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Occurrence, Chemical Composition, and Nutritional Value of Truffles: An Overview

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Abstract

Truffle is a delicacy in Saudi Arabia and many other countries ; however, information on its nutritious values and chemical composition is limited. The objective of this paper is to review the available data on chemical composition and nutritional quality. Saudi truffles contains moisture (75.21-79.38 %), protein (19.59-27.18 %), fat 92.81-7.42 %), crude fiber (7.81-14.89 %), ash (4.33-6.39 %), and ascorbic acid (0.7.0-5.10 mg/100 g). It also contains high amounts of K, P, and fair levels of Ca, Mg, Na, Fe, Cu, Zn, and Mn. Reports show that truffle contains all essential amino acids. This review suggests further investigation on local truffle with special emphasis on its production, cultivation, soil environment, impact of rainfall, associated microflora, storage effects on truffle quality, marketing, and economic evaluation in Saudi Arabia.

Introduction

Truffles (hypogeous ascomycetes or mycorrhizal fungi) are locally known as "Al-Kamaa or Al-Fag'a. In the United States of America (USA), truffles are also called black diamond (Garland, 1995).These are a group of desert fungi, which grow in wild. These usually appear after the rainy season in the months of February to April in Saudi Arabia (Bokhary, 1987; Bokhary and Parvez, 1988).

Truffles are generally found between 26-47°E longitude and 30-32°N latitude. Truffles are commonly found in the northern part of Saudi Arabia bordering Kuwait, Iraq and Jordan, some parts of continental Africa (Ahmed *et al.*, 1981, Ackerman *et al.*, 1975, Arabia (Bokhary, 1987; Bokhary and Parvez, 1988; Marasa and Trappe, 1973; Duggar and Pinoyi, 1907). These fungi are also common in deserts of north Africa , west Asia, and other parts of the world (Trappe, 1971; Al-Sheikh and Trappe, 1983), the continent of Europe (Moreno *et al.*, 1986 and Fogel, 1980) and America (Garland, 1995).

Five species, namely *Tirmania nivea*, *Tirmania pinoyi*, *Terfezia boudieri*, and *Phaeangium lefebvrei* have been reported in association with *Helianthemum lippi*, in Saudi Arabia and other Middle Eastern countries. The European truffles commonly grow in association with forest trees.

Truffles are an expensive delicacy in Saudi Arabia and many other countries. For example, the cost of one kg of truffles may reach as high as US$ 55 in Saudi Arabia (Bokhary 1987). In France, the price of truffles had reached up to 2300 Francs ($200) in 1984 (Patterson, 1984). The high cost of the truffles may be due to their scarcity and rarity during the poor harvesting season. The popularity of truffles is thought to be due to their constituents of nutritional value and delicious taste (FAO/WHO, 1973).

Medically, *Terfezia claveryi* is reported to be useful in the treatment of eye diseases e.g., trichoma (Al-Marzooky, 1981). *Terfezia* and *Tirmania* sp. are used in folk medicine to treat skin and eye diseases. Fractions of the methanolic extract of *Terfezia* sp. exhibited activity against gram positive bacteria including *Bacillus subtilis* and *Staphylococcus aureus*. Extracts of *Tirmania sp.* were less bacteriostatic than those of *Terfezia sp.* (Chellal and Lukasova, 1995).

Because of high price and demand, truffles can prove to be an economical crop in Saudi Arabia. However, information on agronomic aspects of truffle cultivation is scarce. The objective of this paper is to review the available information on the occurrence, chemical composition and nutritional quality of Truffles.

Description and Taxonomy of Truffles

Various local Arabic names are attributed to truffles but most commonly, it is known as "Al-Fag'a". The classic Arabic name for truffles is 'Al-Kamae or Kame" (Bokhary, 1987). Terfezia spp. by virtue of its blackish ascocarps are locally known as "Al-Kame-Al-Souda" and Al-Kame-Al-Bunia" (Kholeissi). P. lefebvrei, which is commonly known an bird truffle, has also other local names "Faga altoyoor" "heberi" or "hober". This truffle is commonly eaten by birds in Kuwait (Al-Sheik and Trappe, 1983) and also in Saudi Arabia.

Ascocarps of truffles are generally hypogeous, i.e., potato like, with basal attachment. Fresh weight ranges between 1.1 to 173 g per ascocarp. The surface of ascocarps is light brown to dark brown or blackish brown. Asci are variously shaped, double layered, haline, and thin walled with 2-8 spored (mainly 6-8 spored). The size of asci varies from 2500 to 5600 um^2 (Bokhary and Parvez, 1988). Bencivenga and Urbani (1996) found the largest size truffle (white) that had a diameter of about 8 cm and weighed 235 g.

In Saudi Arabia (Sawaya *et al.*, 1985), three types of truffles namely Gibbah, Kholeissi and Zubaidi are found. Actually two of these i.e. Gibbah and Kholeissi (brown truffle) are different forms of the same species. *Terfezia claveryi* Chatin, (*Terfeziaceae*). The species Zubaidi (white truffle) was identified as *Tirmania nivea* (Desf. Fr.) Trappe (Pezizaceae). The white truffle, Tirmania nivea, produces the largest ascocarp (up to 1000 g) and the brown truffle yields smaller heads (kholeissi, up to 300 g and Gibbah up to 700 g).

limatic Conditions

ruffles grow in a wide variety of soils, such as sandy, alcareous, alkaline, saline sodic gypsiferous, gravelly and aline soils. The sites best suited for the production of hite truffles are moist soils with large pores and surface orizons with low bulk density. Rainfall (its amount and stribution) is an important factor for the fructification of e truffles (Awameh and Al-Sheikh, 1980 and Halwagy nd Halwagy, 1974).

Italy, truffles are generally associated with poplar *opulus sp.*) and oak (*Quercus sp.*) plantations (Panini *et* ., 1991). Soil characteristics such as pH, Ca, water ntents, macroporosity and aeration necessary for the oduction of tuber magnatum, T. melanosporum and other ecies in Italy (Lulli and Primavera, 1995). Truffles are ually associated with limestone formations known as caglia rosa". Inspite of favorable environmental nditions, carpophores only occur within particular pographic features, rounded areas with atypical bare pearance (Pianelli), and with almost no herbaceous cover ragato, 1997). Bragato *et al.* (1992) believed that ideal ils for truffles is the one with a low clay content, low lk density, high porosity, high carbonate content and atively high soil water content through the year.

Saudi Arabia, truffles are grown in sandy desert soils in eas that receive relatively high precipitation. Unlike the ropean truffles, which grow in forests in association with k trees, the Saudi truffles are desert species found in the erior of Saudi Arabia excluding the deep sand and bare cky regions. Records for the years 1966-1974 show that e interior regions of Saudi Arabia where such truffles ow have a mean temperature of 24.1°C and an annual erage rainfall of 127 mm (Sawaya *et al.*, 1985), most mmonly in the northern part of Saudi Arabia bordering wait, Iraq and Jordan (Ahmed *et al.*, 1981, Bokhary, 87; Bokhary and Parvez, 1988).

Algeria truffles were found in association *with ianthemum lippi*. Three species of edible desert truffles. *fezia arenaria, Terfezia claveryi, and Tirmania pinoyi* re growing in association with *Helianthemum guttatum* rtas and Chevalier, 1992).

pez and Torres (1994) conducted an irrigation study on ffles in small plots in Spain. They found that water uirements and rainfall distribution is an important factor the production of truffles. Adequate water during the mmer months, particularly in August, is essential for the velopment of truffles of marketable sizes. They ggested irrigation rates in a year of normal rainfall to be , 40 and 60 liters m^{-2} in June, July and August, pectively.

duction and Marketing

rtinez and Grigelmo (1991) reported an average yield of - 60 kg truffles ha^{-1} per annum in Spain and the nomics of truffle cultivation in Spain are considered to excellent. Marone and Mazzei (1996) conducted a survey of licensed collectors, traders, wholesale and retail sellers of truffles (particularly the white truffle [Tuber sp.], which is found throughout Tuscay) in Central Italy. It was found that percent of truffles were sold to friends, 27 per cent to intermediaries, 19 per cent to other known persons, 15 per cent to restaurants and 2 percent to the food industry. Ciani *et al.* (1992) concluded that unofficial statistics show that from 1961 to 1985 total output fluctuated between 1000 and 2000 quintals annually. Bencivenga and Urbani (1996) established a 5 ha. truffle ground in 1992 near Riserva Nuova in the Commune of Aprilia sp. by planting *Pinus brutia* plants in mycorrhizal association with *Tuber albium* at a spacing of 5x5m. Truffles were examined in March, 1995. The largest had a diameter of about 8 cm and weighed 235 g. Another weighing 145 g and several weighing in at 30-100 g.

Table 1: Some Chemical Constituents of Iraqi Truffles (Al-Naama *et al.*, 1988)

Description	Terfezia claveryi	Tirmania nivea	Tirmania pinoyi
Carbohydrates (%)	16.66	21.53	24.87
Protein (%)	8.02	13.84	10.49
Ash (%)	5.90	4.90	5.60
Phosphorus (%)	9.70	25.50	21.90

Table 2: Crude protein and amino acid concentrations (%) in Egyptian desert truffles.

Description	Tirmania nivea (Egypt)	Terfezia boudieri (Egypt)	Terfezia boudieri (Lybia)
Crude protein	16.30	12.82	17.19
Threonine	2.41	18.37	10.98
Methionine	0.82	0.29	3.32
Leucine	3.41	0.80	11.07
Phenylalanine	8.94	3.47	6.74
Lysine	20.11	14.16	5.57
Arginine	17.35	6.96	4.41
Aspartic Acid	4.04	17.19	15.64
Serine	1.77	9.07	9.43
Glutamic Acid	13.92	8.85	22.45
Proline	14.39	4.32	9.83
Glycine	1.82	1.00	7.65
Alanine	2.57	1.20	11.10
Cystine	2.04	0.89	2.84
Tyrosine	3.59	1.55	4.95
Asparagine	< 0.01	10.19	--

In Saudi Arabia (Sawaya *et al.*, 1985), three types of truffles namely Gibbah, Kholeissi and Zubaidi are found, but two of these i.e. Gibbah and Kholeissi (brown truffle) are different forms of the same species. *Terfezia claveryi* Chatin, (*Terfeziaceae*), while Zubaidi (white truffle) was identified as *Tirmania nivea* (Desf. Fr.) Trappe (Pezizaceae). The white truffle (Tirmania nivea, produces the largest ascocarp (up to 1000g) and the brown truffle yields smaller ones (kholeissi, up to 300g and Gibbah up to 700 g).

Table 3: Chemical Composition of Saudi Truffles

Parameter	Unpeeled			Peeled		
	Gibbah (brown)	Kholeissi (brown)	Zubaidi (white)	Gibbah (brown)	Kholeissi (brown)	Zubaidi (white)
Moisture (%)	75.44*	78.89	75.27	79.39	78.29	75.21
Protein (%)	24.96	19.59	27.18	20.26	19.65	25.49
Fat (%)	4.20	2.81	7.42	3.43	3.43	7.19
Crude Fiber (%)	7.02	7.85	13.02	10.48	7.81	14.89
Ash (%)	6.39	4.64	5.40	4.46	4.33	5.00
Ascorbic Acid (mg/100g)	5.10	1.82	1.56	1.42	0.70	1.00

* Values are expressed as percentage for all except Ascorbic Acid.

Table 4: Mineral Composition of Saudi Truffles

Truffles	Ca	Mg	P	Na	K	Fe	Mn	Cu	Zn
				Unpeeled					
Gibbah	*129	104	756	199	1730	10.68	0.48	1.69	5.10
Kholeissi	67	82	506	189	1408	4.81	0.41	2.30	4.14
Zubaidi	62	101	644	110	734	4.35	0.49	11.54	5.04
				Peeled					
Gibbah	41	74	653	184	1548	1.82	0.21	1.33	3.69
Kholeissi	34	73	513	142	1393	1.75	0.22	1.95	3.71
Zubaidi	38	97	623	199	1602	2.31	0.44	8.74	4.53

*Values are expressed as mg/100 g dry weight basis.

Table 5: Amino Acid Composition of Saudi Truffles (g/100 g protein) FAO/WHO (1973)

Parameters	Unpeeled Truffles			Peeled Truffles		
	Gibbah	Kholeissi	Zubaidi	Gibbah	Kholeissi	Zubaidi
Aspartic acid	8.04	8.25	8.83	8.24	7.81	8.57
Threonine	5.38	4.09	7.81	5.24	4.00	7.19
Serine	3.96	3.52	4.29	4.19	3.38	4.56
Glutamic acid	13.37	14.78	14.37	17.98	17.98	15.19
Proline	5.03	4.01	4.95	5.67	3.97	5.94
Glycine	3.58	3.64	4.33	3.90	3.51	4.35
Alanine	6.42	5.01	6.46	6.69	4.90	6.43
Valine	3.96	3.71	4.65	3.95	3.74	4.77
Methionine(M)	4.23	3.14	3.22	4.01	3.00	3.80
Cystine©	1.62	1.26	1.30	1.78	1.14	1.44
Isoleucine	3.69	3.54	4.42	3.74	3.36	4.39
Leucine	5.23	5.28	5.50	5.65	4.94	5.14
Tyrosine	2.90	3.42	3.09	2.76	3.11	3.11
Phenylalanine	2.97	3.17	3.37	3.11	3.04	3.32
Lysine	4.13	5.49	5.70	5.22	5.40	4.93
Histidine	1.45	2.09	2.18	2.00	2.18	1.70
Arginine	3.20	7.95	4.46	4.46	8.37	3.52
Tryptophane	1.20	1.23	1.44	1.27	1.20	1.30

Table 6: General Analyses of Truffles (all values are percentages).

Truffle species	Protein	Carbohydrate	Crude Fibre	Ash	Crude Fat
Terfezia claveryi	1.60	28.00	4.00	4.0	2.0
Tirmania nivea	0.33	--	--	--	--
Tirmania pinoyi	0.62	--	--	--	--
Terfezia boudieri	0.46	59.73	3.80	12.85	6.40

Table 7: Chemical Analysis of Saudi Truffles (on dry weight basis)

Chemical Parameter	Tirmania nivea	Tirmania pinoyi	Terfezia boudieri	Terfezia claveryi
Calcium (%)	0.83	1.07	1.41	0.50
Magnesium (%)	1.90	1.47	1.61	1.00
Sodium (%)	0.68	0.55	0.60	1.30
Potassium (%)	12.70	11.89	9.63	11.30
Iron (%)	1.30	2.16	2.44	1.10
Copper (%)	0.19	0.05	0.09	0.03
Manganese (%)	0.33	0.44	0.39	0.15
Zinc (%)	-	-	-	0.05
Phosphorus (%)	2.74	2.70	2.85	4.30
Cobalt (%)	1.71	0.57	0.76	0.70
Arginine (mg/kg)				6500.00
Cystine (mg/kg)	525.00	1314.00	500.00	1340.00
Histidine (mg/kg)	159.00	403.00	1510.00	1900.00
Leucine (mg/kg)	--	4279.00	698.00	3600.00
Lysine (mg/kg)	145.00	2326.00	136.00	5000.00
Methionine (mg/kg)	--	--	--	2800.00
Phenylalanine (mg/kg)	809.00	16714.00	5480.00	3100.00
Threonine (mg/kg)	2815.00	257.00	--	4300.00
Tryptophan (mg/kg)	--	--	--	1220.00
Valine (mg/kg)	--	6120.00	61.00	3800.00

Terfezia claveryi (a truffle sp.) is commonly sold in the market of Saudi Arabia at a higher price than Tirmania nivea. While P. lefebvrei is not sold in the market but is reported to be eaten raw by Bedouins. It is also used as a trap to catch birds (Al-Sheikh and Trappe, 1983).

Mineral Composition of Truffles

The importance of truffles is well known due to its richness in protein, amino acids, minerals and carbohydrates. The main limiting factor, regarding the commercial production of truffles, is the lack of information on its cultivation, production potential, impact of rainfall (its amount and distribution) in a season, other mycoflora, effect of storage on its quality, and bacteria that could spoil them.

Many investigators have analyzed truffles in different countries to determine the kind and amount of nutrient elements present in different species of truffles growing under different climatic conditions. Some of such information is given in Table 1.

Ibrahim and Saeed (1994) carried out protein and amino acids analysis of two varieties of desert truffles in Egypt (Table 2). The essential amino acids were detected in the protein hydrolysates from *Terfezia nivea* and *Terfezia boudieri*, respectively.

In Saudi Arabia, the Ministry of Agriculture and Water and College of Science of King Saud University, Riyadh have conducted some research on truffles.. The Saudi truffles were analyzed for mineral composition and nutritional evaluation (Abdalla *et al.*, 1979 and Sawaya *et al.*, 1985). Some of the main constituents of Saudi truffles are presented in Tables 3-5. Recent investigations (Bokhary *et al.*, 1987; Bokhary and Parvez, 1993) have provided some additional information on the chemical composition of Saudi Truffles (Tables 6 and 7).

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