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CONTRIBUTIONS FOR FEED CAPITALIZATION STUDY AT BOMBYX MORI BREED

Doliș Marius Gheorghe*, Simeanu Daniel , Pânzaru Claudia***, Simeanu Cristina*****

**University of Agricultural Sciences and Veterinary Medicine "Ion Ionescu de la Brad" from Iasi, Romania
e-mail: dsimeanu@yahoo.com

Abstract

In order to assess how efficient is the use of Mulberry leaf by the Bombyx mori larvae, some determinations were made regarding the nutritional value and digestibility of the worm leaf administered as food, during a series of summer growth. The results showed that ongoing vegetation and growth process of this hybrid, the Mulberry leaves suffer an aging phenomenon, revealed by diminishing its chemical composition quality. According to this, most of the nutritional substances from Mulberry leaves, except cellulose, manifest a continuous decline during the growth period. The digestibility of these nutritional components registered a value of 56.08%, the raw energy value was 4213 kcal/kg dry substance, the digestive energy was 2308 kcal/kg (DS), while the metabolic energy was 2134 kcal/kg (DS). The efficiency of converting ingestion into silk had a value of 9.40% and the digestion was 16.19%.

Key words: leaves, Mulberry, larvae, energy, use.

INTRODUCTION

Besides the continuous improvement of the growth technologies, one of the main concerns of the specialists in sericulture is represented by the production of biological material of high genetic value as the Bombyx mori larvae with an increasing productive potential, more resistant to the environmental factors and to diseases and to use nutrients offered by the Mulberry to the best of their advantage.

Thus, from this point of view, the performances of the used larvae in intensive breeding systems have greatly increased, but at the same time, in order for them to be able to reach their full potential, it is necessary to improve all the factors involved in the breeding process. From the multitude of factors that directly influence the growth process of the larvae and the economic results obtained, it is encountered also nutrition.

The quantity and especially the quality of the worm leaf used in feeding of larvae, directly influence the growth rate, their health and vitality, but also the quantitative and qualitative production of silk. In turn, the quality of the leaf is also influenced by many factors related to the pedoclimatic conditions, season, variety of the mulberry, the way of harvesting and storage etc.

In the specific literature, depending on different factors, the relative humidity values of the Mulberry leaf vary between 65-75% *(Doliş M., 2008)*.

Compared with the common Mulberry (69.80-73%), the selected varieties have more water content *(Bura M. et al., 1995)*. The dried substance from the worm leaf, harvested in the same period, can record, depending on the variety/hybrid, different values, for example, between 23.61% and 27.56% *(Matei A., 1995)*.

Also, if the spring moisture of the mulberry leaf is 71.85-77.81%, then it decreases to 68.42-75.64%, in the summer period, respectively to 64.10-73.64%, in the fall *(Ifrim S., 1998)*.

Digestibility of the dry substance from the worm leaf decreases from 71.07% in age I, to 39.99% (for male larvae), 48.26% (for female larvae) in age V *(Rath S.S. et al., 2003)*. The worm leaf administered to the larvae of the fifth age has an approximate digestibility between 27.99% and 32.44% *(Rahmathulla V.K. et al., 2002)*.

The raw leaf protein is estimated to have an average value of 6.16% in the fresh leaf, 20.97% in the dry substance and 24.36% in its organic substance *(Doliş M., 2008)*. The raw leaf protein values can vary depending on the season, the time of day, the variety/hybrid of the dude: 32.40% in spring, 28.21% in summer and 24.53% in autumn *(Borcescu A., 1966)*, 26.80% in the morning and 29, 10% in the evening *(Mărghitaş L. A., 1995)*, between 22.55% and 25.73% depending on the variety *(Matei A., 1995)*. In the specialty literature, for raw leaf protein, the value of digestibility coefficients is between 69.21% and 78.92 *(Borcescu A., 1966)*, 60.06% and 74.69% *(Petkov N.,1980)*, 71.62% and 93.48% *(Matei A., 1995)*.

The limits presented by specific literature regarding the fat content in mulberry leaves are 2.85- 6.07% *(Pop E.C., 1967)* The values of the digestibility coefficient for raw fat are between 63.28% and 74.19% *(Petkov N.,1980)*.

According to the data from the specialized literature, in the common Mulberry the weight of the raw cellulose ranges between 12.33-14,38%, while in the different varieties selected oscillates between 10.43-13,70% *(Craiciu E., 1966)*. In the vegetation period of the mulberry the content in raw cellulose from the leaves increases from 14.47% to 21.16% *(Pop E.C., 1967)*. Increased cellulose content causes aging of the worm leaf, which becomes harder and harsher, therefore harder to consume by, which is why those varieties whose leaves have less cellulose content are considered more valuable. At the beginning of the last century, some authors *(Acqua, 1930 – cited by Dolis M., 2008)* found that the leaf cellulose passes undigested through the digestive tract of the larvae and later it was concluded that this substance has a digestibility of approx. 20% *(Legay, 1955 - cited by Dolis M., 2008).* Recently, some authors state that in the first two ages, raw cellulose would not be digested, but only from the third (8%), its digestibility reaches 21.13% in the third period *(Matei A., 1995).*

The values regarding the mineral substances, offered by the specialized literature, ranges between: 9.13- 17.38% *(Pop E.C., 1967)*, 11.52-12.80% *(Matei A., 1995)* and 8, 7.13.15% *(Bura M. et al., 1995)*.

At the end of the last century, Romania could be considered an important point on the map of European sericulture. Thus, in her record, Romania can boast in this field with a quite complex literature, as well as with the creation of new varieties and valuable hybrids of worm, as *Bombyx mori*, all being the result of some decade research work of Romanian specialists *(Dolis M., 2008; Lazăr S. and Vornicu O.C., 2013; Pătruică S., 2013)*.

For this reason, we consider appropriate to bring a modest contribution to the study of using the mulberry leaf, derived from indigenous varieties, by larvae of breeds or hybrids created in Romania.

MATERIAL AND METHOD

The biological material used in the experiments was represented by a batch of 150 larvae of Bombyx mori from Romanian hybrid Baneasa Super, obtained by a simple cross between the female breed of Japanese type and the male type of Chinese. To be easier to follow, the group was devided into three sub-lots (repetitions) of 50 larvae each, which were raised in paper trays sized according to the age and size of the larvae; in addition, it was also made up a separate lot, with 50 larvae reared separately, but under the same conditions, which served to replace the dead larvae from the experimental group.

The growth of the larvae was in August, in an air-conditioned room, in compliance with all the microclimate factors. Each divided group received the same amount of leaf, from the same variety of worm, Eforie, from where samples were previously collected, for chemical analysis.

The Romanian variety of mulberry Eforie, which is characterised by a high production capacity, a early budding and a high resistance to freezing and drought. It was selected from a local population from Dobrogea in 1955 and introduced into production in 1970.

Daily and at the same time, from each group were collected, weighed and recorded what was not consumed from the Mulberry leaves and what was excreted by the larvae.

The quantities of residues, respectively of excrements, obtained from each group were summed, the result being divided into three, thus obtaining the average quantity of residues from each 50 larvae. The values obtained were subsequently used in the calculation relationships to find the digestibility coefficients. Also, from each group were collected samples of excrements, which were mixed in order to obtain medium samples for analyze.

Also, the groups were weighed at the beginning of growth (after hatching) and at the end (before budding), the difference between the two weights, divided by the number of larvae in each group, representing the increase in body mass accumulated by a larva.

From the separated lot were extracted 10 larvae, whose content was determined in dry matter; thus, multiplying the average dry substance content of larvae, calculated from the separated lots, with the increasing body mass of the larvae in the experimental lots, it was determined the average increasing of body mass of a larva.

After gobbling, 15 cocoons were harvested, from which the silk wrapper was separated, weighed and its dry matter content determined, thus obtaining the average dry wool content of the silk wrapper.

The working methods used were mainly the specific ones used to determine the nutritional value of the worm leaf and they were based on the chemical composition (the "proximate analysis" scheme), the digestibility of its components (the "in vivo" method - simple digestibility, with a single control period) and raw energy (use of specific computation equations and regression coefficients recommended by the OKIT system), digestible (calculation equation recommended for monogastric species) and metabolizable (equations recommended for monogastric animals and birds) contained *(Halga P. et al., 2005).*

The efficiency of the use of nutrients in the worm leaf by the larvae was expressed by the amount of ingested/digested dry matter required for increasing 1 gram of body mass/weight (silk wrap), respectively by the efficiency of conversion of ingested substances (ECI%)/ digested (ECD%) in body mass/weight *(Matei A., 1995; Rahmathulla V.K. et al., 2002; Sarkar A., 1993).*

RESULTS AND DISCUSSION

Table 1 shows the data of the chemical composition evolution of larvae in relation to their age.

The average values obtained for each nutrient separately are set in the limits presented by specific literature, where the data regarding the crude chemical composition of the mulberry leaves varies according to each author, to the research period, to the varieties of mulberry, etc. The average relative humidity of the mulberry leaves during the research was 70.44%, and an decreasing evolution being registered average values between 71.86% (at the first determination corresponding to the first age of the silkworm larvae) and 68.15% (to the last determination when the silkworm larvae are in the age V-th). The dry matter represented 29.56 ± 0.725%.

Table 1

The chemical composition evolution of the Eforie variety mulberry tree leaves during the silkworm larvae growth (%)

Determination	**Water**	**DM**	**CP**		**EE**		**CF**		**NFE**		**Ash**	
			F*	DM**	F*	DM**	F*	DM**	F*	DM**	F*	DM**
I	71.86	28.14	6.23	22.14	0.85	3.02	4.79	17.02	12.43	44.17	3.84	13.65
II	71.98	28.02	6.21	22.16	0.88	3.14	4.76	16.99	12.24	43.68	3.93	14.03
III	70.68	29.32	6.41	21.86	1.17	3.99	5.26	17.94	12.30	41.95	4.18	14.26
IV	69.53	30.47	6.00	19.69	1.22	4.00	5.58	18.31	13.37	43.89	4.30	14.11
V	68.15	31.85	6.06	19.03	1.38	4.33	6.15	19.31	13.58	42.64	4.68	14.69
$\overline{X}$	70.44	29.56	6.18	20.98	1.10	3.70	5.31	17.88	12.78	43.29	4.19	14.15
$S_{\overline{x}}$	-	0.725	-	0.670	-	0.260	-	0.434	-	0.418	-	0.169
Cv%	-	5.486	-	7.143	-	15.700	-	5.412	-	2.163	-	2.667

* fresh leaves; ** dry matter

The crude protein had an average value of 6.18% (20.98± 0.670% from DM). It is noticed a progressive decreasing of the protein content throughout the studied period, the content decreasing being with 3.11 percentage points, from 22.14% to 19.03%, respectively.

The fat content from the mulberry leaves was in average 1.10% in the fresh leaves, and 3.70% ±0.260 in DM. It is the only nutrient with a high variability, of 15.700%. The fat content increased uniformly throughout the silkworm larval growth, from 0.85% to 1.38% when it was expressed in fresh leaves, or 3.2 % to 4.33% respectively, when it was reported to the dry matter.

The crude cellulose was in average 5.31% in fresh leaves, 17.91±0.434%, respectively when in was reported to DM. Throughout the research, for a month, the crude cellulose increased with 2.29 percentage points, from 17.02% to 19.31%, respectively.

Nitrogen free extract represented in average 43.27 ± 0.418% from the dry matter of the mulberry leaves; the average values decreased from the first determination to the third, from 44.17% to 41.95%, then was an increasing to the fourth determination, being 43.89%, decreasing to the last analyses to 42.64%.

The ash represented in average 4.19% in the fresh leaves and 14.15 ± 0.169% from dry matter. The minerals from the mulberry leaves throughout the research registered a continuous increase from analyse to another. The average values varied from 3.84% to 4.68% to fresh leaves and from 13.65% to 14.69% from dry matter. An exception was registered to the third determination which had a higher value than the fourth one. The increasing in mineral content from mulberry leaves throughout the research was 1.04%.

Knowing the raw chemical composition of the mulberry leaf, using the specific calculation equations, it was possible to assess the nutritional value of the mulberry leaf based on its content of raw energy, which was, on average, over the entire studied period, of 1245 Kcal/kg, in fresh leaf, respectively 4213 Kcal/kg, in the dry matter (table 2).

Table 2

Raw average energy of Mulberry leaf

Specification	**%**		**Caloric equivalent**	**Kcal/100g**		**Kcal/100g**	
	*	**		*	**	*	**
CP	6.18	20.98	5.72	35.35	120.01	353.5	1200.1
EE	1.10	3.70	9.50	10.45	35.15	104.5	351.5
CF	5.31	17.88	4.79	25.43	85.65	254.3	856.5
NEF	12.78	43.29	4.17	53.29	180.52	532.9	1805.2
						1245	**4213**

By recording the quantities of the worm leaf administered, the non-consumed and excreted residues and also determining their chemical composition (table 3), its digestibility coefficients could subsequently be calculated (table 4) and also the content of digestible substances in the leaf (table 5).

Following the complex phenomenon of digestion, nutrients are transformed into simple substances, which can thus be absorbed through the epithelium of the digestive tract, at different levels, thus being retained in the organism of silk larvae, representing practically the difference between the amount of substances ingested through food and the amount of appropriate substances found in droppings. Because not all the substances found in excrement are of dietary origin, some of them are of endogenous origin, which can be obtained by this difference, indicating only apparent digestibility. If you admit the fact that at Bombyx mori excretions are also found in their excrement, which complicates the establishment of the digestibility of nutrients in the wormwood even more accurately, the use of the approximate digestibility term seems to be more correct *(Miranda J.E.and Takahashi R., 1998; Rahmathulla V.K. et al., 2004; Rath S.S. et al., 2003; Sabhat A. et al., 2011; Tzenov P., 1993).*

Table 3

Data needed to calculate digestibility coefficients

The larvae age	**Specifi-cation**	**Quantity (g)**	**Chemical composition (%/g)**					
			DM	**CP**	**EE**	**CF**	**NEF**	**Ash**
I	Leaves	15.5	28.140	6.230	0.850	4.790	12.430	3.840
			4.362	0.966	0.132	0.743	1.927	0.595
	Leftovers	5.11	62.580	13.910	2.010	14.020	24.480	8.160
			3.198	0.711	0.103	0.716	1.251	0.417
	Excreta	0.17	78.250	14.010	14.680	15.110	26.120	8.330
			0.133	0.024	0.025	0.026	0.044	0.014
II	Leaves	26	28.020	6.210	0.880	4.760	12.240	3.930
			7.285	1.615	0.229	1.238	3.182	1.022
	Leftovers	8.01	58.850	14.330	2.160	13.890	22.060	6.410
			4.714	1.148	0.173	1.113	1.767	0.513
	Excreta	0.88	74.680	12.570	3.970	14.010	29.010	15.120
			0.657	0.111	0.035	0.123	0.255	0.133
III	Leaves	77	29.320	6.410	1.170	5.260	12.300	4.180
			22.576	4.936	0.901	4.050	9.471	3.219
	Leftovers	22.65	61.540	12.340	2.620	15.860	25.660	5.060
			13.939	2.795	0.593	3.592	5.812	1.146
	Excreta	4.07	64.060	15.920	2.080	9.910	24.120	12.030
			2.607	0.648	0.085	0.403	0.982	0.490
IV	Leaves	242	30.470	6.000	1.220	5.580	13.370	4.300
			73.737	14.520	2.952	13.504	32.355	10.406
	Leftovers	65.94	56.490	12.050	2.020	15.930	25.670	0.820
			37.250	7.946	1.332	10.504	16.927	0.541
	Excreta	19.99	64.440	11.980	2.180	12.010	26.210	12.060
			12.882	2.395	0.436	2.401	5.239	2.411
V	Leaves	1000	31.850	6.060	1.380	6.150	13.580	4.680
			318.500	60.600	13.800	61.500	135.800	46.800
	Leftovers	269.01	57.920	9.960	2.970	11.920	24.820	8.250
			155.811	26.793	7.990	32.066	66.768	22.193
	Excreta	119.82	60.460	10.060	3.080	14.890	24.020	8.410
			72.443	12.054	3.691	17.841	28.781	10.077

During the whole period studied, the digestibility of the dried substance from the worm leaf had a digestibility of 58.06%. The highest digestibility was recorded in larvae of age I (88.57%), after which, by the end of the larval period, there was a decrease of 31.76 percent.

The raw protein had a digestibility coefficient for the entire studied period of 64.78%. The raw protein digestibility decreased progressively during the studied period, with 26.32%, respectively from 90.66%, in the first larval age, to 64.34%, in the last one. The high digestibility of age I could be explained by the rich content in amides, simple nitrogenous substances, which are found in the young leaf and which are digested much easier than the protein nitrogenous substances, which have the weight in the old leaf.

Table 4

Digestibility coefficients of Băneasa Super hybrid

The larvae age	DM	CP	EE	CF	NEF
I	88.57	90.66	14.09	1.53	93.43
II	75.81	76.31	37.46	1.36	81.96
III	70.29	69.73	72.46	11.92	73.17
IV	66.15	63.57	73.11	19.96	66.04
V	56.81	64.34	36.48	39.39	58.31
I-V	**58.06**	**64.78**	**45.41**	**37.07**	**60.87**

The raw fat from the worm leaf had the minimum digestibility value of 14.09%, in the larvae of the first age and maximum of 73.11%, in the larvae of the fourth age. The results of the digestibility tests regarding the raw fat in the worm leaf are generally inconclusive, as many of these can come from the intestine of the larvae and not from the leaf, which is why, we cannot speak of a determination of the digestibility of the fat itself but of the "ethereal extract", which also contains very large quantities of pigments. Thus, the big differences regarding the evolution of the digestibility of the raw fat during the studied period could be explained.

During the whole larval period, the digestibility of the raw cellulose from the mulberry leaf was 37.07%, being very low in age I, 1.53%, after which it increased progressively, by over 17%, reaching the end of the period studied up to the value of 39.39%. This increase in the digestibility of raw cellulose, as the larvae grow older, is in line with the development of the enzymatic equipment in their digestive tract. Thus, if at age I, in the digestive tract of the larvae, the enzymes involved in the process of cellulose digestion are as non-existent, then they gradually increase, reaching the peak at age V, at which point the weight of raw cellulose from the worm leaf it is also bigger. This aspect, however, negatively influences the digestibility of the raw leaf protein, which during the same period, is experiencing a reduction.

Unclaimed extractive substances from the worm leaf had a digestibility over the entire studied period of 60.87%, the digestibility coefficients registering decreasing values, from 93.43%, in the case of the larvae of age I, at 58.31%, in the case of those of fifth age.

Knowing the value of digestibility coefficients, it was possible to calculate the digestible content for each nutrient separately, then the content of digestible substances in the leaf, so when the report was made to the fresh leaf, 148.75 g of Total Digestive Substance/kg were obtained, and when the report was made on the dried substance from the leaf of the mulberry, its nutritional value was 503.50 g TDS/kg (table 5).

Table 5

The nutritional value calculation of the mulberry leaves (g TDN/kg)

Specification	**Raw chemical composition %**		**Digestibility coefficients**	**Digestive content %**		**G Total Digestive substance /kg**	
	*	**		*	**	*	**
CP	6.18	20.98	64.78	4.00	13.59	40.03	135.91
EE	1.10	3.70	45.41	0.50	1.68	11.24	37.80
CF	5.31	17.88	37.07	1.97	6.63	19.68	66.28
NEF	12.78	43.29	60.87	7.78	26.35	77.79	263.51
Total						**148.75**	**503.50**

* Reported to the fresh leaves; ** reported to DM

The determination of the digestible energy content of the worm leaf administered in the feed of silk larvae was made based on the relative digestible content of the nutrients contained in it, using the calorific equivalents recommended for monogastric animal species (table 6). In the case of the fresh leaf, the digestible energy content was 639 Kcal/kg, and in the case of the dry substance, 2173 Kcal/kg.

Table 6

Digestive energy of Mulberry leaf

Specification	**Digestive content %**		**Caloric equivalent (Kcal/g)**	**Kcal/kg**	
	*	**		*	**
CP	4.00	13.59	5.78	231.20	785.50
EE	0.50	1.68	9.42	47.10	158.26
CF	1.97	6.63	4.40	86.68	291.72
NEF	7.78	26.35	4.07	316.65	1072.45
Total				**681.63**	**2307.92**

* Reported to the fresh leaves; ** reported to DM

The calculation of the metabolic energy from the worm leaf administered in the feed of silk larvae was done by multiplying the digestible content of each nutrient with the energy equivalents recommended for monogastric (pig) animal species. Considering, however, the specificity of the silkworm's digestion, respectively the similarity with the digestion of the birds, for the estimation of the metabolic energy from the worm leaf, the energetic equivalents recommended for the birds were used (table 7).

The average content in metabolic energy from the fresh mulberry leaf was 630.24 Kcal/kg, when the recommended energy ratios for pigs were used, respectively 630.33 Kcal/kg, when the recommended coefficients for birds were used. In relation to the dry matter of the leaf, the content in metabolic energy was on average 2134.04 Kcal/kg, when the recommended energy coefficients for pigs were used, and 2133.59 Kcal/kg, when the recommended coefficients for birds were used.

Table 7

Metabolic energy of Mulberry leaf

Specification	**Digestive content %**		**Caloric equivalent (Kcal/g)**		**Kcal/kg**			
	*	**			*		**	
			swine	birds	swine	birds	swine	birds
CP	4.00	13.59	5.01	4.26	200.40	170.40	680.86	578.93
EE	0.50	1.68	8.93	9.50	44.65	47.50	150.02	159.60
CF	1.97	6.63	3.44	4.23	67.77	83.33	228.07	280.45
NEF	7.78	26.35	4.08	4.23	317.42	329.09	1075.08	1114.61
					630.24	**630.33**	**2134.04**	**2133.59**

* Reported to the fresh leaves; ** reported to DM

In order to determine the efficiency of use of the nutrients in worm leaf by the silk larvae, except for the intake and digestion, which were calculated during the course of the digestibility tests, it was necessary to determine the average growth rate of the larvae and the mass of the silk shell. The data necessary for calculating the efficiency of the use of the worm leaf by the larvae, as well as the results obtained in this respect, were centralized in table 8.

From the data of this table it is observed that in the case of the *Bombyx mori* Baneasa Super larvae hybrid, for every gram of silk wrap is required 10.64 grams of dry matter ingested from the wormwood, respectively 6.18 grams of digested dry matter, resulting in an efficiency of conversion of silk intake (CEI) of 9.40%, respectively of digestion (CED) of 16.19%

Table 8

Efficiency of using Mulberry leaf by Bombix mori Băneasa Super larvae hybrid

Average body mass gained during the whole larvae stage (g)	**Living larvae**	5.0385
	Dry matter	0.9185
Silky shell mass (g Dry Matter)		0.3978
Dry Matter of ingested leaf (g)		4.2310
Dry Matter of digested leaf (g)		2.4566
Ingested Dry Matter/Body mass Dry Matter (g)		4.6067
Dry matter ingested/ Body mass Dry Matter (g)		2.6747

Dry matter ingested/Silky shell Dry Matter (g)	10.6360
Dry matter digested/ Silky shell Dry Matter (g)	6.1754
CEI body mass %	21.7076
CED body mass %	37.3873
CEI silky shell %	9.4020
CED silky shell %	16.1932

The data obtained from the experience performed, regarding the efficiency of the use of the mulberry leaf by the larvae of Bombyx mori, are comparable with those presented in the literature *(Matei A., 1995; Rahmathulla V.K. et al., 2002; Rath S.S. et al., 2003; Sarkar A., 1993; Tzenov P., 1993).*

CONCLUSIONS

Expressed to dry matter from the mulberry leaves, Eforie variety the average values were: CP- 20.98 ± 0.670%, EE- 3.70 ± 0.260%, CF- 17.91 ± 0.4.34%, NEF- 43.27 ± 0.418% and ash- 14.15 ± 0.260%.

At once with vegetation advancement and implicitly during each growth period of silkworm larvae, the mulberry leaf ages and its quality from the chemical composition point of view is decreasing.

During the 30 days of the research, was noticed a decreasing of the moisture with 3.71% and of the CP with 3.11% and in the same time an increasing of the CF with 2.29%.

During the whole period studied, the digestibility of the dried substance from the worm leaf had a digestibility of 58.06%. The dry matter digestibility decreased with 31.76%.

Digestibility coefficients of the CP (64.78%) and of the NFE (60.87%) from the mulberry leaves decreased during the study with 26,03% and 35.12%, respectively.

The CF digestibility, very low at the beginning (1.53%), increased progressively till the fifth larval stage when it was 39,39%.

Nutritional value of the mulberry leaves was 474 g TDN/ kg DM.

Throughout the studied period, the gross enrichment of the worm leaf was on average 4213 Kcal/kg, in the dry substance

In the leaf, the content of digestible energy was, in the case of dry matter, 2308 Kcal/kg.

In relation to the dry matter of the leaf, the content in metabolic energy was on average 2134 Kcal/kg.

In the case of the Băneasa Super hybrid, for each gram of silk wrap, 10.64 grams of dry matter ingested from the mulberry tree are required, respectively 6.18 grams of digested dry substance, resulting an efficiency of conversion of ingestion (CEI) into silk of 9.40%, respectively of the digestion (CEI) of 16.19%

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