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The Feed Sugar Minimum as a Precondition of Good Quality Silage

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Abstract: Minimal amount of sugar sufficient to create so much lactic acid as it could permanently maintain pH value of 4.2 to 3.9 we are calling »sugar minimum«. The aim of this work was to investigate sugar minimum of feeds that are used or could be used for ensilage at different combinations of feeds.

Fourteen samples have been used for determination of sugar minimum. On the basis of the results obtained it may be found that the lowest sugar minimum have those feeds which are most often used in practice for silage making, because they have sufficient dry matter, high amount of sugar, and low buffering capacity. Barley in the phase of graining having dry matter content of 29.57% had the sugar minimum of 1.42%. Samples of grain and whole plant of maize as that of field pea with dry matter of 45.32%, 2.86% and 3.69% which enables quality ensilage. Samples of sugar beet tops because of low dry matter content of 7.98% had the sugar minimum of 4.75%. In other feeds (alfalfa, Jerusalem artichoke and red clover(due to high buffering capacity the sugar minimum was from 5.53% to even 10.21%.

Key words: silage making, sugar minimum, buffering capacity

Introduction

Silage process implies providing conditions suitable for an intensive exertion of the lactic-acidic fermentation, with a particular amount of lactic acid to be swiftly accumulated in the ensilaged mass and so effectively conserved (Vučković and Kovčin, 1999). Successful ensilage of the unwilted plant mass calls for: sufficient amounts of dry matter, an adequate sugar minimum depending on the feeds and on the adequate amount of soluble sugars as the major metabolite of the lactic-acidic bacteria over the conservation process (Čobić et al., 1984, Čobic and Antov 1996., Wieringa 1968., Giardini 1976., Gouet 1968.)

Any plant mass intended for ensilage must contain a certain amount of dry matter comprising a group of nutritive matters (crude proteins, crude fat, crude cellulose, crude ash and nitrogen-free extractive matters), some of which represent the metabolites of the microorganisms growth over the silage process, whereas the others remain in the plant mass and serve as domestic animal feeds (Vučkovic and Kovčin 1999., Čobić 2002., Glamočić, 2002, Wilkinson 1978., Gouet 1968.).

Jovanović et al., (2001) pointed out that the feed containing more than 60 to 67% moisture was harder and more expensive for handling, prone to producing mucous, mildewy ensilage in the presence of butter and other undesirable acids, resulting in the loss of juice and other nutritive matters. Furthermore, the silo's walls may be extremely damaged due to high acidity and overpressed due to increased moisture. The higher plant mass moisture content requires that plants be strongly compacted to prevent air retention favouring aerobic bacteria growth and propagation.

Soluble sugars share to be determined in the plant mass content may help roughly assess the feed suitability for ensilaging. However, the process of ensilage, i.e. the accomplishment of the stable optimal pH value (4,2 to 3,9) is remarkably affected by its buffer capacity. Through the microorganism metabolism, the soluble carbohydrates (monosaccharides and disaccharides) are translated into the lactic acid, as the best ensilage conserving agent. However, some amount of the lactic acid is spent to offset buffer capacity in feeds and to increase sugar minimum.

Therefore, the entirely consumed lactic acid solution over the titration was assumed to more accurately assess the ability of the plant mass to ensilage. By their chemical composition, different plant species and their mixtures contain differing amount of dry and nutritive matters (.Kovčin, 1993). However, some of the plant species are not able to produce good-quality silage despite substantial carbohydrates, whereas the other ones can be ensilaged despite insufficiently contained sugars. The minimal amounts of sugars enough to produce as much lactic acid as it can permanently keep pH value within the boundaries from 4,2 to 3,9 are defined as sugar minimum (Vučković and Kovčin, 1999).

When determining the soluble carbohydrate amounts (expressed in dry matter) over the assessment of the ability of the plant mass and its mixtures, neither dry matter in the mass nor the buffer capacity was considered, assuming that achievement of the stable pH by titration with lactic acid solution and by computing sugar minimum would be enough to provide such an assessment.

Therefore, the objective of the research was to determine the sugar minimum of some feeds and to establish their possibilities of ensilaging.

Materials and Method

The experiments were carried out in the chemical laboratory for feed analysis at the Facutly of Agriculture in Novi Sad. Fourteen feed samples were taken from the plots owned by the Institute of Field and Vegetable Crops – fodder department in Rimski Šancevi, as well from the privately owned plots in the vicinity of Beočin. The above-ground plant parts were used:

- Barley in the pheno-phase of graining
- Wheat in the pheno-phase of earing

- Corn as an entire plant with grain being in the stage of milk-wax maturity and grain itself being in the stage of milk-wax maturity
- Jerusalem artichoke 50 cm high
- Lucerne in full growth, before flowering and in full flowering
- Red clover before flowering (1. and 2. swath)
- Vetch before flowering
- Field pea with grain in the stage of graining
- Cocksfoot after flowering
- Sugar beet's head and leaf

The specimens were ground up to the particles 1 mm by size. 10 g of the feed was measured and put into the glass 400 ml by volume and 100 ml distilled water added. So prepared sample was properly mixed with glass rod and left for 15 minutes at room temperature. pH was measured by means of ISKRA pH meter, titration performed with 0,1 N lactic acid solution until pH reached its value of 3,9 .

This procedure was repeated after one, four, five, six, seven, eight, eleven and twelve days (as the case might be). After each one of the re-tritrations, the consumed amount of the lactic acid solution was recorded. Finally, when the stable pH was reached, the consumed amounts were summed up and sugar minimum calculated. The samples were held in the fridge at +4°C for protection against microorganisms.

Standard chemical analysis following the method of AOAC (1980) and the total sugars determination after BERTRAND were made, too.

Results and Discussion

Based on the obtained results (table 1), the feeds most commonly used in practice for silage production have shown the lowest consumption of lactic acid. Thus, with its consumption of lactic acid of only 4,65 ml and sugar minimum of 1,42%, barley ranked first due to extremely high level of dry matter (29,57%) and sugars (21,68%) and a low level of proteins (7,53%) (table 2). Corn grain, the entire corn plant and field pea have also shown a low consumption of lactic acid (16,10 ml; 9,34 ml and 12,05 ml, respectively) and a low sugar minimum (1,87%; 2,86% and 3,69%, respectively), enabling them to be swiftly and fully conserved (table 2). Due to a low sugar level and a high buffering capacity, other feeds of low sugar minimum, seemed to be hard for ensilaging and, as such, could not produce good quality ensilage. As can be seen from the Fig. 1 their total consumption ranged from 15,52 ml of even up to 33,35 ml lactic acid, and sugar minimum from 4,75% to 10,21%.

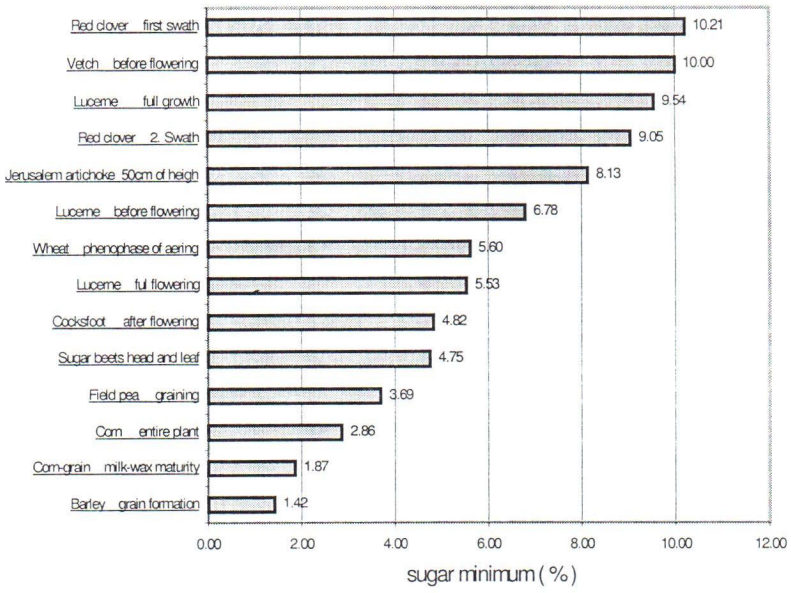
Standard chemical analysis and soluble sugars determination provided the data (table 2) showing that, despite relatively suitable chemical composition, the sample of the sugar beet's head and leaf had a low content of dry matter (7,98%) and, therefore, a low amount of the soluble sugars, threby requiring a higher consumption of lactic acid (15,52 ml) and sugar minimum of 4,75% to attain stable pH value.

The samples of cocksfoot and wheat had a high level of dry matter (33,59% and 25,98%), however, the common effect of proteins (11,37% and 12,18%) and of minerals (5,83% and 6,19%) through that of buffering capacity also required a higher amount of lactic acid (15,75 ml and 18,30 ml).

Tab. 1. The Feeds Sugar Minimum

No of sample	Name of sample	Titration	Retitration								Total consumption	Sugar minimum
			1 day	4 days	5 days	6 days	7 days	8 days	11 days	12 days		
		ml	ml	ml	ml	ml	ml	ml	ml	ml	ml	%
1	Barley, pheno-phase graining	4.65	-	-	-	-	-	-	-	-	4.65	1.42
2	Corn grain	1.65	1.00	1.35	1.30	0.60	-	0.20	-	-	6.10	1.86
3	Corn entire plant	4.37	2.02	0.85	1.50	-	0.45	0.15	-	-	9.34	2.86
4	Field pea	4.60	5.65	-	1.80	-	-	-	-	-	12.05	3.69
5	Sugar beet's head and leaf	2.42	1.60	2.00	2.70	2.85	1.15	1.65	1.15	-	15.52	4.75
6	Cocksfoot after flowering	3.75	7.50	1.35	0.65	1.50	1.00	-	-	-	15.75	4.82
7	Lucerne full flowering	6.55	4.60	1.55	3.40	1.95	-	-	-	-	18.05	5.53
8	Wheat, pheno-phase earing	5.05	6.30	2.45	1.60	1.15	1.75	-	-	-	18.30	5.60
9	Lucerne before flowering	3.40	11.80	2.45	1.75	1.70	1.05	-	-	-	22.15	6.78
10	Jerusalem artichoke 50cm	4.80	17.40	4.05	4.30	-	-	-	-	-	26.55	8.13
11	Red clover second swath	5.05	13.94	3.60	2.50	2.05	2.40	-	-	-	29.54	9.05
12	Lucerne full growth	5.05	20.25	-	5.85	-	-	-	-	-	31.15	9.54
13	Vetch pre-flowering	4.80	22.80	3.15	1.90	-	-	-	-	-	32.65	9.99
14	Red clover first swath	5.35	20.65	2.95	4.10	0.30	-	-	-	-	33.35	10.21

Fig.1. The Feeds Sugar Minimum



In terms of the results of standard chemical analysis and a relatively low level of dry matter, the other samples (of lucerne, red clover and Jerusalem artichoke) indicated high amounts of the proteins and minerals with high buffering capacity. The consumed portions of lactic acid in these feeds pointed at their having much lesser possibility of good quality ensilaging. Their sugar minimum was found to range from 6,78% to 10,21%.

Statistical calculations through the method of linear regression and calculation of the correlation coefficient between the levels of soluble sugars and consumed lactic acid solution indicated the correlation coefficient to be negative amounting to 82% (Fig.2).

Fig. 2 Sugar Minimum in Dependence of the Total (soluble) Sugars

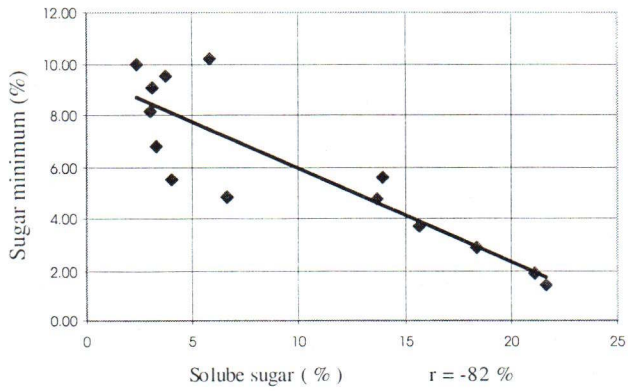
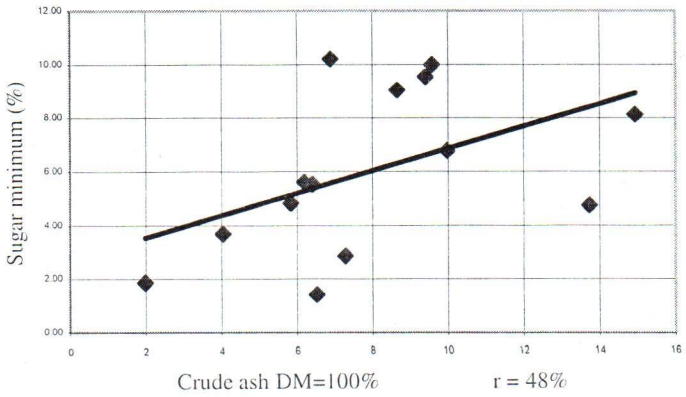


Fig. 3. Sugar Minimum in Dependence of Crude Ash Contained in the Feed Dry Matter



As can be seen from the Fig 3., the content of dry matter in the feed has a high correlation coefficient with sugar minimum of –60%.

Tab.2. Chemical Composition of Feeds

No of sample	Name of sample	DM	Moisture	Dry mater=100%									
				CP	CF	CC	Ash	NFE	Ca	P	Sugar	Consumption of acid	Sugar minimum
1	Barley, pheno-phase graining	29,57	70,43	7,53	1,69	25,05	6,52	55,21	0,17	0,24	21,68	4,65	1,42
2	Corn grain	45,32	54,68	11,48	7,06	2,35	1,98	77,13	0,06	0,39	21,13	6,10	1,86
3	Corn entire plant	18,66	81,34	8,66	2,35	21,64	7,28	60,07	0,43	0,33	18,36	9,34	2,86
4	Field pea	16,67	83,33	16,46	1,77	17,41	4,04	60,32	0,81	0,25	15,70	12,05	3,69
5	Sugar beet's head and leaf	7,98	92,02	20,23	1,67	8,64	13,73	55,72	0,76	0,28	13,64	15,52	4,75
6	Cocksfoot after flowering	33,59	66,41	11,37	3,00	33,23	5,83	46,58	0,38	0,22	6,58	15,75	4,82
7	Lucerne full flowering	23,01	76,99	15,54	1,65	32,86	6,40	43,55	1,95	0,15	3,96	18,05	5,53
8	Wheat, pheno-phase earing	25,98	74,02	12,18	2,05	27,58	6,19	51,99	0,30	0,18	13,28	18,30	5,60
9	Lucerne before flowering	8,56	91,44	29,52	3,44	21,12	9,97	35,94	1,71	0,44	3,25	22,15	6,78
10	Jerusalem artichoke 50cm	11,72	88,28	20,43	1,84	19,68	14,94	43,10	1,48	0,47	2,97	26,55	8,13
11	Red clover second swath	16,55	83,45	30,02	2,71	12,06	8,65	46,56	2,25	0,33	3,06	29,54	9,04
12	Lucerne full growth	8,39	91,61	33,87	2,57	17,08	9,40	37,07	1,73	0,48	3,71	31,15	9,54
13	Vetch pre-flowering	13,07	86,93	31,74	2,30	19,73	9,57	36,67	1,61	0,43	2,36	32,65	9,99
14	Red clover first swath	18,66	81,43	17,02	2,10	21,55	6,89	52,44	1,77	0,23	5,79	33,35	10,21

Conclusion

Based upon the obtained results of the chemical study, it may be inferred that the amount of dry matter and/or moisture, buffering capacity and the level of soluble sugars exerted a marked influence on the feed ensilaging quality.

Soluble sugars were inversely correlated with sugar minimum (r=-82%). However, this index is not the surest one allowing for the feed buffering capacity induced by proteins and mineral matter abundantly contained in the lucerne and red clover samples. The consumption of lactic acid caused by buffering capacity is directly correlated with sugar minimum. The feeds rich in minerals and proteins with low level of soluble sugars (red clover and lucerne) are hard to ensilage. Therefore, the feeds cited in the paper may be combined with those of lower sugar minimum in order to offset adverse effects.

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ŠEĆERNI MINIMUM HRANIVA KAO PREDUSLOV ZA KVALITETNO SILIRANJE

- originalni naučni rad -

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Rezime

Minimalnu količinu šećera dovoljnu da se stvori toliko mlečne kiseline koja bi pH vrednost trajno održala u granicama od 4,2 do 3,9 nazivamo šećernim minimumom. Cilj ovih istraživanja je bio da se ispita šećerni minimum hraniva koja se koriste ili bi se mogla koristiti za siliranje pri različitim kombinacijama hraniva.

Za određivanje šećernog minimuma uzeto je 14 uzoraka. Na osnovu dobijenih rezultata može se ustanoviti da najmanji šećerni minimum imaju ona hraniva koja se najčešće koriste u praksi za spravljanje silaže, jer imaju dovoljno suve materije, visoku količinu šećera i nizak puferski kapacitet. Ječam u fazi nalivanja zrna sa suvom materijom od 29,57 % je imao šećerni minimum od 1,42 %. Uzorci zrna i cele biljke kukuruza kao i stočnog graška sa suvom materijom od 45,32 % , 18,66 % i 16,67 % imali su šećerni minimum 1,86 %, 2,86 % i 3,69 % koji omogućava kvalitetno siliranje. Uzorak glave i lista šećerne repe zbog niskog nivoa suve materije od 7,98 %, imao je šećerni minimum od 4,75 %. Kod ostalih hraniva (lucerka, čičoka i crvena detelina) zbog visokog puferskog kapaciteta šećerni minimum je bio od 5,53 % do čak 10,21 %.