NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro

ROMANIAN AGRICULTURAL RESEARCH, NO. 35, 2018
Print ISSN 1222–4227; Online ISSN 2067–5720

SEEDS COMPOSITION AND THEIR NUTRIENTS QUALITY OF SOME PEA (*PISUM SATIVUM* L.) AND LENTIL (*LENS CULINARIS* MEDIK.) CULTIVARS

Georgeta Ciurescu[1*], Ion Toncea[2], Mariana Ropotă[1] and Mihaela Hăbeanu[1]

[1]National Research & Development Institute for Animal Biology and Nutrition (IBNA),
077015 Baloteşti, Ilfov County, Romania

[2]Research, Innovation and Technical Assistance Centre for Organic Agriculture, National Agricultural Research and Development Institute, 915200 Fundulea, Călăraşi County, Romania.

*Corresponding author. E-mail: ciurescu@ibna.ro

ABSTRACT

A comparative study was carried out on the proximate composition, mineral, amino acid and fatty acid contents of two legume [five cultivars of peas [(*Pisum sativum* L. cv. Nicoleta, cv. Vedea, cv. Specter, cv. Windham and cv. Biathlon)] and four cultivars of lentils (*Lens culinaris* Medik. cv. Eston, cv. Georgÿ, cv. Berglinse, and cv. Black] grown in Romania. The protein values of the legumes ranged from 233 and 260 g kg DM^{-1} for the raw pea and from 256 and 289 g kg DM^{-1} for the raw lentils. The fat, fibre and carbohydrates (NFE) contents were low and the average values were different depending on cultivars in both legumes. The seeds of studied lentils cultivars were found to be good sources of essential minerals such as copper, iron and manganese, but total phosphorous, calcium and zinc were comparable with peas. The amino acid profile in pea and lentil seeds was also typical of legumes, with a high level in lysine (6.2% of the protein) and a low level in sulphur-containing amino acids (methionine and cysteine: 2%). Lentils' lipids were rich in alpha-linolenic acid, which comprised 11.95-14.62% of total fatty acids methyl esters. The alpha-linolenic acid was also higher in the pea cv. Vedea. It is deduced that pea and lentil seeds have better potential to be used in protein enriched poultry feed formulations.

Key words: pea, lentil, cultivars, chemical composition.

INTRODUCTION

In the temperate areas, such as in many European countries, Romania among them, it is possible to grow peas (*Pisum sativum* L.), lentil (*Lens culinaris* Medik.), beans (*Phaseolus vulgaris* L.), as well as other leguminous crops. There are some leguminous cultivars with distinct nutrient content.

In Romania, the cultivation and use of leguminous grains in poultry feeding has not been and is still not promoted like in other countries, although it is a viable alternative to the imported soybean meals, both in terms of bioproductive performance, and in terms of economic and ecosanogenous aspects (they are not genetically modified). This would reduce the dependence on the massive imports of soybean meal, which required an impressive annual hard currency effort, while creating an addiction of the poultry production on these imports.

Nutritionists and feed manufacturers require accurate nutrient information of specific raw pea and lentil cultivars to formulate the balanced diets containing these legume seeds. Plant breeders also need such information to enable them to develop better varieties to improve the nutritional value of the seeds.

The raw peas (*Pisum sativum* L.) and lentils (*Lens culinaris* Medik.), are relatively low in anti-nutritional factors compared to dry edible beans (*Phaseolus vulgaris*) or soybeans and are easily manageable; it is not considered necessary to use heat treatment prior to inclusion in formulated feeds. Anti-tryptic factors are of no practical significance.

The use of legume seeds as protein sources in animal production is at present limited because of the lower quality (imbalanced amino acid composition) of their protein compared with animal proteins, and the presence of so-called anti-nutritional

Received 24 October 2016; accepted 15 January 2018. First Online: February, 2018. DII 2067-5720 RAR 2018-122

factors that interfere with the nutritional utilization of diets based on these seeds as the main source of protein (Wiseman and Cole, 1988).

Lentils (*Lens culinaris* Medik.) become occasionally available to the animal feed industry, especially when they suffer from quality problems (such as frost damage, discoloration, or seed damage) low for human consumption. Nevertheless, these issues do not pose any problems when such lentils are fed to pigs and poultry of all ages (Bell and Keith, 1986). Among the few researchers who have studied the nutritive value of Mediterranean legume seeds, special reference must be made to the work of Wiseman and Cole (1988) with pigs and Castanon and Perez-Lanzac (1990) with layer hens.

The objective of this study was to draw attention to the nutritive value of some varieties of Romanian common pea (*Pisum sativum* L.) and lentil (*Lens culinaris* Medik.) seeds, and to study them comparatively, with a view to providing useful information towards effective utilization in poultry nutrition and feeding.

MATERIAL AND METHODS

Collection and preparation of samples

Five different cultivars of pea [(*Pisum sativum* L., cv. Nicoleta and cv. Vedea (Romanian), cv. Specter and cv. Windham (USA) and cv. Biathlon (France)] and four different colour cultivars of lentils (*Lens culinaris* Medik., cv. Eston (green), cv. Georgÿ (brown), cv. Berglinse (brown coat with red inside), and cv. Black or Beluga (got their name for small grains, which are similar to beluga caviar)], seeds grown in Romania were investigated for their proximate composition, minerals, amino acid and fatty acid contents.

The pea and lentil were collected from the seeds collection of the National Agricultural Research & Development Institute, Fundulea, Călăraşi, Romania.

All beans were sorted in order to remove the immature and damaged grains, after which they were ground to pass through a 1 mm sieve for chemical analysis.

Proximate analysis

The proximate analyses of the samples for moisture, total ash, crude protein, crude fat, and crude fibre were carried out in duplicate. Samples were analysed for moisture from which dry matter (DM) content was calculated. Crude protein ($N \times 6.25$) and crude fat were analysed according to Commission Regulation (EC) no. 152/2009 (Official Journal of the European Union, 2009) procedures, using an automatic system Foss Tecator AB, Höganäs, Sweden (Kjeltec 2300 and Soxtec 2055 apparatus). Acid detergent fibre (ADF), neutral detergent fibre (NDF) and crude fibre were analysed with an automatic Fibertec 2010 apparatus (Foss Tecator AB, Höganäs, Sweden) by the method of Van Soest (1976). Ash content was calculated from the weight of the sample after burning at 550°C for 2 h. Carbohydrate content was estimated as nitrogen-free extract (NFE).

Apparent metabolisable energy values corrected to zero nitrogen retention (AMEn) of the legume beans were calculated based on the proximate analysis used regression lines method as accepted by the European Table of Energy Values for Poultry Feedstuffs (1989). All composition data and AMEn values are on a dry-matter basis (MJ kg DM^{-1}).

Mineral analysis

Macro and micro-minerals were determined after microwave mineralization by hydrochloric acid and hydrogen peroxide, calcium (Ca), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) by flame atomic absorption spectrometry using Solaar M6 Dual Zeeman Atomic Absorption Spectrometer (Thermo Electron Ltd., Cambridge, UK) at wavelengths of 422.7 nm (Ca), 324.7 nm (Cu), 248,3 nm (Fe), 279.5 nm (Mn) and 213.8 nm (Zn). Total phosphorous (P) was determined spectrophotometrically as vanadate yellow using an UV/VIS Spectrophotometer (Jasco V-530, Tokyo, Japan) at wavelengths of 422 nm.

Amino acid analysis

Total amino acid (excluding tryptophan, which not determined) were analysed following Commission Regulation (EC) no. 152/2009 (Official Journal of the European Union, 2009) procedures. Amino acids content were separated using a high performance liquid chromatography HPLC Thermo Scientific Surveyor Plus System (Thermo Fisher Scientific Inc., San Jose, CA USA), fitted with a quaternary system for solvent pumping, and with photodiode array detectors (Surveyor PDA Plus Detector). We used a highly pure Hypersil GOLD silica chromatographic column, particle sizes 1.9 µm to 12 µm designs to optimise separations and maximize productivity. Specialized hardware includes KAPPA, capillary columns, PicoFrit^{TM}, nanobore columns, Javelin, HTS direct-connection columns and DASH, HTS columns, designed for high throughput screening.

Fatty acid analysis

The fatty acid compositions of legume beans were analysed using a gas chromatography system, according to Commission Regulation (EC) no. 152/2009 (Official Journal of the European Union, 2009) procedures. Fatty acid methyl esters (FAME) were prepared from total lipid extract using methanolic HCl as the derivatizing agent. Analyses of FAME were performed with a Clarus 500 gas chromatograph (PerkinElmer, Inc., SUA) equipped with an autosampler, flame ionization detector (FID), and fused silica capillary column (cis/trans FAME), 60 m x 0.25 mm x 0.2 µm film thickness (PerkinElmer, Inc., SUA). The calibration and the peak determinations were based on authentic standards fatty acids from Sigma-Aldrich (St. Louis USA). The results were expressed for each fatty acid (as % of total FAME).

Statistical analysis

The data were subjected to ANOVA statistical analysis using the General Linear Models (GLM) procedure of SPSS 17.0 (SPSS, 2008). Significant differences among means were determined at $p<0.05$ by post hoc Tukey's multiple range test.

RESULTS AND DISCUSSION

Table 1 presents the composition of some varieties of raw pea and lentil seeds grown in Romania. Data are from analysis carried out by a National Research Development Institute for Animal Biology and Nutrition (INCDBNA-IBNA) in Balotești, Chemistry Laboratory.

Proximate composition on dry weight bases (Table 1) showed significant ($p<0.05$) variations among legume samples for crude protein, crude fat, crude fibre, NDF and ADF content whereas, DM, ash and NFE exhibited non-significant ($p>0.05$) differences in the evaluated legumes. The DM content ranged between 890 and 906 g/kg. The protein concentration was higher in raw lentil seeds, ranged between 256 and 289 g kg DM^{-1}, depending of cultivar, and compared with peas (ranged between 233 and 260 g kg DM^{-1}). Among the cultivars of pea analysed, Romanian variety Vedea, created at Agricultural Research & Development Station (SCDA), Teleorman had the highest crude protein (260 g kg DM^{-1}). All these protein contents are lower than in un-extracted soybeans (370 g kg DM^{-1}), value recorded by NRC (1994). The fat content of lentils is low, as are the levels of fibre and ADF, whilst the content of carbohydrates (NFE) is similar with raw peas regardless of the cultivar analysed. The crude fibre level was highest in pea cv. Specter and cv. Windham (81 g kg DM^{-1}) followed by cv. Biathlon (70 g kg DM^{-1}) and lowest in the Romanian cultivars (63 g kg DM^{-1} Vedea and 67 g kg DM^{-1} Nicoleta, respectively). NDF content was highest in pea cv. Windham, Specter and Biathlon (348 g kg DM^{-1}, 321 g kg DM^{-1} and 319 g kg DM^{-1} respectively) and slightly lower, but non-significantly ($p>$ 0.05) in the Romanian cultivars (304 g kg DM^{-1} Nicoleta and 299 g kg DM^{-1} Vedea, respectively). The content of NDF was lower ($p<0.05$) in lentils in comparison with peas (ranged between 244 and 283 g kg DM^{-1}, depending on cultivar).

The AMEn values, calculated for poultry ranged between 12.7 - 12.8 MJ kg DM^{-1} in raw lentils, and was similar to peas, which ranged from 12.5 to 12.7 MJ kg DM^{-1}, respectively. These values showed that the studied legumes have favourable energy concentrations, comparable to cereals.

The variation in chemical composition could be a reflection of the conditions under which they were grown, or could be due to inherent genetic differences. Part of the variation can be explained by the observed differences among cultivars and as an effect of drought during seed development on the quality and nutritive value of the legume species. Protein concentration is known to vary with soil type and nitrogen fertilizer application (Igbasan and Guenter, 1996), genotypes (Matthews and Arthur, 1985), location and year of harvest (Ali-khan and Youngs, 1973; Nell et al., 1992).

Table 1. Proximate composition of the raw pea (*Pisum sativum* L.) and lentils (*Lens culinaris* Medik.)

Raw legumes	Cultivars	Nutrients (g kg DM^{-1})								
		DM (g kg^{-1})	Crude protein	Crude fat	Crude fiber	NDF*	ADF**	Ash	NFE***	AMEn (MJ kg DM^{-1})
Pea	Vedea	896	260^{b}	7^{a}	63^{b}	299^{a}	64^{a}	38	634	12.7
	Nicoleta	902	233^{c}	9^{a}	67^{ab}	304^{a}	62^{b}	42	651	12.6
	Specter	903	251^{b}	9^{a}	81^{a}	321^{a}	74^{a}	34	624	12.5
	Windham	903	255^{b}	10^{a}	81^{a}	348^{a}	74^{a}	37	618	12.5
	Biathlon	897	236^{c}	8^{a}	70^{a}	319^{a}	63^{b}	28	658	12.7
Lentil	Eston	890	263^{ab}	5^{b}	60^{b}	283^{ab}	57b	33	639	12.8
	Georgÿ	905	256^{b}	4^{b}	59^{b}	244^{b}	53^{b}	39	642	12.7
	Berglinse	897	289^{a}	5^{b}	53^{b}	279^{ab}	58^{b}	39	614	12.8
	Black	906	279^{a}	5^{b}	60^{b}	245^{b}	59^{b}	36	621	12.8

*NDF = Neutral detergent fiber; **ADF = Acid detergent fiber; ***NFE = Nitrogen-free extract.
Means sharing the same letter in a column are not significantly different ($p>0.05$)

The mineral composition of the raw peas and lentils are presented in Table 2. Legumes supply adequate protein while being a good source of minerals. The data (Table 2) indicated that lentil seeds had a very high content of copper, iron, and manganese ($p<0.05$) and moderate content of calcium, phosphorous and zinc, compared with raw pea seeds, except in pea cv. Windham (detected 118.05 ppm iron). The values obtained in this study are fairly comparable to those reported by Campos-Vega et al., 2010. They reported that beans and lentils have the highest iron (110 and 122 µg g^{-1}, respectively), and zinc contents (44 and 48 µg g^{-1}, respectively).

*Table 2***.** Mineral element contents of the raw pea (*Pisum sativum* L.) and lentils (*Lens culinaris* Medik.)

Raw legumes	Cultivars	Ca (%)	P (%)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Pea	Vedea	0.10	0.41	1.50^{d}	81.48^{b}	9.16^{b}	42.97^{ab}
	Nicoleta	0.10	0.50	1.84^{d}	87.84^{b}	6.75^{b}	34.38^{b}
	Specter	0.10	0.52	3.51^{c}	97.85^{ab}	8.25^{b}	38.21^{b}
	Windham	0.11	0.50	4.39^{c}	118.05^{a}	8.54^{b}	40.34^{b}
	Biathlon	0.12	0.37	2.36^{d}	83.65^{b}	6.37^{b}	28.45^{c}
Lentil	Black	0.12	0.60	7.00^{a}	103.46^{a}	14.25^{a}	44.24^{a}
	Berglinse	0.14	0.58	5.09^{b}	115.75^{a}	14.17^{a}	52.33^{a}
	Georgÿ	0.14	0.63	6.36^{a}	100.62^{a}	13.34^{a}	51.88^{a}
	Eston	0.12	0.43	5.00^{b}	117.32^{a}	10.28^{a}	34.77^{b}

Means sharing the same letter in a column are not significantly different ($p>0.05$).

However, the content of these essential elements as Cu, Cr, Fe and Zn in legumes varies considerably with the species, cultivars and the soil pH. Cabrera et al. (2003) investigated the mineral content of different legumes widely consumed in Spain and detected in lentil seeds (*Lens esculenta* Moench.) a mean content of 2.5 μg Cu, 71.0 μg Fe and 56.5 μg Zn and levels of 1.7 μg Cu, 20.2 μg Fe and 38.9 μg Zn in fresh green peas (*Pisum sativum* L.), respectively.

The amino acid (AA) composition of the raw peas and lentils analysed, are shown in Table 3 and 4. Similarly to the trend of protein concentrations, there were also variations between the cultivars in AA concentrations. Protein quality of a feed is usually based on the content of essential amino acids and their availabilities for the specific non-ruminant. The data (Tables 3 and 4) indicated that all essential amino acids, except the sulphur amino acid (methionine and cysteine) were present in excessive amounts in all the cultivars tested. As characteristic of legumes, the pea and lentil seeds were high in lysine (6.2% of the protein) but low in the sulphur-containing amino acids (methionine and cysteine: 2%), compared to the requirements of broilers in the starter phase.

Table 3. Amino acid composition (g/100 g) of the raw pea (*Pisum sativum* L.)

Amino acid	Pea				
	Vedea	Nicoleta	Windham	Specter	Biathlon
Lysine	1.776	1.698	1.731	1.832	1.730
Methionine + cystine	0.692	0.585	0.625	0.598	0.559
Threonine	1.044	1.092	1.032	0.996	1.037
Leucine	1.860	1.661	1.796	1.773	1.818
Arginine	2.097	1.980	2.179	2.145	2.160
Isoleucine	1.087	1.077	1.012	1.062	1.124
Valine	1.212	1.030	1.183	1.146	1.039
Phenylalanine	1.260	1.156	1.128	1.239	1.058
Tyrosine	0.617	0.631	0.749	0.735	0.719
Aspartic acid	3.198	2.768	3.276	2.783	2.775
Glutamic acid	4.660	3.839	4.542	4.512	3.581
Serine	1.418	1.114	1.258	1.445	1.130
Glycine	1.142	0.868	1.090	0.972	0.921
Alanine	0.990	1.083	1.085	1.169	1.069

Table 4. Amino acid composition (g/100 g) of the raw lentils (*Lens culinaris* Medik.)

Amino acid	Eston	Black	Georgÿ	Berglinse
Lysine	1.816	2.026	2.032	1.928
Methionine + cystine	0.792	0.786	0.673	0.778
Threonine	1.016	1.178	1.148	1.124
Leucine	1.926	2.144	1.593	2.078
Arginine	2.012	2.555	1.976	2.557
Isoleucine	0.913	1.029	0.991	1.051
Valine	1.056	1.274	1.311	1.292
Phenylalanine	1.247	1.523	1.065	1.451
Tyrosine	0.634	0.719	0.624	0.692
Aspartic acid	2.900	3.045	2.946	3.154
Glutamic acid	4.967	4.597	4.876	5.007
Serine	1.252	1.474	1.056	1.492
Glycine	0.922	1.042	0.861	1.072
Alanine	1.408	1.345	1.397	1.443

The lysine content of the lentils used in this study (16.79 to 20.93 g kg^{-1}) was in the same range as that found in peas (16.98 to 18.32g kg^{-1}), although lower than in un-extracted soybeans (24g kg^{-1}), value recorded by NRC (1994). Glutamic acid and aspartic acid were found to be major non-essential amino acids in the sample tested. The results are in fair agreement with those reported by Gatel (1994) and Perez-Maldonado et al. (1999) who stated that pea protein contains a similar proportion of threonine, but less sulphur containing amino acids than soybean protein.

The fatty acid content of raw legume samples is presented in Tables 5 and 6.

Lentils lipids were predominantly polyunsaturated fatty acid (PUFA) (55.45 to 62.16% of total FAME, depending of cultivar) with low content of unsaturated fatty acids (16.51 to 21.47%). Also, content of linoleic (18:2, n-6) and alfa-linolenic (18:3, n-3) acids were higher in lentil, than in pea seeds, except cv. Vedea, whose levels are close to that of lentils. For this reason the proportion of n-6 to n-3 fatty acids was the opposite in lentil; more n-3, as compared to pea.

In terms of specific fatty acids, we were most interested in the linoleic acid and α-linolenic acid contents, because both are essential for humans and animals. The proportions of total n-6 PUFA to total n-6 PUFA ranged between 1:3.83 and 1:4.96 in raw peas and between 1:3.03 and 1:3.48 in raw lentils, respectively.

Table 5. Fatty acids profile (% of total FAME - fatty acids methyl esters) of the raw pea (*Pisum sativum* L.)

Fatty acids profile		Pea				
		Nicoleta	Vedea	Windham	Specter	Biathlon
Lauric	C12:0	0.25	0.23	0.20	0.22	-
Myristic	C14:0	0.70	0.69	0.78	0.78	0.59
Pentadecanoic	C15:0	0.27	0.27	0.25	0.28	0.27
Palmitic	C16:0	15.76	12.39	17.57	19.24	15.10
Stearic	C18:0	3.97	3.39	3.84	4.06	3.95
Heneicosenoic	C21:0	0.60	0.49	0.51	0.37	0.28
TOTAL SAT		21.55	17.46	23.15	24.95	20.19
Pentadecenoic	C15:1	-	-	-	-	0.19
Palmitoleic	C16:1	0.33	0.40	0.41	0.60	0.51
Heptadecenoic	C17:1	-	-	-	-	-
Oleic	C18:1n-9	31.27	21.46	32.57	32.44	30.56
TOTAL MUFA		31.60	21.86	32.98	33.04	31.26
Linoleic	C18:2n-6	37.75	47.74	36.50	34.56	39.25
α-Linolenic	C18:3n-3	9.10	12.55	7.37	7.45	8.98
Octadecatetraenoic	C18:4n-3	-	-	-	-	0.31
Eicosadienoic	C20:2n-6	-	0.39	-	-	-
Eicosatrienoic	C20:3n-6	-	-	-	-	-
Docosatetraenoic	C22:4n-6	-	-	-	-	-
TOTAL PUFA		46.85	60.68	43.87	42.01	48.54
Total n-3 PUFA[1]		9.10	12.55	7.37	7.45	9.29
Total n-6 PUFA[2]		37.75	48.12	36.50	34.56	39.25
n-6/n-3		**4.15**	**3.83**	**4.96**	**4.64**	**4.22**

[1]Total n-3 PUFA = sum percentage of C18:3n-3, C18:4n-3.
[2]Total n-6 PUFA = sum percentage of C18:2n-6, C20:2n-6, C20:3n-6, C22:4n-6.

Table 6. Fatty acids profile (% of total FAME - fatty acids methyl esters) of the lentils (*Lens culinaris* Medik.)

Fatty acids profile		Lentil			
		Eston	Black	Berglinse	Georgÿ
Lauric	C12:0	-	0,26	0,61	0,35
Myristic	C14:0	0,93	0,83	1,09	1,02
Pentadecanoic	C15:0	0,38	0,35	0,40	0,57
Palmitic	C16:0	16,75	12,50	11,48	13,01
Heptadecaenoic	C17:0	-	-	-	-
Stearic	C18:0	2,60	1,81	2,14	2,15
Heneicosenoic	C21:0	0,81	0,82	0,78	0,25
TOTAL SAT		21,47	16,56	16,51	17,36
Pentadecenoic	C15:1	0,33	0,15	-	-
Palmitoleic	C16:1	0,56	0,38	0,39	0,45
Heptadecenoic	C17:1	-	-	-	1,91
Oleic	C18:1n9	22,19	20,74	26,23	19,90
TOTAL MUFA		23,08	21,27	26,62	22,26
Linoleic	C18:2n6	41,82	46,74	44,17	45,98
α-Linolenic	C18:3n3	13,09	14,62	11,95	13,54
Octadecatetraenoic	C18:4n3	0,54	0,80	0,76	-
Eicosadienoic	C20:2n6	-	-	-	-
Eicosatrienoic	C20:3n6	-	-	-	0,85
Arachidonic	C20:4n6		-	-	-
Docosatetraenoic	C22:4n6	-	-	-	-
TOTAL PUFA		55,45	62,16	56,88	60,37
Total n-3 PUFA		13,63	15.43	12,71	13,54
Total n-6 PUFA		41,82	46,74	44,17	46,83
n-6/ n-3		1:3,07	1:3,03	1:3,48	1:3,46

[1]Total n-3 PUFA = sum percentage of C18:3n-3, C18:4n-3.
[2]Total n-6 PUFA = sum percentage of C18:2n-6, C20:2n-6, C20:3n-6, C20:4n-6, C22:4n-6.

These results are in agreement with those reported in available literature. The major acid among the unsaturated FA is linolenic (18:3) acid, there is 43.1% in FA of the common bean (Grela & Gunter, 1995). Ponquett et al. (1992) found 45% of linoleic acid in lentil, the next being linolenic acid with 20%, oleic acid with 18% and palmitic acid with 13% of total fatty acids in fats. Also, Bhatty 1986) found that linoleic acid was the major fatty acid in lentil fat, which is in accordance with our results, when most lentil cultivars had higher values (41.82 to 46.74% of total FAME).

CONCLUSIONS

The data suggest that there is a variation among cultivars, both in pea and lentil seeds, with respect to the proximate composition, mineral, amino acid and fatty acid contents.

The growing popularity of these legumes in recent years on the basis of their nutritional properties requires additional data and a periodical control. Research is continuing to evaluate the nutritive values of several of these pea and lentil cultivars, and to find their optimal inclusion levels in poultry diets.

ACKNOWLEDGEMENTS

The authors are grateful to NASRI/ ANCSI (National Authority for Scientific Research and Innovation from Bucharest, Romania) for the financing of this research project (PN16-41.01.02 / 2016).

REFERENCES

Ali-khan, S.T., Youngs, C.G., 1973. *Variation in protein in field peas*. Can. Journal of Plant Sci., 53: 37-41.

AOAC, 2005. *Official Methods of Analysis of AOAC International*. Section 4.6.03 and 4.6.04. Methods 973.18.

Bell, J.M., Keith, M.O., 1986. *Nutritional and monetary evaluation of damaged lentils for growing pigs and effects of antibiotic supplements*. Can. Journal of Anim. Sci., 66: 529-539.

Bhatty, R.S., 1986. *Protein subunits and amino acid composition of wild lentil*. Phytochemistry, 25: 641-644.

Cabrera, C., Lloris, F., Gimenez, R., Olalla, M., Lopez, M.C., 2003. *Mineral content in legumes and nuts: contribution to the Spanish dietary intake*. The Sci. of the Total Environment, 308: 1-14.

Campos-Vega, R., Loarca-Piña, G., Oomah, D., 2010. *Minor components of pulses and their potential impact on human health*. Food Research International, 43(2): 461-482.

Castanon, J.I., Perez-Lanzac, J., 1990. *Substitution of fixed amounts of soyabean meal for field beans (Vicia faba), sweet lupin (Lupinus albus), cull peas (Pisum sativum) and vetchs (Vicia sativa in diets for high performance laying Leghorn hens*. Brit. Poultry Science, 31: 173-180.

Castell, A.G., Guenter, W., Igbasan, F.A., 1996. *Nutritive value of peas for nonruminant diets*. Animal Feed Science Technology, 60: 209-227.

Commission Regulation (EC) No. 152/2009. Official Journal of the European Union, L 54, 2009.

D'Mello, J.P.F., 1995. *Anti-nutritional substances in legume seeds*. In: Tropical legumes in animal nutrition. Eds. D'Mello, J.P.F. & Devendra, C., Cab International, Wallingford, UK, pp. 135-172.

European *Table of Energy Values for Poultry Feedstuffs,* 1989. 3rd Edition, Working Group No. 2 of the European Branch, World's Poultry Science Association, Beekbergen, Netherlands.

Gatel, F., 1994. *Protein quality of legume seeds for non-ruminant animals: a literature review*. Animal Feed Science and Technology, 45: 317-348.

Grela, E.R., Gunter, K.D., 1995. *Fatty acid composition and tocopherol content of some legume seeds*. Animal Feed Science and Technology, 52: 325-331.

Igbasan, F.A., Guenter, W., 1996. *The evaluation and enhancement of the nutritive value of yellow, green and brown-seeded pea cultivars for unpelleted diets given to broiler chickens.* Animal Feed Science and Technology, 63: 9-24.

Matthews, P., Arthur, E., 1985. *Genetic and environmental components of variation in protein content in peas*. In: The pea crop. A basis for improvement. Eds.: Hebblethwaite P.D., Health M.C. & Dawkins, T.C.K., Butterworths, London, UK: 369-381

Nell, F.J., Siebrits, F.K., Hayes, J.P., 1992. *Studies on the nutritive value of cowpeas (Vigna unguiculata)*. South African Journal of Animal Science, 22: 157-160.

NRC, 1994. *Nutrient Requirements of Poultry. 9th revised edition*. National Academy Press, Washington DC, USA.

Perez-Maldonado, R.A., Mannion, P.F., Farrell, D.J., 1999. *Optimum inclusion of field peas, faba beans, chick peas, sweet lupins in poultry diets. I. Chemical composition and layer experiments*. Br. Poultry Science, 40: 667-673.

Ponquett, R.T., Smith, M.T., Ross, G., 1992. *Lipid autoxidation and seed ageing: putative relationships between seed longevity and lipid stability*. Seed Science Research, 2(1): 51-54.

SPSS, 2008. *Statistical Package for the Social Sciences, version 17.0*. IBM SPSS Inc, Chicago IL, USA.

Van Soest, P.J., 1976. *Influence of environment on forage composition*. Proceedings of Workshop on Nutritional Evaluation of Forages (Ed.: V.D. Mugdal), pp. 80. Nail. Dairy Res. Inst, Karnal, India.

Wiseman, J., Cole, D.J.A., 1988. *European legumes in diets for non-ruminants*. In: Haresing, W. & Cole, D.J.A. (Eds.), Recent Advances in Animal Nutrition: 13-27.