STUDY REGARDING THE USE OF MULBERRY LEAVES BY *BOMBYX MORI* - BĂNEASA SUPER HYBRID

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Abstract

In order to assess how efficient is the use of Mulberry leaf by the Bombyx mori Băneasa Super larvae hybrid, some determinations were made regarding the nutritional value and digestibility of the worm leaf administered as food (leaves from a Japanese variety, Kokuso 21), 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 53.77%, the raw energy value was 4216 kcal/kg dry substance, the digestive energy was 2112 kcal/kg (DS), while the metabolic energy was 1946-1966 kcal/kg (DS). The efficiency of converting ingestion into silk had a value of 10.24% and the digestion was 19.04%.

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.

The knowledge of the nutritional value and of the influence factors, as well as the way in which Bombyx mori larvae are harnessed to kill the nutrients in the wormwood, has attracted the attention of a significant number of researchers.

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.

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 research was done during the growth period of the silkworm larvae from summer series, the biologic material being

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represented both by silkworm larvae and mulberry leaves which were administrated.

The animal biologic material was the hybrid of silkworm *Baneasa Super*, obtained by a simple cross between the female breed of Japanese type and the male type of Chinese.

The vegetal biologic material used in the research was represented by *Kokuso 21* a mulberry variety which derives from the crossing between *Naganua*, *Gariin* and *Shiso* varieties. It is a variety of Japanese origin with whole leaf which has adapted fairly well to the climatic conditions from the south of Romania. In plantations of the intensive type may be produced from the first years a high quantity of leaves with a high protein content.

Working methods aimed to determine the nutritive value of the mulberry leaves taking into account the chemical composition and the digestibility of its components.

The chemical composition was determined using the „Proximate Analysis" scheme and the digestibility (approximate digestibility) through „*in vivo*" method- simple digestibility with a single period control [35].

The chemical analyses were done on samples previously dried to 65ºC and grinded. The obtained results were processed and noted in tables being expressed in both fresh and dried leaves. The collected samples moisture determination was done by drying them into the hot air oven for 4-5 hours at 105ºC [11, 30].

The ashes content was determined using the incineration of the samples method [31].

To determine the protein content (CP), the Kjeldhal method was used [32].

The fat content (EE) was determined using Soxhlet method; its principle is based on the fat property of dissolving in the organic solvent (such as, petroleum ether) [33].

The crude fiber (CF) was determined by the sample acid-basic hydrolyze, after which from the leaf is removed the hydrolysable part, on the filter paper remaining only the cellulose and minerals; by calcination are determined the minerals and the crude cellulose is calculated through difference [34].

Nitrogen free extract was calculated through difference from fresh leaf or dried one. In the first case, from 100 were decreased the percentages of water, protein, fat, cellulose and ashes. In the second case, from the dry matter percentage were decreased the percentages of crude protein, extract etherate, crude fiber and ash.

In order to determine the nutritive matter digestibility from mulberry leaves which were administered in silk larvae feeding, it was respected the digestibility principle "in vivo", with a single control period. There were calculated the digestibility coefficients

$$(DC\% = \frac{\text{Digest}}{\text{Intake}} \text{ x } 100) \text{ [1, 8-12].}$$

Based on the quantity of administered leaves, the leftover waste, excrete and on the data obtained from chemical analyses firstly, were found out the intake nutrients or ingest (the difference between administered quantities and the ones leftover) and finally the intake of the nutritive substances or digest (difference between ingest and faeces). Expressing in percentage the digest from ingest, were obtained the digestibility coefficients, which shows how much from the leaves nutrients are digested into the digestive system of the larvae.

Based on the digestible coefficients, there was calculated the digestible content for each nutrient it represents the result between the crude chemical content and the digestible coefficient which was divided to 100.

The obtained values were summed obtaining in the end the total digestible nutrients (TDN) from the mulberry leaves. The fat content was multiplied with 2.25 because it is considered that the fat has 2.25 times more energy than the others intake nutrients.

Also, because the nutritive value was expressed in TDN/kg, and the calculated values were reported to 100 g, it was multiplied with 10 [8-11, 16, 28].

For energy value, The working methods used were mainly the specific ones used to determine the 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 [11, 21, 28].

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 [16, 22, 27].

The main experimental data obtained were statistically processed being calculated the arithmetic average, variance, the average standard deviation and the variability coefficient [6, 15, 26].

During the silkworm larvae growth, the research objective was to establish the nutritive values of the mulberry leaves depending on its maturity and silkworm larvae age, respectively. This was accomplished through digestibility trials.

There were organized an experimental lot formed from 150 larvae, which were grouped in three repetitions of 50 larvae each. In the calculations during the research were used the average values obtained in all three repetitions, the data being extrapolated to all 50 silkworm larvae.

In each repetition were used trays with paper sized accordingly with the larvae's age and size.

To each repetition had been administered the same quantity of mulberry leaves from which previously were collected samples for chemical analyses.

Daily and at the same time from each repartition were collected, weighted and registered the leftover mulberry leaves and the excreta.

The number of leftovers mulberry leaves from each repetition were summed, the result being than divided to 3, obtaining the average quantity of leftover leaves from the 50 larvae; the value being representative for the entire lot. This value was used to calculate the digestibility coefficients of the nutrients from mulberry leaves. Similarly, was done in the case of the excreta.

From each repetition were collected samples of leftover, excreta respectively, which were homogenized in order to obtain an average sample for each lot; those samples were chemically analyzed.

Also, there were organized three reserve repetition with 50 larvae raised separately, but under the same conditions.

During the experiment was watched the larval mortality from each lot and if necessary the dead larvae were immediately replaced with ones from reserve lot.

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 larvae growth was held during 31st of July and 31st of August, respecting the breeding technology recommended by the specific literature.

RESULTS AND DISCUSSIONS

The values regarding the mulberry leaves chemical composition evolution throughout growth period of the silkworm larvae were centralized and statistically processed (table 1).

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 70.63%, and a decreasing evolution being registered average values between 72.09% (at the first determination corresponding to the first age of the silkworm larvae) and 68.86% (to the last determination when the silkworm larvae are in the age Vth). The dry matter represented 29.37±0.575%.

The mulberry leaves humidity influences its consumption by the silkworm larvae. The larvae, especially in the early stages of life, prefers young leaves with a high percentage of water. In the data presented by different authors, the average humidity of the mulberry leaves varies between 65-75% [13, 14].

Depending on the variety, the dry matter of the mulberry leaves varies between 23.61-27.56% [16].

In the specific literature, the crude protein from mulberry leaves has the following average values: 32.40% in the spring, 28.21% in the summer and 24.53% in the autumn [2], during the morning 26.80% and evening 29.10% [17]; it also varies between 22.55 and 25.73% depending on the mulberry variety [16].

Table 1 Chemical composition of Mulberry leaf in relation to larvae's age (%)

Determination	Water	DM	CP		EE		CF		NFE		Ash	
			F*	DM**	F*	DM**	F*	DM**	F*	DM**	F*	DM**
I	72.09	27.91	6.31	22.61	0.79	2.83	4.74	16.98	12.33	44.18	3.74	13.40
II	71.66	28.34	6.28	22.16	0.88	3.11	4.88	17.22	12.34	43.54	3.96	13.97
III	70.31	29.59	6.23	21.05	1.14	3.85	5.31	17.95	12.64	42.72	4.27	14.43
IV	70.13	29.87	6.04	20.22	1.16	3.88	5.44	18.21	13.09	43.83	4.14	13.86
V	68.86	31.14	6.15	19.75	1.25	4.01	5.93	19.04	13.41	43.07	4.40	14.13
$\overline{X}$	70.63	29.37	6.20	21.16	1.04	3.54	5.26	17.88	12.77	43.46	4.10	13.96
$S_{\overline{x}}$	-	0.575	-	0.547	-	0.237	-	0.368	-	0.261	-	0.169
Cv%	-	4.381	-	5.782	-	14.975	-	4.599	-	1.342	-	2.713
Min	-	27.91	-	19.75	-	2.83	-	16.98	-	42.72	-	13.40
Max	-	31.14	-	22.61	-	4.01	-	19.04	-	44.18	-	14.43

* fresh leaves; ** dry matter

The crude protein had an average value of 6.20% (21.16±0.547% from DM). It is noticed a progressive decreasing of the protein content throughout the studied period, the content decreasing being with 2.86 percentage points, from 22.61% to 19.75%, respectively.

The protein content in the mulberry leaves may be considered a real indicator of the leaf's quality. The protein intake from mulberry leaves strongly influences both the silkworm larvae growth and development and, especially, the silk production of the larvae.

The fat content from the mulberry leaves was in average 1.04% in the fresh leaves, and 3.54%±0.237 in DM. It is the only nutrient with a high variability, of 14.975%.

The fat content increased uniformly throughout the silkworm larval growth, from 0.79% to 1.25% when it was expressed in fresh leaves, or 2.83% to 4.01% respectively, when it was reported to the dry matter.

The limits presented by specific literature regarding the fat content in mulberry leaves are 2.85-6.07% [20].

The crude cellulose was in average 5.26% in fresh leaves, 17.88±0.368%, respectively when in was reported to DM. Throughout the research, for a month, the crude cellulose increased with 2.06 percentage points, from 16.98% to 19.04%, respectively.

The cellulose is highly responsible for aging processes of the mulberry leaves. As the cellulose content grows, the leaf becomes tougher and rougher, being more difficult to be consumed by the silkworm larvae.

For this reason, in the silkworm larvae's growth are considered the most valuable mulberry varieties, the ones that have a lower cellulose content.

The values obtained for crude cellulose from mulberry leaves were comparable with the ones from specific literature. The crude cellulose quota varies between 12.33-14.38% to the common mulberry tree and between 10.43-13.70% to different selected varieties [5]. Throughout the mulberry vegetation period, the cellulose content from leaves increase from 14.47 to 21.16% [20].

Nitrogen free extract represented in average 43.46±0.261% from the dry matter of the mulberry leaves; the average values decreased from the first determination to the third, from 44.18% to 42.72%, then was an increasing to the fourth determination, being 43.83%, decreasing to the last analyses to 43.07%.

The ash represented in average 4.10% in the fresh leaves and 13.96±0.169% from dry matter.

The minerals from the mulberry leaves throughout the research registered a continuous increase from analyze to another. The average values varied from 3.74% to 4.40% to fresh leaves and from 13.40% to 14.13% 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 0.90%.

The obtained data regarding the mineral content are in conformity with the ones from specific literature, 9.13-17.38% [20], 11.52-12.80% [16], 8.7-13.15% [4].

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 1238 Kcal/kg, in fresh leaf, respectively 4216 Kcal/kg, in the dry matter. (table 2)

Table 2 Raw average energy of Mulberry leaf

Specification	%		Caloric equivalent	Kcal/100g		Kcal/kg	
	*	**		*	**	*	**
CP	6.20	21.16	5.72	35.46	121.04	354.6	1210.4
EE	1.04	3.54	9.50	9.88	33.63	98.8	336.3
CF	5.26	17.88	4.79	25.20	85.65	252.0	856.5
NEF	12.77	43.46	4.17	53.25	181.23	532.5	1812.3
						1238	**4216**

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 [18, 23- 25, 29].

Table 3 Data needed to calculate digestibility coefficients

The larvae age	Specification	Quantity (g)	Chemical composition (%)					
			DM	CP	EE	CF	NEF	Ash
I	Leaves	15.5	27.91	6.31	0.79	4.74	12.33	3.74
	Leftovers	4.98	67.99	15.87	2.03	14.62	26.44	9.03
	Excreta	0.16	70.02	20.97	8.88	4.12	27.91	8.14
II	Leaves	26	28.34	6.28	0.88	4.88	12.34	3.96
	Leftovers	8.01	62.18	13.01	2.02	15.09	20.98	11.08
	Excreta	1.02	65.52	15.42	2.11	5.81	29.01	13.17
III	Leaves	77	29.59	6.23	1.14	5.31	12.64	4.27
	Leftovers	23.82	62.07	9.85	3.01	16.08	25.12	8.01
	Excreta	3.97	63.11	14.98	2.02	6.01	25.93	14.17
IV	Leaves	242	29.87	6.04	1.16	5.44	13.09	4.14
	Leftovers	66.94	60.01	10.91	1.91	16.68	23.55	6.96
	Excreta	20.31	62.73	13.18	2.91	8.19	28.44	10.01
V	Leaves	1000	31.14	6.15	1.25	5.93	13.41	4.4
	Leftovers	269.01	59.09	11.51	1.65	14.01	24.89	7.03
	Excreta	121.94	61.12	9.81	3.83	13.49	25.18	8.81

Table 4 Digestibility coefficients of *Băneasa Super* hybrid (g)

The larvae age	Specification	DM	CP	EE	CF	NEF
I	Leaves	4.3261	0.9781	0.1225	0.7347	1.9112
	Leftovers	3.3859	0.7903	0.1011	0.7281	1.3167
	Ingest	0.9402	0.1878	0.0214	0.0066	0.5945
	Excreta	0.112	0.0336	0.0142	0.0066	0.0447
	Digest	0.8282	0.1542	0.0072	0.0000	0.5498
	DC%	**88.09**	**82.11**	**33.64**	**0.00**	**92.48**
II	Leaves	7.3684	1.6328	0.2288	1.2688	3.2084
	Leftovers	4.9806	1.0421	0.1618	1.2087	1.6805
	Ingest	2.3878	0.5907	0.0670	0.0601	1.5279
	Excreta	0.6683	0.1573	0.0215	0.0593	0.2959
	Digest	1.7195	0.4334	0.0455	0.0008	1.2320
	DC%	**72.01**	**73.37**	**67.91**	**1.33**	**80.63**
III	Leaves	22.7843	4.7971	0.8778	4.0887	9.7328
	Leftovers	14.7851	2.3463	0.717	3.8303	5.9836
	Ingest	7.9992	2.4508	0.1608	0.2584	3.7492
	Excreta	2.5055	0.5947	0.0802	0.2386	1.0294
	Digest	5.4937	1.8561	0.0806	0.0198	2.7198
	DC%	**68.68**	**75.73**	**50.12**	**7.66**	**72.54**
IV	Leaves	72.2854	14.6168	2.8072	13.1648	31.6778
	Leftovers	40.1707	7.3032	1.2786	11.1656	15.7644
	Ingest	32.1147	7.3136	1.5286	1.9992	15.9134
	Excreta	12.7405	2.6769	0.591	1.6634	5.7762
	Digest	19.3742	4.6367	0.9376	0.3358	10.1372
	DC%	**60.33**	**63.40**	**61.34**	**16.80**	**63.70**
V	Leaves	311.4000	61.5000	12.5000	59.3000	134.1000
	Leftovers	158.9580	30.9631	4.4387	37.6883	66.9566
	Ingest	152.4420	30.5369	8.0613	21.6117	67.1434
	Excreta	74.5297	11.9623	4.6703	16.4497	30.7045
	Digest	77.9123	18.5746	3.3910	5.1620	36.4389
	DC%	**51.11**	**60.83**	**42.07**	**23.89**	**54.27**
I-V	Leaves	418.1642	83.5248	16.5363	78.5570	180.6302
	Leftovers	**222.2803**	**42.4450**	**6.6972**	**54.6210**	**91.7018**
	Ingest	195.8839	41.0798	9.8391	23.9360	88.9284
	Excreta	**90.5560**	**15.4248**	**5.3772**	**18.4176**	**37.8507**
	Digest	105.3279	25.6550	4.4619	5.5184	51.0777
	DC%	**53.77**	**62.45**	**45.35**	**23.05**	**57.44**

During the whole period studied, the digestibility of the dried substance from the worm leaf had a digestibility of 53.77%. The highest digestibility was recorded in larvae of age I (88.09%), after which, by the end of the larval period, there was a decrease of 36.98 percent.

In the specialty literature, the main explanation for reducing the digestibility of nutrients from the worm leaf as a whole, during the growth period of the silk larvae, would be as seen from the data in table 1, precisely the qualitative degradation of the leaf, in terms of chemical composition [27]. 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 [24]. The worm leaf administered to the larvae of the fifth age has an approximate digestibility between 27.99% and 32.44% [22].

The raw protein had a digestibility coefficient for the entire studied period of 62.45%. The raw protein digestibility decreased progressively during the studied period, with 21.28%, respectively from 82.11%, in the first larval age, to 60.83%, 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.

In the specialty literature, for raw leaf protein, the value of digestibility coefficients is between 69.21% and 78.92 [3], 60.06% and 74.69% [19], 71.62% and 93.48% [16].

The raw fat from the worm leaf had the minimum digestibility value of 33.64%, in the larvae of the first age and maximum of 67.91%, in the larvae of the second 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 23.05%, being null in age I, after which it increased progressively, reaching the end of the period studied up to the value of 23.89%. 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.

At the beginning of the last century, some authors 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% [7-10]. 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 [8-10, 16].

Unclaimed extractive substances from the worm leaf had a digestibility over the entire studied period of 57.44%, the digestibility coefficients registering decreasing values, from 92.48%, in the case of the larvae of age I, at 54.27%, in the case of those of fifth age.

According to Matei, 1995, for the extracts not recorded from the leaf of the worm, the digestibility coefficients for the whole larval period record average values between 63.40% and 94.97%.

From the data in table 3 it can be observed that the digestibility of the nutrients of the worm leaf showed a medium variability for dry matter, raw protein and high for raw fat and raw cellulose.

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, 134.81 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 459.11 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	6.20	21.16	**62.45**	3.87	13.21	38.72	132.14
EE	1.04	3.54	**45.35**	0.47	1.61	10.61	36.12
CF	5.26	17.88	**23.05**	1.21	4.12	12.12	41.21
NEF	12.77	43.46	**57.44**	7.34	24.96	73.35	249.63
						134.81	**459.11**

*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 619.94 Kcal/kg, and in the case of the dry substance, 2112.35 Kcal/kg.

Table 6 Digestive energy of Mulberry leaf

Specification	Digestive content %		Caloric equivalent (Kcal/g)	Kcal/kg	
	*	**		*	**
CP	3.87	13.21	5.78	223.69	763.54
EE	0.47	1.61	9.42	44.27	151.66
CF	1.21	4.12	4.40	53.24	181.28
NEF	7.34	24.96	4.07	298.74	1015.87
				619.94	**2112.35**

* 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.

Table 7 Metabolic energy of Mulberry leaf

Specification	**Digestive content %**		**Caloric equivalent (Kcal/g)**		**Kcal/kg**			
	*	**			*		**	
			swine	birds	swine	birds	swine	birds
CP	3.87	13.21	5.01	4.26	193.89	164.86	661.82	562.75
EE	0.47	1.61	8.93	9.50	41.97	44.65	143.77	152.95
CF	1.21	4.12	3.44	4.23	41.62	51.18	141.73	174.28
NEF	7.34	24.96	4.08	4.23	299.47	310.48	1018.37	1055.81
					576.95	**571.18**	**1965.69**	**1945.78**

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

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 576.95 Kcal/kg, when the recommended energy ratios for pigs were used, respectively 571.18 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 1965.69 Kcal/kg, when the recommended energy coefficients for pigs were used, and 1945.78 Kcal/kg, when the recommended coefficients for birds were used.

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 9.77 grams of dry matter ingested from the wormwood, respectively 5.25 grams of digested dry matter, resulting in an efficiency of conversion of silk intake (CEI) of 10.24%, respectively of digestion (CED) of 19.04%.

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**	5.075
	Dry matter	0.919
Silky shell mass (g Dry Matter)		0.401
Dry Matter of ingested leaf (g)		3.918
Dry Matter of digested leaf (g)		2.107
Ingested Dry Matter/Body mass Dry Matter (g)		4.265
Dry matter ingested/ Body mass Dry Matter (g)		2.293
Dry matter ingested/Silky shell Dry Matter (g)		9.767
Dry matter digested/ Silky shell Dry Matter (g)		5.252
CEI body mass %		23.45
CED body mass %		43.61
CEI silky shell %		10.24
CED silky shell %		19.04

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 [16, 22, 24,27, 29].

CONCLUSIONS

From those mentioned in the paper, the following conclusion may be drawn:

Expressed to dry matter from the mulberry leaves, Kokuso 21 variety the average values were: CP – 21.16%, EE – 3.54%, CF – 17.88%, NEF – 43.42% and ash – 13.96%.

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 3.23% and of the CP with 2.86 % and in the same time an increasing of the CF with 2.06%.

The leaves nutrients digestibility was in average 53.77%. The dry matter digestibility decreased with 36.98 %.

Digestibility coefficients of the CP (62.45%) and of the NFE (57.44%) from the mulberry leaves decreased during the study with 21,28% and 38.21%, respectively.

The CF digestibility, very low at the beginning, increased progressively till the fifth larval stage when it was 23.89%.

Nutritional value of the mulberry leaves was 459.11 g TDN/ kg DM.

Throughout the studied period, the gross enrichment of the worm leaf was on average 1238 Kcal/kg, in the fresh leaf, respectively 4216 Kcal/kg, in the dry substance

In the case of fresh leaf, the content of digestible energy was 619.94 Kcal/kg, and in the case of dry matter, 2112.35 Kcal/kg.

In relation to the dry matter of the leaf, the content in metabolic energy was on average 1965.69 Kcal/kg, when the recommended energy coefficients for pigs were used, and 1945.78 Kcal/kg, when the recommended coefficients for birds were used.

In the case of the Băneasa Super hybrid, for each gram of silk wrap, 9.77 grams of dry matter ingested from the mulberry tree are required, respectively 5.25 grams of digested dry substance, resulting an efficiency of conversion of ingestion (CEI) into silk of 10.24%, respectively of the digestion (CEI) of 19.04%.

REFERENCES

[1] Al-Kirshi R.A., Alimon A., Zulkifli I., Atefeh S., Wan Zahari M., Ivan M., 2013: Nutrient Digestibility of Mulberry Leaves (Morus Alba). Italian Journal of Animal Science, Volume 12: e36, 2013, page 219-221.

[2] Borcescu A., 1966: Feeding silkworm larvae in summer and autumn farms. Sericulture, nr. 3, page 6-9.

[3] Borcescu A., 1966: Particularities of digestion of silkworms, Sericulture, no. 1, pp. 25-30.

[4] Bura M.; Acatincăi S.; Pădeanu I., 1995: Silkworm larvae – biology and growth, Helicon Publishing, Timişoara.

[5] Craiciu E., 1966: Contributions to identification and description of mulberry variety in Romanian Socialist Republic. Scientific papers S.C.A.S., 6th vol., Agricultural magazine Publishing, Bucharest, page 245-285.

[6] Cucu G.I., Maciuc V., Maciuc D., 2004: Scientific research and elements of experimental techniques in animal husbandry, Alfa Publishing, Iaşi.
[7] Doliş M., 2008: Sericulture, Alfa Publishing, Iaşi.
[8] Doliş M.G., Simeanu C., Usturoi A., Simeanu D., 2017: Research Regarding Chemical Composition and the Digestibility of the Mulberry Leaves from Eforie Variety. Rev. Chim. (Bucharest), 68, no.1, 2017, pp. 151-156.
[9] Doliş M.G., Boişteanu P.C., Simeanu D., 2017: Research Regarding Apparent Digestibility of Selected Hybrid Mulberry Leaf Chemical Content. Rev. Chim. (Bucharest), 68, no.6, pp. 1459-1462.
[10] Doliş M.G., Boişteanu P.C., Usturoi M.G., Simeanu D., Bodescu D., Nacu G., Usturoi A., Simeanu C. 2017: Research on Digestibility of the Mulberry Leaf from the Kokuso 21 Variety in Relation to the Dynamics of the Chemical Content. Rev. Chim. (Bucharest), 69, no.2, 2018, pp. 439-444.
[11] Halga P., Pop I.M., Bădeliţă C., Popa V., Man D., 2005: Nutrition and animal feeding, Alfa Publishing, Iaşi.
[12] Hirano S., Yoshida S., Takabuchi N., 1993: Acetylchitosan and its digestibility by silkworms, Carbohydrate Polymers, 22, no.2, pp.137-140.
[13] Ifrim S., 1998: Natural silk, Ceres Publishing, Bucharest.
[14] Lazăr Ş., Vornicu O.C., 2013: Biological and technical foundation in sericulture production, Ion Ionescu de la Brad Publishing, Iaşi.
[15] Maciuc V., Creangă Ş., Maciuc D., Vidu L., 2015: A New Programme for Data Management in Dairy Farms. ''ST26733". International Conference "Agriculture for Life, Life for Agriculture". Agriculture and Agricultural Science Procedure 6, 2015, page 226-231.
[16] Matei A., 1995: Determination of nutritional values in main variety and hybrid of mulberry used in industrial husbandry of Bombyx mori. PhD Thesis, U.Ş.A, Bucharest.
[17] Mărghitaş L.A., 1995: Silkworm larvae farming, Ceres Publishing, Bucharest.
[18] Miranda J.E., Takahashi R., 1998: Efficiency of food utilization by the silkworm, Bombyx mori L. (Lepidoptera: Bombycidae) feed on artificial diets. Sericologia, 38, no. 4, pp. 601-610.
[19] Petkov N., 1980: Studies on the utilization of mulberry leaves of some varieties at different norms and seasons of silkworm feeding. II Expenditure of mulberry leaves per unit of production, and their repayment by spring feeding of silkworms. Sericologia, 20, no. 1-2, p. 32.
[20] [13] Pop E. C., 1967: Chemical composition of mulberry leaves in various periods and its expendability. Sericulture, 4th no., page 12-18.
[21] Pop I.M., Halga P., Avarvarei T., 2006: Animal nutrition and feeding, Publishing house Tipografia Moldova, Iaşi.
[22] Rahmathulla V.K., Suresh H.M., Mathur V.B., Geetha Devi R.G., 2002: Feed conversion efficiency of elite bivoltine CSR hybrids silkworm Bombyx mori L. Reared under different environ mintal conditions. Sericologia, 42, no. 2, pp. 197-203.
[23] Rahmathulla V.K., Suresh H.M., Mathur V.B., Geetha Devi R.G., 2004: Growth and Dietary Efficiency of Mulberry Silkworm (Bombyx mori L.) Under Various Nutritional and Environmental Stress Conditions. Philippine Journal of Science 133, no. 1, pp. 39-43.
[24] Rath S.S., Narain R., Prasad B.C., Roy G.C., Sinha B.R.R.P.,2003: Food allocation budgeting in tropical tasar, Antheraea mylitta feed on Terminalia tomentosa. Sericologia, 43, no. 4, pp. 557-564.
[25] Sabhat A., Malik M.A., Malik F.A., Sofi A.M., Mir M.R., 2011: Nutritional efficiency of selected silkworm breeds of Bombyx mori L. reared on different varieties of mulberry under temperate climate of Kashmir. African Journal of Agricultural Research, 6, no.1, pp. 120-126.
[26] Sandu G., 1995: Experimental models in animal science, Coral Sanivet Publishing, Bucharest.
[27] Sarkar A., 1993: Effect of feeding different races of silkworm (Bombyx mori L.) with Mulberry (Morus indica L.) leaves varying in ploidy level. Sericologia, 33, no. 1, pp. 25-34.
[28] Stan G., Simeanu D., 2005: Animal nutrition, Alfa Publishing, Iaşi.
[29] Tzenov P., 1993: Study on the food utilization in genetic sex- limited breeds for egg and larval traits of the silk worm, Bombyx mori L., at moderate, reduced and excess feeding amounts. Sericologia, 33, no. 2, pp. 247-256.
[30] Regulation (EC) no. 152/2009 SR ISO 6496: 2001.
[31] Regulation (EC) no. 152/2009 SR EN ISO 2171: 2010.
[32] Regulation (EC) no. 152/2009 SR EN ISO 5983-2: 2009 AOAC 2001.11.
[33] Regulation (EC) no. 152/2009 SR ISO 6492: 2001.
[34] Regulation (EC) no. 152/2009 SR EN ISO 6865: 2002.
[35]http://www.fao.org/docrep/field/003/ab479e/ab47 9e03.htm