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Determination of the chemical composition of acorn (Quercus branti), Pistacia atlantica and Pistacia khinjuk seeds as non-conventional feedstuffs

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ABSTRACT

An experiment was conducted to determine the chemical composition of acorns, Pistacia atlantica and Pistacia khinjuk by sampling seeds from 3 different climates in the Zagrossian region of Iran from an area of about 500,000 hectares of forests. The seed samples were analysed for dry matter, protein, fat, fibre, ash, starch, minerals, amino acids and fatty acids. It was established that acorn have a very low crude protein content and a relatively high starch and crude fat content. Their amino acid composition is very poor; their protein contains, in particular, very few sulphur-containing amino acids (cystine and methionine). Their fat contains considerable quantities of essential linoleic acid. The crude protein content of wild pistachios seeds is very similar to that of corn, and a little lower than that of the other grains. Pistachia protein has a relatively high amount of threonine, serine, valine and lysine, which is very important if it is to be used as poultry feed. The crude fat content of Pistacia khinjuk is 39.10%, that of Pistacia atlantica 26.80%, with a very high content of essential linoleic acid, which is very useful in poultry nutrition.

(Keywords: Acorn, Pistacia atlantica, Pistacia khinjuk, chemical composition, protein)

ÖSSZEFOGLALÁS

A nem konvencionális takarmánykomponensek, a makk (Quercus branti), a Pistacia atlantica és a Pistacia khinjuk kémiai összetételének meghatározása

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Kísérletet állítottak be a makk, a Pistacia atlantica és a Pistacia khinjuk kémiai összetételének meghatározására. A minták Irán Zagrossian tartományának 3 különböző éghajlatú részéről, mintegy 500 ezer hektáros erdőből származtak. Meghatározták a minták szárazanyag-, fehérje-, zsír-, rost-, keményítő-, ásványi anyag-, aminosav- és zsírsav tartalmát. Megállapították, hogy a makk nyersfehérje tartalma rendkívül alacsony, keményítő és nyersrost tartalma viszont viszonylag magas. Aminosav összetétele igen szegényes. A fehérje nagyon kevés kéntartalmú aminosavat (cisztin és metionin) tartalmaz. Zsírtartalmának tekintélyes részét az esszenciális linolsav teszi ki. A vadpisztácia magok nyersfehérje tartalma rendkívül hasonlít a kukoricáéhoz, és egy

kissé alacsonyabb a többi gabonafélénél. A pisztácia fehérjéje viszonylag nagy mennyiségű treonint, szerint, valint és lizint tartalmaz, amely igen fontos ha baromfitakarmányként használjuk fel. A Pistacia khinjuk nyerszsír tartalma 39,10%, a Pistacia atlanticaé pedig 26,80%, és mindkettő jelentős mennyiségű esszenciális linolsavat tartalmaz, mely rendkívül hasznos a baromfitakarmányozás során.
(Kulcsszavak: makk, Pistacia atlantica, Pistacia khinjuk, kémiai összetétel, fehérje)

INTRODUCTION

Wild pistachio seeds (Pistacia atlantica and Pistacia khinjuk) are the fruit of the Pistacia species. The Pistacia species is classified into the Anacardiaceae family. Pistacia atlantica contains 3 subspecies: Cabulica, Kurdica and Mutica. Pistacia atlantica and Pistacia khinjuk are two major species that grow in the Zagrossian region with various Quercus species. Pistacia atlantica grows 600 to 3000 metres and Pistacia khinjuk 700 to 1900 metres above sea level (*Sabeti, 1994*). The acorn is the fruit of oak trees. The species of oak, the Quercus genus, are classified into the Fagaceae family, which contains about 200 species of oak. Four species of oak (Quercus branti, Quercus infectoria, Quercus libani and Quercus petrea) grow in the Zagrossian region, but Quercus branti is dominant among them (*Sabeti, 1994*). Acorn and wild pistachio provided by the forest are new and unconventional energy sources. Acorns contain considerable amounts of tannin and other anti-nutritional substances. Given in large amounts they may be toxic. (Poisoning of cattle has been recorded). Rations with containing over 25% acorn meal result in eggs with coloured yolks and low hatchability (*De Boer and Bickel, 1988*).

This investigation was carried out on Quercus branti, which is a famed Iranian oak, or the Zagrossian oak, and grows in the Zagros mountain chain in Iran, in an area of about 4 million hectares. This plant grows 650 to 2700 metres above sea level, at -31°C to +45°C and with 250 to 900 mm rainfall. Acorn have been a part of the local diet for some time, furnishing up to 25% of the food consumed by the poorer classes of Italy and Spain (*Hill*, *1937*). They are consumed in the form of bread cake and as a coffee substitute (*Fernald and Kinsey, 1943*). The north Americans and Indians used acorn in the preparation of porridge and mush (*Hill, 1937*). The nuts are ground, leached with boiling or water-ash soak to extract the tannin and other bitter constituents, and pounded into meal. *Fernald and Kinsey* (*1943*) reported that acorn of the white oak groups are only slightly bitter and, after leaching out tannin, the flour produced can be used for the baking of cakes and bread.

Few laboratory analyses have been performed on acorns. Proximate analyses have revealed the chemical composition of acorns to be similar to that of cereals (*Baumgras, 1944; Wanio and Forbes, 1941*). Amino acid analyses have suggested that acorn protein is more nutritious than that of pecans (*Racia et al., 1956*). Starch is the main component of acorns, amounting to over 55% of the kernel. No chemical analyses between varieties within species have been published. Neither is there available any information regarding the physical properties of acorns.

The widespread availability and previous use of acorns as food suggest that the development of this crop for human consumption is feasible. *Ofcarcik and Burns* (*1971*) reported the result of a trial on the chemical and physical properties of selected acorns in Texas. Acorn varieties within twelve species were analysed for chemical and physical attributes. The kernels were evaluated for moisture, ether extract, crude fibre, ash, crude protein, tannin, nitrogen-free extract (less tannins), texture and surface colour. The

acorns were evaluated for length, width, shape and percentage kernel. With the exception of the crude fibre assay, all chemical and physical analyses at the variety level showed significant differences. Generally, all attributes varied significantly between species.

It was reported total phenolics in acorns from different species of oak tree in conjunction with acorn poisoning. In this study acorn poisoning was more commonly seen in cattle, as a susceptible animal species. Three species of acorn (Quercus alba, Q. velutina and Q. rubera) were analysed for their total phenolic content. Q. velutina was found to have the highest level of total phenolics and Q. alba the lowest among the 3 species. The experimental data suggest that in the evaluation of a pasture for the likelihood of acorn toxicity, one containing mainly Q. alba may be safer than one containing Q. velutina or Q. rubera.

The objective of this investigation was to determine the chemical composition of Pistacia atlantica, Pistacia khinjuk and acorn seeds.

MATERIALS AND METHODS

For the determination of the nutritive value of feedstuffs, experiments were carried out by sampling seeds from three different climates in the south-west of the Zagross mountain chain in an area of about 500,000 hectares, in Kohkiloie Boyerahmad province in Iran. In each of the climates 5-10 samples of about 1-2 kg of these seeds from different places were collected and dehulled, in the case of the acorns, then mixed together to make a representative diet for that climate: therefore, 3 samples of acorn, 3 samples of P.at. and 3 samples of P.kh. were provided for the determination of chemical composition.

The chemical composition of P.at., P.kh. and acorn seeds was determined at the Institute of Chemistry of Pannon University of Agriculture, Kaposvar, Hungary. The dry matter content of the samples was determined according to Hungarian standard No 6830-66 by drying to constant weight at 105°C.

The crude protein content of the samples was measured by Kjel-Foss 16200 type nitrogen analyser (protein content=N%×6.25). Crude fat content was determined by the Stoldt method (Hungarian standard No 6830/6-78). Crude fibre content was determined according to Hungarian standard No 6830/7-81. The ash content of the samples was determined according to Hungarian standard No 6830/8-85 after combustion at 550°C for 3 hours. The nitrogen free extract (NFE) content of the samples was calculated. Starch content was determined by the Ewers polarimetric method (Hungarian standard No 6830-66).

Macro- and microelement content (potassium, sodium, calcium, magnesium, zinc, iron, copper and manganese) was determined by UNICAM SP191 type atomic absorption spectrophotometer (Hungarian standard 6830/20-30/80; the elements were measured at the following wavelengths: Ca, 422.7 nm; Mg, 285.2 nm; K, 766.5 nm; Na, 589 nm; Mn, 279.5 nm; Cu, 324.7 nm; Zn, 213.9 nm; Fe, 248.3 nm). Phosphorus content was determined by photometry of the blue colour produced with ammonium molybdenate, by a spectrophotometric method (Hungarian standard ISO 6491). Selenium content was determined by a fluorometric method in accordance with the Hungarian Food Code.

The amino acid composition of the samples was measured by automatic amino acid analyser (Type: LKB 4101, Biochrom). The samples were hydrolysed at 110°C with 6M hydrochloric acid for 24h. The determination of the amino acids was performed with

post-column derivatisation with ninhydrin by photometric detection at 570 nm for all amino acids and at 440 nm for proline. Before each analysis a cysteic acid standard was run to check the decomposition of the ninhydrin.

Determination of fatty acid composition was performed by a Chrompack 9000 gas chromatograph equipped with a flame ionising detector, in the form of methyl esters, as described in Hungarian Food Code.

Statistical analysis: Statistical analysis of the experimental results was performed by means of Excel software for calculation mean values and standard deviation of the data.

RESULTS AND DISCUSSION

The gross chemical composition of acorns, P.at. and P.kh. seeds, including dry matter, crude protein, crude fat, crude fibre, ash, nitrogen-free extract and starch, is given in *table 1*, the macroelement content in *table 2*, the microelement content in *table 3*, the essential amino acid content in *table 4*, the non-essential amino acid content in *table 5*, the fatty acid composition in *table 6* and the comparison of the chemical composition of P.at., P.kh. and acorns with that of certain cereal grains in *table 7*.

Table 1

Gross chemical composition of acorns, Pistacia atlantica and Pistacia khinjuk seeds

Sample name(1)	*Dry matter(2)*	*Crude protein(3)*	*Crude fat(4)*	*Crude fibre(5)*	*Crude ash(6)*	*N.F.E (7)*	*Starch (8)*
	(g/100g sample)						
Acorn-C1(9)	91.40	3.70	6.50	0.40	1.50	79.30	59.90
Acorn-C2	91.60	3.80	7.90	0.30	1.30	78.30	59.90
Acorn-C3	92.00	4.30	8.70	0.40	1.70	76.90	56.60
Mean(10)	91.67	3.93	7.70	0.37	1.50	75.17	58.80
±SD	0.31	0.32	1.11	0.06	0.20	1.21	1.91
Pistacia atlantica-C1	95.30	7.40	24.30	33.80	2.10	27.70	5.40
Pistacia atlantica-C2	95.00	8.70	25.90	32.70	2.10	25.60	4.90
Pistacia atlantica-C3	95.10	8.20	30.20	30.80	2.00	23.90	5.40
Mean	95.13	8.10	26.80	32.43	2.07	25.73	5.23
±SD	0.15	0.66	3.05	1.52	0.06	1.90	0.29
Pistacia khinjuk-C1	95.70	9.60	38.00	22.70	2.50	22.90	4.40
Pistacia khinjuk-C2	96.10	8.70	40.20	23.00	2.50	21.70	4.40
Mean	95.90	9.15	39.10	22.85	2.50	22.30	4.40
±SD	0.28	0.64	1.56	0.21	0.00	0.85	0.00

C1: tropical climate (*trópusi klíma*), C2: Mediterranean climate (*mediterrán klíma*), C3: cold climate (*hideg klíma*)

1. táblázat: A makk, a Pistacia atlantica és a Pistacia khinjuk bruttó kémiai összetétele

A minta neve(1), Szárazanyag(2), Nyersfehérje(3), Nyers zsír(4), Nyers rost(5), Nyers hamu(6), Nitrogénmentes kivonható anyagok(7), Keményítő(8), Makk(9), Átlag(10)

The crude protein content of acorns proved lowest (3.7%) in those from the tropical climate, and highest (4.3%) in those from the cold climate. The mean value was 3.93±0.32%. The difference in crude protein content between tropical and cold climates was significant. The crude fat content of dehulled acorns was 6.5% in the tropical climate, 7.90% in the Mediterranean climate and 8.7% in the cold climate, the mean value being 7.7±1.11%. There was significant difference between the crude fat content of acorns produced in the tropical and the cold climate. The values for crude protein and ether extract increased from tropical climate to cold climate with increase in height above sea level. This may be due to increasing rainfall rate or decreasing temperature, or other conditions better for the trees and more enriching for the seeds. On average crude fibre content was 0.37±0.06%; crude ash content 1.5±0.2%; nitrogen free extract 78.17±1.2%; and starch content 58.8±1.9%. These results for all three climates are very close to each other with no significant differences. The significant differences observed in crude protein and crude fat in different climates were in agreement with the results who reported that acorns of Quercus leucotrichophora from three localities in Himachal Pradesh showed significant differences in fat and protein content.

On average the dry matter content of Pistacia atlantica seed was 95.13±0.15%, crude protein content 8.1±0.66%, crude fat content 26.8±3.05%, crude fibre content 32.43±1.52, crude ash content 2.07±0.06%, nitrogen free extract 25.73±1.9% and starch content 5.23±0.29%. There were no significant differences in the chemical composition of Pistacia atlantica seeds from different climates with the exception of crude fat and also nitrogen free extract of seeds showed significant differences in the climates.

On average the dry matter content of Pistacia khinjuk was 95.9±0.28%, crude protein content 9.15±0.64%, crude fat content 39.1±1.56%, crude fibre content 22.85±0.21%, crude ash content 2.50%, nitrogen free extract 22.3±0.85% and starch content 4.4%. There were no significant differences in the chemical composition of Pistacia khinjuk seeds from different climates.

The mineral content of acorns, Pistacia atlantica and Pistacia khinjuk is shown in *tables 2 and 3*. The mineral content of acorn with mean values and standard deviation were: Ca, 0.73±0.14 g/kg; P, 0.71±0.09 g/kg; Mg, 0.35±0.08 g/kg; K, 6.37±0.4 g/kg; Na, 156.67 mg/kg; Mn, 3.2±0.2 mg/kg; Cu, 4.63±0.32 mg/kg; Zn, 9.17±0.55 mg/kg; Fe, 23.67±3.21 mg/kg; Se, 0.05±0.1 mg/kg.

With the exception of sodium content there was only very slight difference in macro- and microelement content on comparison of Pistacia atlantica and Pistacia khinjuk seeds. On average the calcium content varied between 1.13 and 1.43 g/kg; phosphorus content between 1.56 and 1.90 g/kg; magnesium content between 0.48 and 0.64 g/kg; potassium content between 7.33 and 8.85 g/kg; sodium content between 161 and 519 mg/kg; manganese content between 5.00 and 6.15 mg/kg; copper content between 7.85 and 8.33 mg/kg; zinc content between 11.90 and 12.73 mg/kg; iron content between 36.00 and 51.67 mg/kg and selenium content between 0.05 and 0.06 mg/kg.

The amino acid content of acorns, Pistacia atlantica and Pistacia khinjuk seeds (gram amino acid/100 g sample) is given in *tables 4 and 5*. Due to the very low crude protein content of acorns, the total quantity of amino acids is very low, approximately half that of corn. The amino acid content of the acorns from different climates was almost the same, with only very slight standard deviation.

Table 2

Macroelements content of acorns, Pistacia atlantica and Pistacia khinjuk seeds

Sample name (1)	*Macroelements (g/kg)(2)*				
	Ca	*P*	*Mg*	*K*	*Na*
					(mg/kg)
Acorn-C1(3)	0.90	0.65	0.30	6.00	50.00
Acorn-C2	0.65	0.66	0.31	6.30	40.00
Acorn-C3	0.65	0.81	0.45	6.80	380.00
Mean	0.73	0.71	0.35	6.37	156.67
±SD	0.14	0.09	0.08	0.40	193.48
Pistacia atlantica-C1	1.60	1.92	0.50	8.00	76.00
Pistacia atlantica-C2	1.00	1.67	0.49	6.70	980.00
Pistacia atlantica-C3	0.80	1.40	0.45	7.30	500.00
Mean	1.13	1.56	0.48	7.33	518.67
±SD	0.42	0.14	0.03	0.65	452.29
Pistacia khinjuk-C1	1.45	1.90	0.65	9.30	42.00
Pistacia khinjuk-C2	1.40	1.90	0.63	8.40	280.00
Mean	1.43	1.90	0.64	8.85	161.00
±SD	0.04	0.00	0.01	0.64	168.29

C1: tropical climate, C2: Mediterranean climate, C3: cold climate (*ld. 1. táblázat*)

2. táblázat: A makk, a Pistacia atlantica és a Pistacia khinjuk makroelem tartalma

A minta neve(1), Makroelemek(2), Makk(3)

Table 3

Microelement content of acorns, Pistacia atlantica and Pistacia khinjuk seeds

Sample name	*Microelements (mg/kg)*				
	Mn	*Cu*	*Zn*	*Fe*	*Se*
Acorn - C1	3.00	5	9.7	26	0.05
Acorn - C2	3.40	4.4	8.6	20	0.04
Acorn - C3	3.20	4.5	9.2	25	0.05
Mean	3.20	4.63	9.2	23.7	0.05
±SD	0.20	0.32	0.55	3.21	0.01
Pistacia atlantica -C1	9.20	14.80	19.60	72	0.06
Pistacia atlantica -C2	3.10	4.20	9.00	48	0.06
Pistacia atlantica -C3	2.70	6.00	9.60	35	0.06
Mean	5.00	8.33	12.73	51.67	0.06
±SD	3.64	5.67	5.67	18.77	0.01
Pistacia khinjuk-C1	4.90	8.70	12.80	50	0.06
Pistacia khinjuk-C2	7.40	7.00	11.00	22	0.05
Mean	6.15	7.85	11.90	36	0.05
±SD	1.77	7,00	1.27	19.80	0.01

C1: tropical climate, C2: Mediterranean climate, C3: cold climate (*ld. 1. táblázat*)

3. táblázat: A makk, a Pistacia atlantica és a Pistacia khinjuk mikroelem tartalma

Table 4

Essential amino acid content of acorns, Pistacia atlantica and Pistacia khinjuk seeds

Feedstuff	*Threo-nine*	*Cystine*	*Valine*	*Methio-nine*	*Isoleu-cine*	*Leucine*	*Tyro-sine*	*Phenyl-alanine*	*Lysine*
Component(1)									
Acorn-C1	0.15	0.03	0.19	0.03	0.16	0.32	0.15	0.20	0.17
Acorn-C2	0.15	0.04	0.22	0.02	0.16	0.32	0.13	0.21	0.18
Acorn-C3	0.19	0.04	0.24	0.04	0.23	0.42	0.21	0.27	0.22
Mean	0.16	0.04	0.22	0.03	0.18	0.35	0.16	0.23	0.19
±SD	0.02	0.01	0.03	0.01	0.04	0.06	0.04	0.04	0.03
Pistacia atlantica C1	0.24	0.08	0.35	0.07	0.28	0.04	0.24	0.43	0.47
Pistacia atlantica C2	0.28	0.10	0.46	0.04	0.32	0.69	0.27	0.44	0.55
Pistacia atlantica C3	0.29	0.11	0.41	0.03	0.37	0.67	0.27	0.47	0.53
Mean	*0.27*	*0.10*	*0.41*	*0.05*	*0.32*	*0.67*	*0.26*	*0.45*	*0.52*
±SD	0.03	0.02	0.06	0.02	0.05	0.03	0.02	0.02	0.04
Pistacia khinjuk-C1	0.36	0.14	0.53	0.09	0.38	0.76	0.30	0.55	0.52
Pistacia khinjuk-C2	0.35	0.11	0.47	0.07	0.35	0.70	0.32	0.43	0.52
Mean	0.36	0.13	0.50	0.08	0.37	0.73	0.31	0.49	0.52
±SD	0.01	0.02	0.04	0.01	0.02	0.04	0.01	0.08	0.00

C1: tropical climate, C2: Mediterranean climate, C3: cold climate (*ld. 1. táblázat*)

4. táblázat: A makk, a Pistacia atlantica és a Pistacia khinjuk esszenciális aminosav tartalma (g/100g)

A minta neve(1)

Table 5

Non-essential amino acid content of acorns, Pistacia atlantica and Pistacia khinjuk seeds

Feedstuff	*Aspartic*	*Serine*	*Glutamic*	*Proline*	*Glycine*	*Alanine*	*Histidine*	*Arginine*	*Ammonia*
Component	*-acid*		*-acid*						
Acorn-C1	0.57	0.16	0.56	0.19	0.17	0.21	0.09	0.23	0.06
Acorn-C2	0.66	0.17	0.51	0.20	0.16	0.21	0.09	0.23	0.08
Acorn-C3	0.45	0.21	0.53	0.22	0.23	0.24	0.11	0.30	0.08
Mean	0.56	0.18	0.53	0.20	0.19	0.22	0.10	0.25	0.07
±SD	0.11	0.03	0.03	0.02	0.04	0.02	0.01	0.04	0.01
Pistacia atlantica-C1	0.61	0.40	1.45	0.53	0.37	0.35	0.23	0.51	0.08
Pistacia atlantica-C2	0.81	0.48	1.72	0.62	0.39	0.41	0.26	0.73	0.07
Pistacia atlantica-C3	0.78	0.44	1.54	0.50	0.34	0.42	0.21	0.64	0.10
Mean	0.73	0.44	1.57	0.55	0.37	0.39	0.23	0.63	0.08
±SD	0.11	0.04	0.14	0.06	0.03	0.04	0.03	0.11	0.02
Pistacia khinjuk-C1	0.88	0.55	1.80	0.53	0.46	0.48	0.26	0.76	0.16
Pistacia khinjuk-C2	0.22	0.50	1.42	0.50	0.40	0.47	0.21	0.80	0.10
Mean	0.90	0.53	1.61	0.52	0.43	0.48	0.24	0.78	0.13
±SD	0.03	0.04	0.27	0.02	0.04	0.01	0.04	0.03	0.04

C1: tropical climate, C2: Mediterranean climate, C3: cold climate (*ld. 1. táblázat*)

5. táblázat: A makk, a Pistacia atlantica és a Pistacia khinjuk nem esszenciális aminosav tartalma (g/100g)

The amino acid content values for Pistacia atlantica and Pistacia khinjuk from different climates were very close to each other, and the standard deviation was very small. Since the crude protein content of pistachios is very similar to that of corn, the total quantity of amino acids is also very similar to that of corn. The threonine, serine, valine and particularly lysine content of pistachio protein is relatively high, while the sulphur-containing amino acid content of the protein is relatively low. Leucine content is also relatively low.

Table 6

Fatty acid composition of acorns, Pistacia atlantica and Pistacia khinjuk seeds

Sample name	*Fatty acids (relative percentage of the fatty acid methyl esters) (carbon number and unsaturated bonds)*									
	14:0	*16:0*	*16:1*	*18:0*	*18:1*	*18:2*	*20:0*	*20:1*	*18:3*	*20:0*
Acorn-C1	*0.15*	*16.05*	*0.13*	*2.00*	*60.09*	*19.65*	*0.31*	*0.45*	*0.94*	*0.23*
Acorn-C2	0.16	15.90	0.13	2.12	60.47	19.52	0.31	0.42	0.76	0.21
Acorn-C3	0.17	17.29	0.13	1.99	58,00	20.51	0.29	0.38	1.04	0.2
Mean	0.16	16.41	0.13	2.04	59.52	19.89	0.30	0.42	0.91	0.21
±SD	0.01	0.76	0.00	0.07	1.33	0.54	0.01	0.00	0.14	0.02
Pistacia atlantica-C1	0.07	17.76	5.40	2.56	54.41	18.76	0.17	0.26	0.61	-
Pistacia atlantica-C2	0.07	15.71	6.29	2.22	53.93	20.64	0.15	0.39	0.60	-
Pistacia atlantica-C3	0.07	18.40	6.59	2.27	55.65	16.13	0.13	0.19	0.57	-
Mean	0.07	17.29	6.09	2.35	54.66	18.51	0.15	0.28	0.59	-
±SD	0.00	1.41	0.60	0.18	0.89	2.27	0.02	0.10	0.02	-
Pistacia khinjuk-C1	0.10	21.83	4.42	2.08	57.34	13.19	0.11	0.21	0.72	-
Pistacia khinjuk-C2	0.07	20.80	4.06	2.27	57.47	14.29	0.15	0.20	0.69	-
Mean	0.09	21.32	0.24	2.18	57.41	13.74	0.13	0.21	0.71	-
±SD	0.02	0.73	0.25	0.13	0.09	0.78	0.03	0.01	0.02	-

myristic acid (*mirisztinsav*): 14:0; palmitic acid (*palmitinsav*): 16:0; palmitoleic acid (*palmitolajsav*): 16:1; stearic acid (*sztearinsav*): 18:0; oleic acid (*olajsav*): 18:1; linoleic acid (*linolsav)*: 18:2; eicosanoic acid (*eikozasav*): 20:1; linolenic acid (*linolénsav*): 18:3; behenic acid (*bekénsav*): 20:0.

6. táblázat: A makk, a Pistacia atlantica és a Pistacia khinjuk zsírsavösszetétele

The fatty acid composition of dehulled acorns, Pistacia atlantica and Pistachia khinjuk seeds is given in *table 6*. The fatty acid content values for these feedstuffs from different climates proved very close to each other, with only low standard deviation. The ratio of unsaturated fatty acids in these feeds proved very high: the ratio of unsaturated fatty acid in acorns was 80.86%, in Pistacia atlantica 80.13% and in Pistacia khinjuk 76.31%. The percentage ratio of the essential fatty acid linoleic acid was 19.89±0.54 in acorns, 18.51±2.24 in Pistacia atlantica and 13.74±0.78 in Pistica khinjuk. No significant difference was observed between the different samples originating from different environments.

The mean values for the chemical composition of dehulled acorn, Pistacia atlantica and Pistacia khinjuk and other cereal grains (corn, sorghum, barley, wheat, triticale, rye and oat) are shown in *table 7*. (The analysis results are taken from NRC 1994). The

crude protein content of acorns (3.93%) proved very low, the lowest of all the grains in the table.

Table 7

Comparison of the chemical composition of acorns, Pistacia atlantica and Pistacia khinjuk with some cereal grains

Components(1)	*Feedstuffs(2)*									
	Acorn (3)	*P.at.*	*P.kh.*	*Corn (4)*	*Sor-ghum (5)*	*Barley (6)*	*Wheat (7)*	*Triti-cale (8)*	*Rye (9)*	*Oat (10)*
Dry matter%(11)	91.67	95.13	95.90	89.00	87.00	89.00	89.00	90.00	88.00	89.00
Crude prot.%(12)	3.93	8.10	9.15	8.50	8.80	11.00	11.50	14.00	12.10	11.40
Crude fat%(13)	7.7	26.80	39.10	3.80	2.90	1.80	2.50	1.50	1.50	4.20
Crude fibre%(14)	0.37	32.43	22.85	2.20	2.30	5.5	3.00	4.00	2.20	10.80
Ca,%	0.07	0.11	0.14	0.02	0.04	0.03	0.05	0.05	0.06	0.06
P,%	0.07	0.16	0.19	0.28	0.30	0.36	0.31	0.30	0.32	0.27
Mg,%	0.04	0.05	0.06	0.12	0.15	0.14	0.10	-	0.12	0.16
K,%	0.64	0.73	0.89	0.30	0.35	0.48	0.42	0.36	0.46	0.45
Na,%	0.02	0.05	0.02	0.02	0.01	0.04	0.06	-	0.02	0.08
Mn, mg/kg	3.20	5	6.15	7.00	15.00	18.00	24.00	43.00	58.00	43.00
Cu, mg/kg	4.63	8.33	7.85	3.00	10.00	10.00	7.00	8.00	7.00	8.00
Zn, mg/kg	9.17	12.73	11.90	18.00	15.00	30.00	28.00	32.00	31.00	38.00
Fe, mg/kg	23.67	51.67	36.00	45.00	45.00	78.00	40.00	44.00	60.00	85.00
Se, mg/kg	0.05	0.06	0.05	0.03	0.20	0.10	0.06	-	0.38	0.30
Threonine,%	0.16	0.27	0.36	0.29	0.29	0.37	0.32	0.36	0.36	0.43
Serine,%	0.18	0.44	0.53	0.37	0.40	0.46	0.55	0.52	0.52	0.40
Glycine,%	0.19	0.37	0.43	0.33	0.31	0.44	0.49	0.48	0.49	0.50
Cystine,%	0.04	0.10	0.13	0.18	0.17	0.24	0.22	0.26	0.19	0.22
Valine,%	0.22	0.41	0.50	0.40	0.44	0.52	0.44	0.51	0.56	0.68
Methionine,%	0.03	0.05	0.08	0.18	0.16	0.18	0.15	0.26	0.17	0.18
Isoleucine,%	0.18	0.32	0.37	0.29	0.35	0.37	0.42	0.39	0.47	0.52
Leucine,%	0.35	0.67	0.73	1.00	1.14	0.76	0.59	0.76	0.70	0.89
Tyrosine,%	*0.16*	*0.26*	*0.31*	*0.30*	*0.34*	*0.35*	*0.39*	*0.32*	*0.26*	*0.53*
Phenylalanine,%	0.23	0.45	0.49	0.38	0.47	0.56	0.45	0.49	0.56	0.59
Lysine,%	0.19	0.52	0.52	0.26	0.21	0.40	0.31	0.39	0.42	0.50
Histidine,%	0.10	0.23	0.24	0.23	0.22	0.27	0.20	0.26	0.26	0.24
Arginine,%	0.25	0.63	0.78	0.38	0.35	0.52	0.40	0.57	0.53	0.79
Linoleic acid,%	1.53	4.96	5.37	2.2	1.13	0.83	0.59	-	-	1.47

7. táblázat: A makk, a Pistacia atlantica és a Pistacia khinjuk kémiai összetételének hasonlítása néhány gabonamaghoz

Komponens(1), Takarmány(2), Makk(3), Kukorica(4), Cirok(5), Árpa(6), Búza(7), Tritikálé(8), Rizs(9,) Zab(10,) Szárazanyag(11), Nyersfehérje(12), Nyers zsír(13), Nyers rost(14)

The crude protein content of Pistacia atlantica (8.10%) and Pistacia khinjuk (9.15%) was more than twice as high as that of the acorns, and was very similar to that of corn and sorghum. The crude fat content of the acorns was two or three times as high as that of the other grains in the table, and the crude fat content of Pistacia khinjuk (39.10%) was very high. The crude fibre content of dehulled acorns, 0.37%, was the lowest and that of Pistacia atlantica (32.43%) the highest of all the crude fibre values. It can be seen from the data that the crude fibre content of Pistacia atlantica and Pistacia khinjuk, in comparison cereal grain, is very high, and this may constitute a limiting factor in poultry nutrition.

The calcium and potassium content of acorns, Pistacia atlantica and Pistacia khinjuk seeds proved higher than that of the cereal grains, while phosphorus and magnesium content was much lower. There was no essential difference between the cereal grains, acorns and pistachios with respect to the other macro- and microelements. The iron content of the acorns was 23.67 mg/kg (the lowest), but Pistacia atlantica, with 51.67 mg/kg, was found to contain more than corn, sorghum, wheat and triticale. Pistacia khinjuk, with 36 mg/kg, proved to contain less iron than all of the cereal grains, but this value was very close to those characteristic of wheat, corn, sorghum and triticale. The selenium content of the material investigated was very low, but higher than that of corn (0.03 mg/kg).

The threonine, serine, valine and particularly lysine content of pistachios proved very high, while that of cystine, methionine and leucine was very high compared to the other cereal grains. It should be emphasised that the lysine content of the pistachios was very high, approximately twice that of corn; however, crude protein content proved almost the same. With the exception of the above amino acids no essential difference between the cereal grains listed in *table 7* was observed with respect to amino acid composition. Due to their very low protein content the amino acid content of acorns proved the lowest of all.

The fatty acid content of acorns, and particularly that of pistachios, proved several times higher than that of the cereals grains, due to very high crude fat content. Linoleic acid content (this being a very important essential fatty acid) of barley, for example, is only 0.83%, while that determined for acorns proved to be 1.53% and for Pistacia khinjuk 5.37%. The other fatty acids were also found to be present in the highest concentrations in these.

To summarise, it can be stated that acorns have a very low crude protein content and a relatively high crude fat and starch content. Their amino acid composition is very poor; their protein contains, in particular, very few sulphur-containing amino acids (cystine and methionine). Their fat contains considerable quantities of essential linoleic acid. The crude protein content of pistachios is very similar to that of corn, and slightly lower than that of the other grains. Their protein contains relatively high quantities of threonine, serine, valine and lysine, which is very important if they are to be used as poultry feed. The crude fat content of Pistacia khinjuk was determined at 39.10% and that of Pistacia atlantica at 26.80%, with a very high content of essential linoleic acid, which is very useful in poultry nutrition.

CONCLUSIONS

According to the results obtained in this study it can be seen that all these new feedstuffs from different climates had individual characteristics crude protein, crude fat, nitrogen free extract, starch, minerals, amino acids and fatty acids values, which are compatible

with those of cereal grains in poultry diets. It was established that acorn have a very low crude protein content and a relatively high starch and crude fat content. Their amino acid composition is very poor; their protein contains, in particular, very few sulphur-containing amino acids (cystine and methionine). Their fat contains considerable quantities of essential linoleic acid. The crude protein content of wild pistachios seeds is very similar to that of corn, and a little lower than that of the other grains. Pistachio protein has a relatively high amount of threonine, serine, valine and lysine, which is very important if it is to be used as poultry feed. The crude fat content of Pistacia khinjuk is 39.10%, that of Pistacia atlantica 26.80%, with a very high content of essential linoleic acid, which is very useful in poultry nutrition.

The mean value of AMEn for acorn was 14.08, Pistacia atlantica 13.51 and Pistacia khinjuk 17.33 MJ/kg. The tannin content of acorn was 4.7%, Pistacia atlantica 1.43% and Pistacia khinjuk 1.93%, which are considerable for poultry diets. The rate of urease activity in these seeds was very low.

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