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Improving the nutritional quality of wheat straw by urea processing and molasses

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ABSTRACT

The straw is a feed with a poor nutritional value. It is poor in nitrogenous matter, in fat and in minerals. It is hardly digestible and a little part can be ingested by ruminants. As a consequence, it cannot match the physiological and production needs of the animal.

The development of the straw is important to supply an increasing demand. Indeed, we made a treatment of the wheat straw by urea (5 %) and molasses (10 %). The analytical control showed a clear improvement of the food quality and the nutritional value of the treated straw compared to the control (blank) feeds.

A remarkable increase was recorded for total nitrogenous matter, total sugars and fats. Concerning minerals, we noticed relatively high values for phosphorus, calcium and some magnesium.

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INTRODUCTION

The straw is a source of fodder for cattle which has to be considered. Its promotion depends on the efficiency of the technological process allowing to improve its nutritional value. It is a feed that has a poor nutritional value. It is mainly rich in cellulose and in plant cell walls. It is poor in total nitrogenous matter (TNM), in total fat (TF), in minerals and in vitamins[2].

The improvement of the nutritional quality of this feed is linked to various processes (chemical and biological). The determination of the chemical and energy features of the straw is an important stage to carry out a processing procedure which could be an interesting alternative, in particular in developing countries, and allows to improve and to reward the need of the straw in nitrogenous matter and in minerals.

The addition of urea as a source of nitrogen, and molasses as source of sugars and minerals allows to improve the content in nitrogenous matter. It increased from 0.77g/Kg of the DM (Dry Matter) to 98.40g/Kg of the DM for the straw with urea and molasses. A quite important increase was recorded, especially for phosphorus and calcium, the values were respectively 0.5g/Kg DM, and 1.6g/Kg DM for the blank sample and 0.93g/Kg DM, 4.14g/Kg DM for the straw with urea and molasses.

The chemical processing procedure of the straw is a profitable alternative regarding the energy side. The addition of urea and molasses allows to increase the energy value from 0.43 FU (Fodder Unit) for the straw alone to 0.67 FU by Kg of DM, and from 0.31 to 0.53 MFU (Meat Fodder Unit) by Kg of DM.

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MATERIALS AND METHODS

Chosen processes

The chosen tested processes are:

- Test n°1 : The proportions of urea added to the straw are 5%, 10%, 15% and 20%.
- Test n°2 : For the straw with 5% of urea different contents of molasses are added : 5%, 10%, 1 5 % and 20%.
- Blank : Straw only.

Process

The products were realized on samples with a humidity rate of 60% to 70% and under a temperature of 25°C. The duration of processing of the three tests was fixed to 30 days.

Determination of fat matter

The fat of the sample is extracted by a non polar solvent (ethanol). The solvent when it is boiling rises to the porous cartridge. Then, it brings the fat which is there. The operation repeated in several cycles, allows the extraction of the totality of the fat contained in the sample.

We weigh 5 grams of the prepared dry matter, we close with some cotton to avoid the leaching of dry matter particles with the solvent. We introduce the cartridge into the body of the Soxhlet extractor, then we put in a balloon glass previously tared, 3 to 4 agitating balls and 150 ml of hexane. We warm with a heating mantle, the balloon containing the hexane makes 20 to 25 cycles to catch the fat, then we evaporate the hexane by distillation with a rotavapor. Finally, we weigh the balloon containing the fat after cooling in the dessicator.Expression of the results :

F (%) = (m2-T)/m1 x MS (%) avec

(%) : Fat in g/100g of dry matter; m1 : mass of fat in g; m2 : mass of the balloon + fat in g; DM (%) : Percentage on dry matter.

Determination of total sugars content

Total sugars are determined by the phenol method. This method consists in taking 1 ml of the prepared sample solution in which we add 1 ml of phenol-water and 5 ml of sulfuric acid. The mixture is mechanically homogenized on a IKWERK-type vortex, then boiled for 5 min, after being kept in the dark for 30 min, the reading is made by a UKIVON 950-type spectrophotometer with 1 cm double optical rays at 490 nm. The blank is composed of distilled water and it is prepared in the same conditions. A standard curve is realized with concentrations of 0.3 g/l of glucose and 0.3 g/l of fructose.

Determination of ash content

50 grams of sample are put in a CORNING 16x125 tube for a pre-calcination. The obtained product is mineralized according to the program detailed in the TABLE 20, until we obtain a white residue (ashes). The residue is cooled in the dessiccator before weighing. The temperature is gradually increased according to the program detailed in the TABLE 1, in order to completely destroy organic matter and quite low to avoid the transformation in oxides that are hardly soluble.

TABLE 1 : Mineralization program

Temperature (°C)	25	150	300	480	500
Duration	1h	1h	1h	12 min	12h

Expression of the results

The ash content (C), in g/100 g of product is:

C (%) = [(m2-T)/(m1-T)]*100

With m1: Mass of the sample (g); m2: Mass of calcinated residue (g); T : Mass of the crucible (g).

Measurement of total nitrogen

Total nitrogen is measured by mineralization with concentrated sulfuric acid in the presence of catalysts. The product of the reaction (ammonium sulfate: $(NH_4)2SO_4$) is measured with hydrochloric acid. 1g of sample is put in the flask with a catalyst pastille and 10 ml of concentrated sulfuric acid. The flask is put under a hood, into the mineralization block and then heated at 450°C, during 2 to 4 hours until obtaining of a white viscous solution. The smoke is evacuated through a smoke catcher.

20 ml of boric acid with colored indicator are put in a flask with narrow neck and which fits to the extremity of the cooler of the distillation unit in order to sink the extension leaf into the solution of boric acid. The content of the flask is neutralized by 40 ml of sodium hydroxide and it is connected to the distillation unit. The distillation takes place during 6 to 10 minutes.

The distillate added by 20 ml of boric acid is di-

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rectly measured by the hydrochloric acid 0.1N until purple color change. The content in total nitrogen (N) in gram for 100 g of sample is expressed as below:

N (g) = (V-V°) x N (HCL) x 1.4/p

With V : Volume of HCL (0.1N) used for sample measurement (ml); V° : Volume of HCL (0.1N) used for the blank test (ml); N (HCL) : normality of hydrochloric acid (0.1 eq/l); p : in g of the sample.

The quantity of protein can be estimated by the use of the total nitrogen content with the application of the equation below:

Proteins (g) = 6.25xN (g)

Phosphorus measurement

After calcination and dissolution of ashes in HCL, the solution is crossed in a phial of 300ml and completed with distilled water until the gauge (solution A). 20 ml of the solution A are introduced into a phial of 50 ml, then we add 10 ml of vanadate-molybdate solution and we fill until the gauge line with distilled water. After a rest of approximately 10 minutes, the reading of the standard solution allows to determine the quantity of phosphorus by Kg of dry matter.

Calcium measurement

The measurement of calcium can be done according to the procedure below :

- Calcine the prepared sample in the oven at 525°C during 12 hours and cool the obtained product;
- Dissolve the ashes by adding 2ml of HCL precisely, heat until it boils;
- Filter out then by collecting the filtrate in a becher flask;
- Add 8 to 10 drops of the solution of bromocresol green and enough of NaOH concentrated at 20% to bring the pH to 4.8-5.0 (blue color of the indicator);
- Cover with a small glass plate and heat until it boils;
- Precipitate the calcium slowly by adding a solution of 3% oxalic acid drop by drop until the pH reach 4.4 – 4.6 indicated by the green color of the indicator. Avoid the excess of oxalic acid indicated by a yellow color showing an unwanted change of the pH.
- Boil for one to two minutes and let the mixture rest until it becomes clearer.
- Filter the water pump on a filtered glass, wash the becher glass and the precipitate with roughly 50 ml of NaOH (0.05N) in small portions, using for this, a squeeze bottle giving very small water jets.
- Put the filtered glass in a 2500 ml becher, add with 125 ml of water and 5 ml of HSO4 ;
- Measure between 70°C to 80°C with a micro-burette with KMnO4 0.05N until we have a pale pink color;
- Correct with a blank test under the same conditions;
- The reading of the solution is done with a spectrophotometer with a wavelength of 422.7 nm.

Potassium measurement

The determination of the potassium quantity is done by atomic absorption. Collected ashes are mixed with 0.15 ml of nitric acid in a 100 ml gauged phial. After complete dissolution, we complete the volume to the gauge line with distilled water. The reading of the optical density is made at the wavelength of 589 nm for potassium. The creation of a standard range for potassium from a solution which we know its concentration allows to determine the quantity of potassium in the solution prepared from ashes.

Magnesium measurement (oligo-element)

We did the same way as we did for potassium measurement except the fact that in that case, we made the dilution with HCL 0.1 mol/l instead of nitric acid at 0.01 mol/l.

RESULTS AND DISCUSSION

Chemical composition of straw

The TABLE n°2 shows the results of the physico-chemical analysis of wheat straw.

TABLE 2 : Results of the physico-chemical analysis of wheat straw

Parameters	Average values
Dry matter (%)	85.25
Ashes (g/Kg DM)	5.90
Total nitrogenous matter (g/Kg DM)	0.77
Total sugars (g/Kg DM)	1.50
Fats (g/Kg DM)	0.15
P (g/Kg DM)	0.50
K (g/Kg DM)	11.50
Ca (g/Kg DM)	1.60
Mg (mg/Kg DM)	0.60

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These results show that the straw is a feed with a poor chemical composition and its nutritional value is relatively low regarding nitrogen and minerals on the other hand it is rich in lignified tissues and in cellulose.

Energetical value of straw

TABLE 3 : Energetical value of straw

Energetical values/Kg (DM)	
FU	MFU
0,43	0,31

The wheat straw presents of low content in energy. Indeed the TABLE n°3 shows that the content in FU by Kg of DM of straw is 0.43 and the content in MFU is around 0.31. These two values remain comparable with the contents in FU and in MFU of a good quality straw that has the respective values of 0.45 by Kg of the DM and 0.35 by Kg of the DM. These values are similar to those found by Ait-Amar[1]. The recorded values still very low with compared to the contents of concentrated feeds.

Chemical composition of the straw with urea only and the straw with urea and molasses

TABLE 4 : Average values of the chemical parameters of the straw with urea and the straw with urea and molasses

Parameters	Average values	
	Straw+Urea (5%)	Straw+Urea (5%)+molasses (10%)
Total nitrogenous matter (g/Kg DM)	86.20	98.40
Fats (g/Kg DM)	0.31	1.17
Total sugars (g/Kg DM)	1.65	2.29
Phosphorus (g/Kg DM)	0.55	0.93
Calcium (g/Kg DM)	3.40	4.14
Potassium (g/Kg DM)	11.70	14.70
Magnesium (mg/Kg DM)	0.70	1.03

The TABLE n°4 shows the results of the analyses made on the processed straw with urea (5%) and the other processed straw with urea (5%) and with molasses (10%). The addition of these two compounds allows to improve the chemical and organic composition of the straw with compared to the blank test.

Results of the energetically values of processed straw

TABLE 5 : Energetically values of processed straw

Samples	Energetical values/Kg (DM)	
	UFL	UFV
Straw + Urea (5%)	0.56	0.44
Straw + Urea (5%) + Molasses (10%)	0.67	0.53

The TABLE n° 5 shows the results of the energetically value of the straw with urea only and the straw with urea and molasses.

DISCUSSION ET CONCLUSION

The straw is a feed rich in cellulose and in lignocelluloses fibers and has a very high content in cell walls, on the other hand the contents in nitrogenous matter and in minerals are very low. The nutritional quality of the straw can be improved by adding ammonia[5] and urea[6].

The calculated results show that the straw with urea and molasses is rich in nitrogenous matter (98.40g/Kg DM) compared to the straw only (0.77g/Kg DM) and the straw with urea that has a value of 86.20g/Kg DM. The values of total nitrogenous matter of the straw alone remain lower if they are compared with those of the straw with urea. These results are similar to those found by Ghiati[6]. The content of fat increased from 0.15g/Kg DM for the straw alone to 1.17g/Kg DM for the straw with urea and molasses. A clear improvement was noticed for the straw with urea and molasses. The average values of phosphorus, calcium,

potassium and magnesium were increased respectively from 0.5g/Kg DM, 1.6g/Kg DM, 11.5g/Kg DM and 0.6mg/Kg DM for the blank test to 0.93g/Kg DM, 4.14g/Kg DM, 14.70g/Kg DM and 1.03mg/Kg DM for the straw with urea and molasses.

The wheat straw has a low content in energy. Indeed the TABLE n°5 shows that the content in FU by Kg of DM of the straw with urea and molasses is 0.67 and the content in MFU is around 0.53 by Kg of DM. The values of FU and MFU of the straw with urea only are around 0.56 and 0.44 by Kg of DM, these are almost the same results found by M.Vermoryl[8].

The values recorded for the straw with urea and molasses are higher than those of the straw with urea and those of the blank test (FU = 0.43 /Kg DM and MFU= 0.31/Kg DM).

The complementation of this feed with urea and molasses has a positive effect for animal health. It allows the enrichment of the straw in nitrogen, in carbon and in minerals. These elements enhance the development and the growth of ruminants that require important energy spending to cover their vital and production needs. Incorrect concentrations of the urea and the molasses can have negative effects on the texture and the quality of the straw.

The urea processing appears to be interesting regarding its application and the regarding the obtained result. It is accessible thanks to its relatively affordable price and thanks to its handling ease and its easy use[3].

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