Determination of the feeding value of forage crops for goats, aiming to improve their conversion into milk production

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SUMMARY

The efficient use of the feed resources from a particular geographic area by conversion into animal productions presumes running three essential actions: the exact evaluation, as much as possible, of the feeding value of the forage crops, accurate estimation of the feeding requirements and diet formulation optimization. These elements are mandatory for the development of a software which to formulate and optimise the diet formulations for milk goats. Because the cos of feeding accounts for some 60% of the production costs per unit of product (kg milk), the knowledge of the real bioproductive potential of the forage crops used in goat farming is the factor which determines its profitability.

The knowledge of the real feeding characteristics of the different categories of forages available, at a particular moment, in the farm, in terms of energy, protein, vitamins and mineral contents, is the key to the optimal and balanced feeding of the dairy goats.

Several samples of forage crops used by goat farmers from different areas of Romania have been analysed: pasture and meadow hays, silages and haylages, straws, cereal crops (corn, wheat, barley, oats and triticale) and several by-products (meals, bran, distiller's grains). The chemical analyses performed on samples of these forages have shown that the IDPN and IDPE values show significant differences compared to the table values for similar forages. Thus, the alfalfa hay had 73.8% - 1234% IDPN, compared to the reference value of 107%, while IDPE ranged between 79.41% - 107.4%, compared to the reference value of 68%; in the ear corn, IDPN was 53.1% - 77.1%, compared to 96%, the reference value, and IDPE was 95.7% - 107.8%, compared to 116%, the reference value. The variation was lower for the NEm (net energy for milk production): 84.2% - 100.0%, compared to 0.76, the

reference value, while in corn, the values were 93.0%-102.8%, compared to 1.43, the reference value.

Differences in these values were noticed both between the feeding categories and between the surveyed farms. The variations are most probably due to the different cultivars, moment of harvesting, storage conditions, soil and climate, and their origin (the imported feeds have different compositions). Under these circumstances, the formulation of a balanced diet which to meet the requirements of goats with different physiological and developmental states, using merely the table values (multiannual, average reference values), without using the actual values determined by current laboratory assays, leads mostly to underestimation, rarely to overestimation of the total feeding value of the diets, which has adverse effects on animal response.

Keywords: goats, alfalfa, corn, energy, protein

INTRODUCTION

The prevailing use of corn and alfalfa, in different forms of processing and preservation, in goats feeding, is a common practice not just in Romania, but also in Europe and worldwide, where the climate and soil allow growing these crops. A diet formulation for dairy goats, made of alfalfa hay and whole corn plant ensiled in the milk-dough stage, with slightly higher DM, 30%, both of very good quality, providing about 0.98 FUmilk (30% hay + 70% silage), with no concentrates, may ensure rather good milk yields, of about 1.5-2.5 l/goat/day, for specialised dairy goat breeds. On the other hand, the small farmers aim to provide a diet which to meet the feeding requirements of the goats by mixing alfalfa hay with ear corn, as sole concentrate feed, combination which sometimes provide a fair energy / protein balance. In Romania there is a low number of papers on goat feeding. Given the significant increase of the national stock of goats, mainly due to the price for goat milk and dairy products, and to consumer preferences, a significant number of small holders started to raise goats. The low volume of information and the tradition of associating sheep raising with goat raising, yielded a rather personal manner of feeding goats, be it local or imported breeds. This causes major nutritional imbalances and waste of feeds, while the expected productions fail to show. The deficit of goat milk production may close the market niche in favour of the imported products. This is why it is important to develop a software which to assist the farmers to formulate balanced diets, using the available forages, correlated with the structure and production potential of the goat breeds. The software is much more useful if the goat farmer evaluates the feeding value of each now forage produced in own farm, or purchased from the market.

MATERIAL AND METHODS

Considering the accomplishment of the main objective of NUTRICAP project, the development of efficient feeding strategies for the local and imported goat breeds, which to maximize feed conversion into milk, the investigations aimed to evaluate the feeding potential of the main forage crops available to the goat farmers from different areas of Romania.

We selected 10 representative goat farms. These units use the following types of feeds to feed the goats: pasture and meadow hays, silages and haylages, straw, cereal crops (corn, wheat, barley, oats and triticale) and several by-products (meals, bran, distiller's grains). Since most of the farmers provide feeds for their goats mostly as alfalfa hay and (ground) ear corn, we investigated the variability and feeding characteristics of these two feeds. Feed samples (500-1000 g) have been collected by the farmers from the crops harvested in 2014 and 2015, sealed in plastic bags and delivered to the Laboratory of chemical analyses from IBNA Balotesti. The samples were prepared and weighed and assayed for dry matter (DM), crude protein (CP), ether extractives (EE), crude fibre (CF) and ash (Ash), according to the methods presented in Criste et al., 2003.

To evaluate the energy value of the feeds we determined the *in* vitro organic matter digestibility according to the method of Tilley-Terry (1963), in two stages: sample incubation in rumen fluid collected from fistulated goats, and treatment with pepsin. The resulting digestibility was used to determine the coefficient of energy digestibility:

%DE = %DOM + h,

where 'h' for corn is - 2.2 (Sauvant et al. 1987).

The yield of protein utilization by the goats we run tests for total nitrogen degradability (TD) using the method of rumen bags; the values of the TRUE intestinal digestibility (td) have been taken from reference tables, Burlacu et al. (2002). We used the regression equations and the mathematical model for energy and protein metabolism simulation in ruminants, developed by IBNA Balotesti (Burlacu et al., 2002), to calculate the net energy (NE) of the feeds for milk production, expressed in milk feed units (oats) FU_{milk} (1 FU_{oats} = 6.07 MJ), as well as IDPN and IDPE.

Table 1 shows the gross chemical composition of the alfalfa hay harvested from different areas of Romania, determined in the Laboratory of Chemistry and Nutrition Physiology from IBNA Balotesti, as well as the gross chemical composition mentioned in the reference tables (Burlacu et al., 2002).

Table 1. Alfalfa hay from various sources – gross chemical composition

Unit	DM [g/kg]	OM [g]	CP [g]	EE [g]	CF [g]	NFE [g]	Ash [g]
Reference values	850	771	150	22	285	315	79
(Burlacu, 2002)	1000	907	176	26	335	370	93
Rm. Sarat	920	833	154	8	291	380	87
	1000	905	167	9	316	413	95
CAPRIROM	904	827	152	5	366	304	77
	1000	915	168	6	405	336	85
Nucet	915	851	151	9	375	317	64
	1000	930	165	8	410	346	70
Bodeni BZ	880	774	191	8	284	291	106
	1000	879	217	9	323	331	120
Piatra Neamţ	905	795	168	8	329	272	110
	1000	874	206	9	364	301	120
Timişoara	908	850	167	9	323	351	58
	1000	936	184	10	356	387	64
Baia Mare	882	774	157	12	314	291	108
	1000	876	178	14	356	338	122
Lugoj	950	851	123	7	354	367	99
	1000	896	129	8	373	386	104
Botoşani	933	831	181	10	302	338	102
	1000	891	194	11	324	362	109
ELCOMEX	903	827	149	6	369	303	76
	1000	916	165	7	409	335	84

Table 2 shows the feeding value of the alfalfa hay harvested from different areas of Romania, determined on the basis of the gross chemical composition, shown in Table 1, and using the regression equations specific to the forages, as well as the value mentioned in the reference tables (Burlacu et al., 2002).

Table 2. Alfalfa hay from various sources – feeding value

Unit	GE [MJ/ kg DM]	NE_{milk} [FU_{milk}/kg DM]	IDPN [g/kg DM]	IDPE [g/kg DM]	Ca [g/kg DM]	P [g/kg DM]
Reference values (Burlacu, 2002)	18.41	0.76	107	68	14.9	2.9
Rm. Sarat	97.23 %	100 %	95.33 %	101.47 %	86.58%	96.55%
	17.90	0.76	102	69	12.9	2.8
CAPRIROM	99.08 %	98.68 %	95.33 %	102.94 %	50.34%	103.45%
	18.24	0.75	102	70	7.5	3.0
Nucet	100.87 %	100 %	93.46 %	102.94 %	79.87%	117.24%
	18.57	0.76	100	70	11.9	3.4
Bodeni BZ	96.74 %	100 %	123.36 %	107.35 %	116.78%	82.67%

	17.81	0.76	132	73	17.4	2.4
Piatra Neamţ	96.90 %	84.21 %	105.61 %	105.88 %	93.29%	110.34%
	17.84	0.64	113	72	13.9	3.2
Timişoara	101.58 %	97.37 %	104.67 %	105.88 %	83.89%	141.38%
	18.70	0.74	112	72	12.5	4.1
Baia Mare	97.01 %	98.68 %	100.93 %	100 %	82.55%	155.17%
	17.86	0.75	108	68	12.3	4.5
Lugoj	95.71 %	88.16 %	73.83 %	79.41 %	73.83%	127.59%
	17.62	0.67	79	54	11.0	3.7
Botoşani	97.18 %	88.29 %	110.28 %	104.41 %	116.11%	158.62%
	17.88	0.67	118	71	17.3	4.6
ELCOMEX	99.29 %	86.84 %	85.98 %	86.76 %	80.54%	82.76%
	18.28	0.66	92	59	12.0	2.4

Table 3 shows the gross chemical composition of the ear corn harvested from different areas of Romania, determined in the Laboratory of Chemistry and Nutrition Physiology from IBNA Balotesti, as well as the gross chemical composition mentioned in the reference tables (Burlacu et al., 2002).

Table 3. Ear corn from various sources – gross chemical composition

Unit	DM [g/kg]	OM [g]	CP [g]	EE [g]	CF [g]	NFE [g]	Ash [g]
Reference values	873	859	92	39	23	691	14
(Burlacu, 2002)	1000	984	105	45	26	792	16
Rm. Sarat	818	808	61	20	25	702	10
	1000	988	75	25	30	858	12
Nucet.DB	807	795	51	19	28	697	12
	1000	985	63	24	35	864	15
Buzau	905	893	70	33	23	767	12
	1000	986	77	36	25	847	13
Neamt	837	822	73	68	48	633	15
	1000	982	87	81	57	756	18
Timisoara	816	806	74	21	26	685	10
	1000	988	91	26	32	839	12
Baia Mare	825	818	70	24	23	701	7
	1000	991	85	29	28	850	9
Botosani	845	830	65	28	27	710	15
	1000	982	77	33	32	840	18
Gorj	824	808	74	18	21	695	16
	1000	980	90	22	25	843	20
Mehedinti	838	828	77	31	24	696	10
	1000	988	92	37	29	830	12
Elcomex	908	898	78	27	33	760	10
	1000	989	86	30	36	837	11

Table 4 shows the feeding value of the ear corn harvested from different areas of Romania, determined on the basis of the gross chemical composition, shown in Table 1, and using the regression equations specific to the forages, as well as the value mentioned in the reference tables (Burlacu et al., 2002).

Table 4. Ear corn from various sources – feeding value

Unit	GE [MJ/ kg DM]	NE_{milk} [FU_{milk}/kg DM]	IDPN [g/kg DM]	IDPE [g/kg DM]	Ca [g/kg DM]	P [g/kg DM]
Reference values (Burlacu, 2002)	18.96	1.43	96	116	0.3	2.9
Rm. Sarat	97.10%	96.50%	62.50%	100.86%	200.00%	103.45%
	18.41	1.38	60	117	0.6	3
Nucet.DB	96.36%	93.01%	53.13%	95.69%	133.33%	72.41%
	18.27	1.33	51	111	0.4	2.1
Buzau	97.89%	97.20%	64.58%	100.86%	133.33%	82.76%
	18.56	1.39	62	117	0.4	2.4
Neamt	103.59%	102.80%	72.92%	101.72%	100.00%	106.90
	19.64	1.47	70	118	0.3	3.1
Timisoara	97.57%	97.90%	76.04%	107.76%	400.00%	141.38%
	18.50	1.40	73	125	1.2	4.1
Baia Mare	95.08%	98.60%	70.83%	105.17%	66.67%	137.93%
	18.59	1.41	68	122	0.2	4
Botosani	97.36%	95.80%	64.58%	100.86%	66.67%	106.90%
	18.46	1.37	62	117	0.2	3.1
Gorj	96.26%	94.41%	64.58%	106.90%	133.33%	103.45%
	18.25	1.35	62	124	0.4	3.0
Mehedinti	98.89%	99.30%	77.08%	107.76%	100.00%	79.31%
	18.75	1.42	74	125	0.3	2.3
Elcomex	98.05%	102.10%	70.83%	105.17%	133.33%	68.96%
	18.59	1.46	68	122	0.4	2.0

RESULTS AND DISCUSSION

The analysis of the experimental results shows that, most times, both the gross chemical composition, and the feeding values of the feeds used by goat farmers are different (deviations of ± 2.5%) from the feeding values given in the reference tables, which are commonly used to make diet formulations.

Regarding the chemical composition of the ear corn (Table 3), we noticed that the level of crude protein (CP) varied between 63 g/kg DM, harvested in Dambovița, and 92 g/kg DM, harvested in Mehedinti, being lower than the value of 105 g/kg DM, mentioned by Burlacu (2002) and by Stevanovic et al.,

2012 (105 g/Kg DM), in the reference tables, but comparable to the value of 88 g/kg DM, given by Huntington et al.(1997).

The crude fibre (CF) level of the ear corn varied between 25 g/kg DM, in the samples from Gorj and Buzău, and 57 g/kg DM, in the samples from Neamț, significantly higher than the reference average, Burlacu (2002), 26 g/kg DM. A negative correlation has been determined between the crude fibre content and the crude protein level, the lowest levels of CF being recorded for higher CP levels, and vice versa. The values obtained by us are higher than those reported by Ullah et al. (2011), of 10 and 29 g/kg DM, respectively.

The fat level of the ear corn varied between 24 and 37 g/kg DM, lower than the table reference values, Burlacu (2002), 45 g/kg DM, and also lower than the values of 43.2 and 63 g/kg DM, reported by Ullah et al. (2011). Huntington et al. (1997), however, reported a value of 38 g/Kg DM, which is close to the value reported for our samples.

Different levels of crude protein (CP) have also been determined in the alfalfa hay samples delivered by the farmers (Table 1), from a minimum of 129 g/kg DM, at Lugoj farm, to a maximum of 217 g/kg DM, at Bodeni-Buzău farm, compared to the reference value of 176 g/kg DM. The same minimal value, 127 g/kg DM, has also been reported by Dien et al. (2006), but Martin et al. (2004) reported a much higher value for the crude protein, 254 g/kg DM.

The fat level of the alfalfa hay varied between 6 and 14 g/kg DM, much lower than the value of 26 g/kg DM given by Burlacu et al. (2002), or than the value of 21 g/kg DM given by INRA (1988). Dien et al. (2006) reported 9 g/kg DM, comparable to the values obtained by us from analysed samples, but Ewing et al. (1988) reported a much lower value, 3 g/kg DM.

The crude fibre content of the alfalfa hay ranged between 316 g/kg DM, at Rm. Sarat farm, and 410 g/kg DM, at Nucet farm, the reference value being 335 g/kg DM; a negative correlation with the protein level has also been documented in this case. The obtained values are close to those reported by Donosa et al. (2011), 323 g/kg DM and by INRA (1988), 289 g/kg DM. Balliette et al. (1998) and Ewing et al. (1998), reported a lower value, 277 g/kg DM.

The organic matter (OM) content of the alfalfa hay varied between 874 g/kg DM and 936 g/kg DM, the mean of this interval being close to the table value, 907 g/kg DM, also reported by Pop et al. (2006). Sauvant et al. (2004) reported, however, a lower value, 830 g/kg DM.

The dry matter (DM) content of the alfalfa hay samples ranged from 880 to 950 g/kg, being comparable to the value of 830 g/kg, reported by Preston et al. (2010) and by Stanton et al. (2010), as well as with the value of 932 g/kg, reported by Kamalak et al. (2005).

The feeding value of the studied feeds was evaluated using the methodology and regression equations given by the new system of evaluating

the feeding potential of the feeds (Burlacu et al., 2002), for IDPN (intestinally digestible protein allowed by nitrogen) and IDPE (intestinally digestible protein allowed by nitrogen); for the net energy we used milk oats feed units FU_{milk} (1 FU_{oats} = 6.07 MJ).

Thus, for the corn samples, IDPN was below the table reference value of 96 g/kg DM, the lowest calculated value being 51 g/kg DM, for Nucet farm, and the highest, 74 g/kg DM, for Mehedinti; as percentage, this means 53.13% - 77.08% compared to the reference value (Table 4). The lowest IDPE value was calculated for Nucet farm, de 111 g/kg DM, while the highest for Mehedinti and Timişoara, 125 g/kg DM, which show that PDIE has both higher and lower values than the reference table value of 116 g/kg DM. The variation is 95.69% - 107.76% compared to the reference value.

For the alfalfa samples, IDPN varied between 79 g/kg DM, for Lugoj farm, and 132 g/kg DM, for Bodeni farm, the reference table value being 107 g/kg DM, which show a percentage of variation of 73.83% - 123.36% compared to the reference value. IDPE varied between 54 g/kg DM, for Lugoj farm, and 73 g/kg DM, for Bodeni farm, compared to the reference value of 68 g/kg DM (79.41% and 107.35%, of the reference value, respectively) (Table 2).

The net energy potential of the corn for milk production (NE_{milk}) expressed in feed units for milk production (FU_{milk}), varied between 1.33 FU_{milk}/kg DM, for the corn from Nucet farm, and 1.47 FU_{milk}/kg DM, for the corn from Neamt farm; only two values (1.46, for Elcomex, and 1.47, for Neamt) were higher than the reference, table value of 1.43 FU_{milk}/kg DM. this shows that the energy value of the corn varied between 93.0%-102.8% compared to the table value (Table 4).

The net energy potential of the alfalfa hay for milk production (NE_{milk}), varied between 0.64 FU_{milk}/kg DM, for the Piatra Neamt sample, and 0.76 FU_{milk}/kg DM, for the Nucet and Buzau samples; these values were equal or lower than the reference value of 0.76 FU_{milk}/kg DM, which shows a variation of 84.2% to 100,0% (Table 2).

Table 5 shows a comparative study regarding the supply of IDPN in the diet for a goat with 55 kg live body weight, producing 2 kg milk/day, using table values and the values determined from the gross chemical composition (Tables 2 and 4).

The values calculated with the analytical results of the gross chemical composition and the table values were used to simulate the IDNP parameter of the diet, considering that the goat farmer may feed a strict requirement of 140 g IDP (Table 5). This diet will consist of 1199 g alfalfa hay and 375 g ground ear corn. The IDPN content of these two feeds (alfalfa hay and ground corn), according to the feeding values tables (107g, and 96g, respectively), should supply 140 g IDPN (according to the tables), not 97 g (true supply determined

from the determined values), taking into consideration the most disadvantageous situations for the corn and for the alfalfa hay. In this case, according to the calculations and considering the table values, the IDPN requirement has been supplied. Actually, according to the true date on the IDPN content of these feeds, there is a deficit of 43 g protein (IDPN), which is a minus of about 31% IDPN. Such situations occur frequently in goat rearing in most farms throughout the territory. In order to avoid such situations, it is necessary to determine the true quality parameters of the feeds available in the goat farms and to develop a software used to formulate balanced diets, which to allow updating the feeding value of the particular feeds depending on their actual chemical composition, and the updating of the feeding norms for the different categories of goats.

Table 5. Comparative study regarding the supply of IDPN in the diet for a goat with 55 kg live body weight, producing 2 kg milk/day, using table values and the values determined from the gross chemical composition

Diet formulated with table values					Diet formulated with calculated values	
Feed	Amount (g)	DM (g)	IDPN (g/1000g DM)	Total IDP (g)	IDPN (g/1000g DM)	Total IDP (g)
Alfalfa hay	1199 (416)	1019 (354)	107	109	79	81
Corn	375 (346)	319 (294)	96	31	51	16
Total	-	-	-	140	-	97
Norma	-	-	-	140	-	140
Difference	-	-	-	100%	-	43 (-31%)

In order to meet the IDP requirement according to the norm, the farmer should supplement the diet with 416 g alfalfa hay and 346 g corn. In order to eliminate these possible errors in the formulation and optimisation of the diets, an interactive database was built using NUTRICAP software, which allows the permanent updating of the current feeding value of the feeds, using the true gross chemical composition of the feeds and the digestibility coefficients, determined experimentally, as inputs.

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CONCLUSIONS

The chemical composition of the corn showed a protein content lower than the reference table value of 105 g/kg DM, which varied between 63 and 92 g/kg DM, while the fibre content varied between 25 and 57 g/kg DM. higher than the table value of 26 g/kg DM, an inversely proportional to the protein content. The protein content varied quite a lot in the alfalfa hay, between 217 and 129 g/kg DM, while the reference value was 176 g/kg DM; the crude fibre content of the feeds was 316 to 410 g/kg DM, compared to the reference value of 335 g/kg DM.

The protein potential of the ear corn, expressed in IDPN and IDPE, showed values ranging between 53.13%-77.08%, compared to the reference value of 96 g/kg DM, and between 95.69% - 107.76%, compared to the reference value of 116 g/kg DM. In the alfalfa hay, PDIN ranged between 73.83% - 123.36% of the reference value of 107 g/kg DM, while PDIE ranged between 79.41% - 107.35%, compared to the reference value of 68 g/kg DM. The energy value of the corn varied between 93.0%-102.8%, compared to the reference value of 1.43 FU_{milk}, while in the alfalfa hay it varied between 84.2% - 100.0%, compared to the reference value of 0.76 FU_{milk}.

The calculations showed that IDPN supply in a diet formulation for goats might have a significant negative difference, of about 31%, between the use of true vales determined by chemical analysis and the use of table values. To avoid such situations, a software is required, which to formulate balanced diets and which to allow the permanent updating of the feeding value of the feeds existing in the goat farms

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