cumin	90.4 ^{ab}	9.1 ^{ab}	15.5 ^b	21.2 ^a	25.7 ^f	18.8 ^e
Ginger	89.1 ^{bc}	5.4 ^e	4.0 ^f	9.4 ^{de}	52.1 ^c	18.1 ^f
Cardamom	85.3 ^{de}	10.2 ^a	3.2 ^{gf}	9.9 ^d	40.9 ^{de}	21.1 ^d
Turmeric	90.1 ^{ab}	8.4 ^{bc}	2.9 ^{gf}	8.4 ^e	59.2 ^a	11.1 ^h
Sumac	92.4 ^a	9.2 ^{ab}	19.7 ^a	2.9 ^f	33.3 ^e	27.3 ^b
Cinnamon	86.9 ^{cd}	4.5 ^e	1.7 ^g	4.2 ^f	52.0 ^{cd}	24.5 ^c
Cumin	91.1 ^{ab}	10.4 ^a	13.7 ^c	18.2 ^b	44.2 ^d	4.5 ⁱ
Laurel	90.1 ^{ab}	5.7 ^{de}	5.9 ^e	9.7 ^{de}	56.7 ^{ab}	12.1 ^g
LSD at $P \leq 0.05$	2.6	1.7	1.5	1.4	4.3	0.8
CV (%)	3.15	26.29	57.09	53.20	25.59	46.92

^aMeans are average of four replicates values are computed on dry weight basis. ^bMeans with different letters in the same column are significantly different at $P \leq 0.05$.

exist between different locations [19]. For instance, Viuda-Martos *et al.* [8] reported that approximate composition of the essential oil such as Eugenyl acetate in clover varied from traces to 20%.

3.2. Minerals Analysis

Minerals determination experiment was to study the nutritional value of spices, nine minerals had been inspected, which were the calcium, sodium, potassium, copper, iron, phosphorus, magnesium, manganese and zinc. These minerals are regarded as the most significant minerals in a valuable food. **Table 3** showed that cinnamon, sweet cumin and sweet laurel had the highest levels of calcium (299.1, 221.5 and 214.8 mg/100g, respectively) where turmeric and ginger observed the lowest values of calcium (13 and 66.8 mg/100g, respectively). Also, mineral analysis showed that the calcium contents varied significantly from one spice to another. For the sodium, sumac had the highest level of concentration (85.1 mg/100g) where the coriander had the lowest concentration (11.9 mg/100g). Cumin (81.1 mg/100g), green cardamom (68.8 mg/100g) and cloves (61.6 mg/100g) had high concentrations of sodium while the cinnamon (12 mg/100g) and sweet laurel (15.1 mg/100g) had low contents of sodium. Potassium and the magnesium had higher concentrations than other minerals for all spices; sweet laurel had the highest concentration of potassium (141.4 mg/100g), while the lowest concentration was found in cloves (111.6 mg/100g). Furthermore, the turmeric had the lowest amount of magnesium (91.7 mg/100g) while the sumac (254.1 mg/100g) and sweet cumin (201.7 mg/100g) had the highest amount of magnesium. Copper, manganese, phosphorus and zinc had the lowest concentrations when comparing minerals in all spices. Copper was indicated by small portion of range in all spices (0.3 mg/100g - 0.7 mg/100g), the highest concentration was shown by green cardamom and the lowest concentration was found in turmeric. Manganese content was found to be low and varied significantly among the spices. Cloves had the higher content (20.9 mg/100g) whereas the lowest level found in sumac (0.7 mg/100g). Phosphorous content showed a significant variation among the spices, and ranged from 0.7 mg/100g (green cardamom) to 6.3 mg/100g (coriander). Coriander and turmeric had significantly the highest phosphorous contents (6.3 and 6.1 mg/100g, respectively), cloves, cinnamon, sumac and cumin showed significantly lower level of phosphorous as compared to all other spices. Relatively, the spices were not rich in iron; their concentrations were ranged from 6.5 mg/100g in sweet laurel to 20 mg/100g in cumin. The concentrations of zinc were not varied significantly in most spices; they ranged from 3.7 (green cardamom) to 4.5 mg/100g (ginger), while, the highest concentration of zinc was found in sumac (5.7 mg/100g) and the lowest concentration was found in turmeric (0.8 mg/100g).

Comparing between the minerals concentrations of some of the experimented spices such as cumin, sweet laurel, sumac and sweet cumin with Özcan [20] finding showed that the content of all minerals were higher in Özcan [20] finding for all tested spices except for the copper, zinc and manganese, which indicated a relatively

Table 3. Minerals content of spices marketed in Jordan.

Spices	Minerals (mg/100g)								
	Ca	Na	K	Cu	Fe	P	Mg	Mn	Zn
Cloves ^b	117.5 ^{ef}	61.6 ^b	111.6 ^a	0.4 ^{ab}	8.3 ^{de}	1.6 ^{ef}	196.8 ^{bc}	20.9 ^a	1.4 ^{cd}
Coriander	89.7 ^{ef}	11.9 ^d	127.3 ^a	0.6 ^{ab}	12.2 ^{cd}	6.3 ^a	126.6 ^{ef}	17.9 ^b	4.0 ^b
Cumin	161.7 ^{de}	81.1 ^a	133.3 ^a	0.6 ^{ab}	20.0 ^a	3.6 ^{cd}	166.9 ^{cd}	1.4 ^d	4.2 ^b
Ginger	66.8 ^g	21.3 ^{cd}	127.2 ^a	0.6 ^{ab}	7.6 ^{de}	4.3 ^{bc}	100.8 ^{gf}	1.5 ^d	4.5 ^b
Cardamom	92.9 ^{ef}	68.8 ^{ab}	127.4 ^a	0.7 ^a	18.6 ^{ab}	0.7 ^f	181.5 ^{bc}	9.9 ^c	3.7 ^b
Turmeric	13.0 ^h	29.8 ^c	115.2 ^a	0.3 ^b	17.7 ^{ab}	6.1 ^{ab}	91.7 ^g	1.6 ^d	0.8 ^d
Sumac	175.0 ^{cd}	85.1 ^a	126.9 ^a	0.4 ^{ab}	14.6 ^{bc}	3.3 ^{cde}	254.1 ^a	0.7 ^d	5.7 ^a
Cinnamon	299.1 ^a	12.0 ^d	127.4 ^a	0.5 ^{ab}	8.1 ^{de}	2.1 ^{def}	140.3 ^{de}	8.7 ^c	1.3 ^{cd}
Cumin	221.5 ^b	60.7 ^b	124.8 ^a	0.6 ^{ab}	8.2 ^{de}	4.0 ^c	201.7 ^b	8.0 ^c	3.8 ^b
Laurel	214.8 ^{bc}	15.1 ^{cd}	141.4 ^a	0.4 ^{ab}	6.5 ^e	3.8 ^{cd}	80.6 ^g	1.6 ^d	2.0 ^c
LSD P ≤ 0.05	44.8	17.6	36.3	0.3	4.8	1.8	33.7	2.6	0.9
CV (%)	63.59	69.13	23.92	28	46.7	52.2	44.87	104.2	57

^aMeans are average of four replicates and expressed in mg/100g as dry matter basis. ^bMeans with different letters in the same column are significantly different at P ≤ 0.05.

close content of minerals. Gallaher *et al.* [21] demonstrated the content of minerals in herbal tea, specifically, sodium, potassium, magnesium and calcium contents were higher for spices than the herbal tea whereas the copper, phosphorous, zinc and manganese minerals content in spices were comparable with values in herbal tea.

Aspilia Africana and *Bryophlum pinnatum* were examined for their minerals content by Okwu and Josiah [22]. The investigated spices showed higher levels of minerals when compared with *Aspilia Africana* and *Bryophlum pinnatum* plants except for the zinc, which was higher in *Aspilia Africana* and *Bryophlum pinnatum* plants than that in the current study. In this study, Mn content had the highest variation (CV = 104.28%) whereas K content had the lowest variation (CV = 23.92%).

3.3. Microbiological Test

Table 4 shows the microbiological analysis for the spices. Total plate, aerobic spore forming bacteria, yeast and mold count are presented in **Table 4**. Data showed that total plate count of cloves and sumac had the lowest colonies of bacteria (<10 CFU/g), whereas, other spices had varied significantly; turmeric and sweet laurel had the highest level of total plate count (3.5×10^4 CFU/g) for both spices. This data indicated that most of the spices had antimicrobial properties. Aerobic spore forming bacteria count varied significantly among the investigated spices, both cloves and sumac had the same and almost there was no growth for aerobic spore forming bacteria (<10 CFU/g), turmeric had the highest count for aerobic spore forming bacteria (5.0×10^4 CFU/g), while green cardamom had the lowest count among the spices (2.3×10^3 CFU/g). The investigated spices when examined for yeast and mold; all spices except sweet laurel, green cardamom and coriander showed yeast and mold growth, the count per gram was found as 1.4×10^3 , 3.0×10^2 and 1.0×10^2 CFU/g, respectively. Eugenol and cinnamaldehyde are essential oils extracted from spices and were recognized as antimicrobial compounds, mold inhibitors and prevent the spoilage of food products [20] [23]. During cleaning and processing of spices, progressive reduction in the numbers and types of microorganisms take place [24].

Guarino [25], Julseth and Deibel [26] reported that organisms remaining after physical treatment were generally mixtures of aerobic spore forming bacteria and common molds, other organisms found occasionally, usually in small numbers. Post-harvest treatment of spices ranges from primitive sun-drying and sifting to extensive methods of air-scrubbing, milling; fumigation and encapsulation of soluble extracts [25] [27] will reduced the microbial loads on cumin, coriander, chilies and black pepper. Yano *et al.* [28] observed that the use of spices in food may protect the risk of contamination by different types of bacteria. However, Burdock and Carabin [29] showed that oil extracted from Coriander seeds has wide-spectrum of antimicrobial activity. The normal amounts added to foods for flavoring was not sufficient to inhibit microbial growth. The conducted experiments indicated that the antimicrobial activity varied widely depending on the type of spice or herb, test medium and

Table 4. Total plate count, aerobic sporeforming count, yeast and mold count in spices marketed in Jordan.

Spices	Total plate count	Sporeforming count	Yeast & Mold
Cloves ^b	<10 ^f	<10 ^h	ND
Coriander	1.3×10^{3d}	1.0×10^{3f}	1.0×10^{2c}
Cumin	3.0×10^{3c}	1.2×10^{3ef}	ND
Ginger	2.0×10^{3cd}	2.0×10^{3d}	ND
Cardamom	3.0×10^{2e}	2.3×10^{2g}	3.0×10^{2b}
Turmeric	3.5×10^{4a}	5.0×10^{4a}	ND
Sumac	<10 ^f	<10 ^h	ND
Cinnamon	2.1×10^{3cd}	2.0×10^{3de}	ND
Cumin	8.2×10^{3b}	6.0×10^{3c}	ND
Laurel	3.5×10^{4a}	1.1×10^{4b}	1.4×10^{3a}
LSD at P ≤ 0.05	1.94	1.67	1.09

^aMeans are average of two replicates and expressed as CFU/g. ^bMeans with different letters in the same column are significantly different at P ≤ 0.05.

microorganism. However, the addition of herbs and spices helped in preserving foods held at refrigerated temperatures, at which the multiplication of microorganisms is slow. Cloves, coriander, ginger and cumin had antibacterial activity, which might be beneficial to preserve the risk of bacterial contamination in sea foods [28].

Results in the current investigation found to be in agreement with previously published data. Kossa *et al.* [30] found a strong antimicrobial activity of sumac oil extract against a broad spectrum of bacteria species, such as *Bacillus cereus* and *Helicobacter pylori*. These bacteria were found to be the most sensitive Gram-positive and Gram-negative bacteria. Interestingly, Gündüz *et al.* [31] found that sumac extract inhibited the activity of *Salmonella typhimurium* ATCC 13311 in tomatoes. Similar study conducted by Nasar-Abbas *et al.* [32] found that sumac inhibited the growth of 12 bacterial strains (6 Gram positives and 6 Gram negatives), mostly foodborne including pathogens. Deans *et al.* [33] found that oil extract from clove exhibited significant antimicrobial activity against 25 different genera of bacteria and 20 different isolates of *Listeria monocytogenes*.

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