ProRefine – Working Paper

Legume forage stems and pulp in animal nutrition

Legume forage stems and pulp – what are they?

Forage plants, legume forages, contain much protein and with a good amino acid profile but that are coupled with too much fibre to make them valuable feed for monogastrics. Ruminants can efficiently utilise such fibre, whereas the protein content of these forages is even too high for many categories of animals, like for example heifers and non-lactating cows.

Green biorefinery is a wide concept that includes different techniques, but all aimed to convert a biomass into a wide range of marketable products that include feed and food, chemicals, biofuels, etc. (De Jong et al., 2010).

Applied to these forages, green biorefinery can separate the plants into two fractions, one enriched in protein and low in fibre, the other where fibre is concentrated and low in protein.

This goal can be principally pursued according to two main strategies:

- **screw pressing the whole plant to obtain a watery juice containing the soluble protein fraction (primarily Rubisco) leaving a fibrous pulp. Protein in the juice can be concentrated by drying or heat or acid precipitation;**
- **separately harvesting, by a leaf stripper, the leaves that have a high protein and low fibre content, and then the residual stems.**

Juice protein and leaves can be directed to feed monogastrics like pigs, while pulp and stems can be fed to ruminants, like cattle, sheep, and goats.

Photos: Experimental leaf stripping on alfalfa (left) and stripped stems (right)

Applicability box

Theme

Feed production

Keywords

Animal production, biorefinery, forage fractionation, sustainability, self-sufficiency

Geographical coverage

Countries relying on imported feed protein

Required time

Can be applied immediately, but method is continuing to develop

Period of impact

Continuous

Equipment

Fractionation plant, leaf stripper, silo.

Background

Both pulp and stems have a high fibre content but a quite different composition and digestibility. In the whole plant, the fibre of the stems is the most lignified and least digestible, but the pulp also includes the fibre contained in the leaves, which is more digestible.

The composition of both these roughages depends on the same environmental and agronomic conditions that affect the nutritional value of the whole forage, but largely also on biorefining techniques:

- **Effectiveness of the leaf stripper influences the amount of top stems fraction that is harvested in the leafy fraction and how many leaves still remain attached to the stems, in particular to the lower ones;**
- **The pressing technique affects the amount and composition of the juice that is extracted, and then how much moisture and solubles remain in the pulp.**

Being quite new products, little information is available on their nutritional traits and their effects on ruminant livestock.

The Prorefine project evaluated, for the first time and to a large scale, the main nutritional components and the digestibility of the whole plant and its derived fibrous fractions of red clover and lucerne grown in North (Norway and Sweden) and South (Italy) Europe. How to preserve them at best their quality through ensiling was also verified.

Based on the results obtained in the project and the information available in literature it is possible to suggest some guidelines for the use of these two biorefined co-products in the farm.

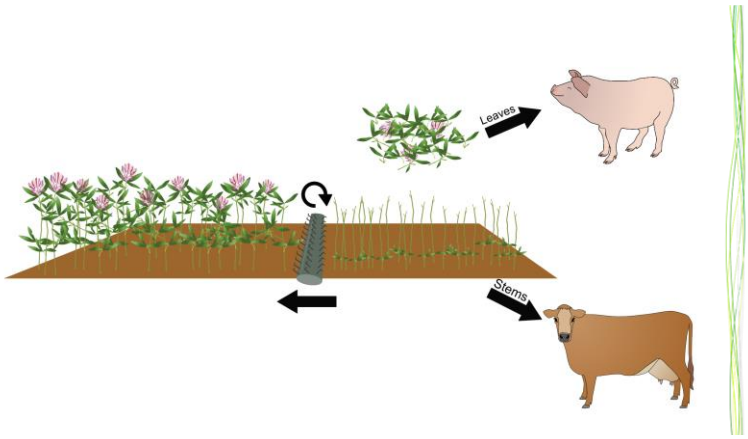

Illustration: Silage made from Lucerne defoliated stems is well accepted by bovines, sheep and goats and, when included in well balanced diets, can support milk yield and growing performance (© Brooke Micke, SLU).

Best harvest time

It is well known that as a plant matures its nutritional value decreases as the proportion of stem increases and they become more lignified, while leaf composition remains more stable. The best time for harvesting legume crops is from late bud to early flowering as it maximises the nutrient yield per hectare and results in a better quality of the pulp or the stems. Moreover, the juice extraction procedure is facilitated.

Photos: Experimental field with lucerne (left) and juice and pulp (right)

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How to preserve stems and pulp?

Stems and pulp have a high moisture content that makes them unstable. Stems could be field dried to make hay, but at the cost of losing most of the still attached leaves. Ensiling is the best alternative for stem preservation and is almost mandatory for the pulp.

The pulp has a dry matter content that allows direct ensiling but stems most often need to be shortly wilted in the field up to 30 – 40% dry matter. Depending on weather conditions, half a day could be enough. Alternatively, stems can be ensiled immediately after leaf stripping and mixed with some dry feeds like sugar beet pulp or cereal meal (100 – 200 kg/ton of fresh stems) to increase their dry matter content, avoiding seepage and improving the fermentation during storage.

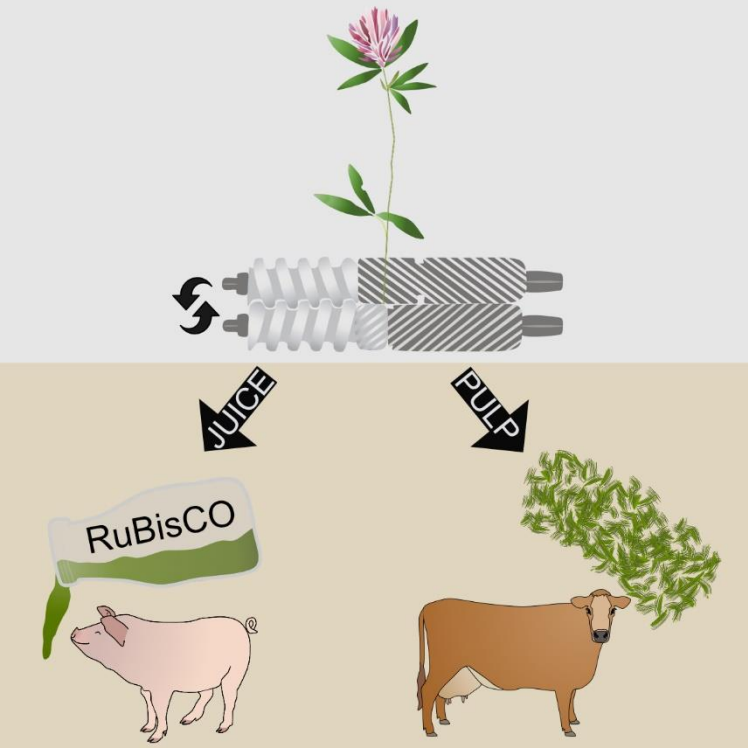

Illustration: Protein concentrate from green juice of biorefined forage legumes is rich in RuBisCo-protein and a valuable feed in pig production.

Biorefined lucerne pulp silage is well accepted by bovines, sheep and goats and, when included in well balanced diets, can support milk yield and growing performance (©Brooke Micke, SLU).

Nutritional information

Stems and pulp silage obtained from pure legume crops can be considered as novel feeds. In the literature, there is little information about them and in particular their use.

The ProRefine project produced original data of the composition and nutritional value of lucerne and clover whole plants and their derived fractions (leaves and stems, juice, and pulp) obtained in different European regions (tables 1 – 3). As already reported above, the nutritional characteristics of these feedstuffs can be highly influenced by genetic, agronomic and environmental factors that can vary widely between cultivation areas and years. Therefore, the data obtained within the project should be considered with some caution as they come from a single agronomic season.

How to use stems and pulp silage in ruminant livestock feeding?

Stems and pulp silages can be used for ruminant livestock feeding according to their chemical composition, that should be monitored before their use. Preliminary analyses carried out on the fresh product at ensiling can give valuable information on dry matter content, that will decrease by a couple of points percentage at feed out, and main components (crude protein, fibre, ash). At

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silo opening it will be advisable to check the fermentation profile: pH, ammonia and main organic acids (lactic, acetic, butyric) will provide a good picture.

When pure legume crops are used, the resulting stems and pulp silages undergo a marked heterolactic fermentation, exiting in a lactic to acetic acid ratio between 1 and 2. Although the silages could present a pungent odour of acetic acid, butyric acid is usually almost absent, and the silages are well accepted by animals. Their high content of acetic acid makes them quite stable when the silo is opened and they do not tend to spoil in a few days.

When stems or pulp silages, mainly from grass or grass-clover mixed crops were used as partial components of diets fed to ruminants no adverse effects were recorded and the animals performed as well as the control groups, usually fed more conventional forages. Although long terms effects have not been studied, there are no apparent reasons to foresee that they will perform differently from other silages of similar composition.

When harvesting takes place at the correct stage of development of the crop, i.e. at bud or early flowering, stems and even more so pulp have a good digestibility, and their protein content, although lower than that of the whole plant, still remains similar or higher than in many grass forages. Their inclusion in diets can be mainly based, like other roughages, on their chemical composition and the related digestibility, at least once the success of the ensiling process has been verified.

Their inclusion in the diet should be gradually completed over 1-2 weeks and during this period it is recommended to look at the animal response (as it should be done when every main change of the diet occurs):

- Is feed intake decreased or increased?
- Is faecal consistency changed?
- Do animals select more or less for TMR of different particle sizes?
- Is milk yield and/or composition changed?
- Any change in animal health?

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Practical recommendation

Stems and pulp obtained after selective harvest of the forage leaves or after screw-pressing of the whole plants, respectively, represent valuable feedstuffs for ruminant nutrition.

They can be ensiled directly (pulp) or after a short wilting or mixed with dry feeds (stems).

Their inclusion in animal diets should follow the same rules as for other silages, i.e. based on their composition and conservation quality.

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Tables

Table 1: Chemical and nutritional traits of lucerne and clover whole plant and biorefined co-products stems and pulp derived from experimental crops grown in Northern (Norway and Sweden) and Southern (Italy) European countries.

Crop	Area	Fraction	DM	CP	aNDFom	Ash	IVTDMD	$NDFD_{48h}$
			%	% DM	% DM	% DM	%	%
Lucerne	North	Whole plant	201	20.6	42.8	11.1	84.6	65.3
		Stems	163	19.9	50.2	11.7	78.6	58.8
		Pulp	362	19.7	60.1	7.2	79.0	66.3
	South	Whole plant	260	20.3	45.8	10.3	81.9	52.0
		Stems	270	12.1	57.1	8.6	69.2	41.2
		Pulp	401	14.1	62.2	6.4	72.0	51.4
Clover	North	Whole plant	144	19.8	39.2	10.1	87.6	69.3
		Stems	163	15.6	41.4	9.0	85.4	66.6
		Pulp	335	16.3	56.2	6.1	82.1	68.9

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Table 2: Chemical composition of whole plant, defoliated stems and pressed pulp obtained from lucerne crops harvested in North Italy.

Item	unit	Fraction	Range	
Dry matter	%	Whole plant	21.34	30.66
		Stems	22.51	31.57
		Pulp	36.62	43.50
Crude protein	% DM	Whole plant	16.90	23.55
		Stems	10.14	14.03
		Pulp	11.16	16.49
Ash	% DM	Whole plant	9.37	11.26
		Stems	7.85	9.26
		Pulp	5.35	7.35
aNDFom	% DM	Whole plant	41.22	50.78
		Stems	51.90	62.28
		Pulp	54.91	67.64
ADF	% DM	Whole plant	31.61	41.57
		Stems	43.42	53.01
		Pulp	41.85	54.57
ADL	% DM	Whole plant	9.14	11.09
		Stems	9.93	13.42
		Pulp	10.15	14.74
Sugars	% DM	Whole plant	3.69	6.27
		Stems	2.45	7.13
		Pulp	2.19	3.93
Starch	% DM	Whole plant	2.07	5.80
		Stems	1.90	2.75
		Pulp	1.81	5.84

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Table 3: Mineral contents of whole plant, defoliated stems and pressed pulp obtained from lucerne crops harvested in North Italy.

Item	unit	Fraction	Range	
Calcium	g/ kg DM	Whole plant	11.3	22.4
		Stems	5.5	14.0
		Pulp	7.5	18.9
Phosphorus	g/ kg DM	Whole plant	2.3	3.3
		Stems	1.7	3.0
		Pulp	1.4	2.2
Magnesium	g/ kg DM	Whole plant	1.7	2.3
		Stems	0.9	2.8
		Pulp	1.1	7.2
Potassium	g/ kg DM	Whole plant	19.2	26.7
		Stems	19.7	28.1
		Pulp	13.1	20.6
Sodium	g/ kg DM	Whole plant	2.3	5.3
		Stems	2.0	4.2
		Pulp	3.2	7.3
Sulphur	g/ kg DM	Whole plant	2.1	4.0
		Stems	1.4	2.1
		Pulp	1.5	4.8
Copper	mg/ kg DM	Whole plant	7.2	8.9
		Stems	6.0	8.0
		Pulp	5.5	8.3
Iron	mg/ kg DM	Whole plant	77.4	147.5
		Stems	43.0	75.2
		Pulp	54.1	80.1
Zinc	mg/ kg DM	Whole plant	23.3	41.1
		Stems	19.7	30.7
		Pulp	16.3	25.2
Manganese	mg/ kg DM	Whole plant	25.9	60.0
		Stems	13.4	28.4
		Pulp	16.3	41.3

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Working Paper

Further information

Weblinks

https://organic-farmknowledge.org/tool/36474

About this Working Paper and ProRefine

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