Hypercritical Separation Technology (HYST):

AN INNOVATIVE TECHNOLOGY FOR RESOURCE USE IN SUSTAINABLE ANIMAL FEEDING

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Introduction

The Hypercritical Separation Technology (HYST) is an innovative biomass processing technology having a great potential in the field of nutrition (both animal and human) and renewable energy. The process carries out the physical disaggregation of the plant tissues followed by multiple classification steps. It can be applied on all types of biomass (straw, wood, grape marc, residues of fruit and vegetable processing, etc.) and it requires only a small amount of electric energy, i.e. about 20 kWh/t. When applied to the animal production sector, the HYST processing of corn straw and cereal bran results in a significant increase of the nutritional value and digestibility of the processed raw materials.

The HYST process

Figure 1: The HYST plant used to process wheat bran and corn stover

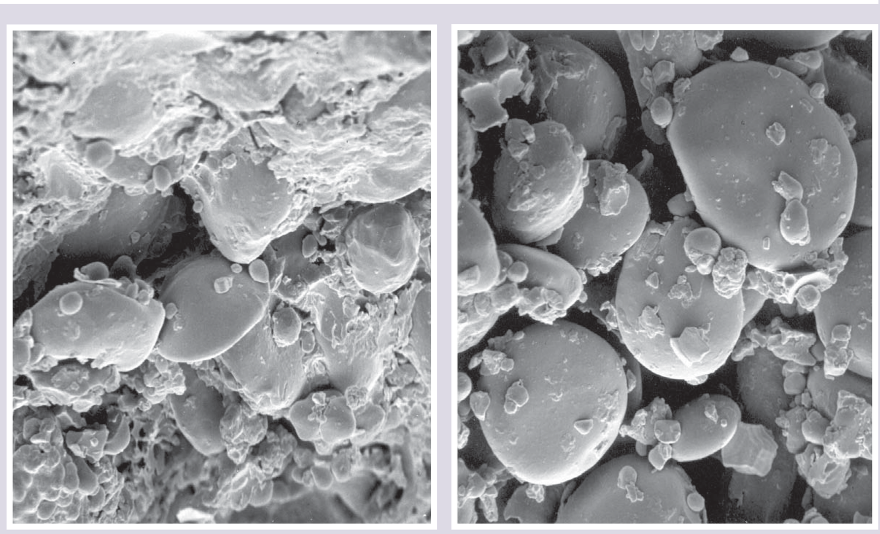

Figure 2: Effect of HYST process: scanning electron micrograph of barley starch granules (2500X) (Piva et al. 1986)
Left: milled barley
Right: HYST processed barley (F4 fraction)

The HYST technology operates a dry disaggregation of the vegetal structure by mean of high speed collisions and pressure variations induced in the air flow transporting the material to be processed. The disaggregated material is then separated into several fractions of different physical and chemical characteristics by centrifugal classifiers. HYST plants need about 20 kWh per ton of processed biomass, that should have a granulometry <5mm and a water content <15%.

Materials and Methods

Corn straw and wheat bran were processed in a HYST plant obtaining three fractions differing by granulometry, named G (Gross), M (Medium) and F4 (Fine), respectively. To evaluate the nutritional value of the HYST products, the in-vitro dry matter digestibility (DMD) and the neutral detergent fibre digestibility (NDFD) (NRC, 2001) have been determined and used for the calculation of Unité Fourragère Lait by using the in-vitro gas method (Menke and Steingass, 1988). The equation applied is the following:

$$UFL\ (n/kg\ DM) = EN_L/7.113$$

$$EN_L\ (Mj/kg\ DM) = 0.54+0.959\ GP24+0.0038\ CP+0.0001733\ EE$$

Where

DM: Dry Matter; GP24: gas production in 24 Hours, mL/ 200mg DM

CP: Crude protein; g/kg DM, EE: ether extract, g/kg DM

The processed corn straw has been also submitted to a biometanation test, in order to evaluate its behavior in an anaerobic digestion process under mesophilic conditions (35°C). The test was carried out at the RES Laboratories, Ravenna - Italy.

Acknowledgements

A special acknowledgment to Danilo SPERANZA and "Scienza per l'Amore" for having financed the research and the development of the Hypercritical Separation Technology.
A special acknowledgment to the inventor of the Hypercritical Separation Technology, Engineer Umberto MANOLA.

Results

The fractions obtained from HYST processing of corn straw and wheat bran present a composition different from that of the respective starting material, particularly as regards fiber and starch content and, in a minor extent, crude protein content (Tab. 1 and 2). The improvement in the nutritional value of these fractions has been confirmed by an higher digestibility of DM and NDF, as well as an improved Gas Production yield in in vitro testing (Tab. 3 and 4).
The finest fraction obtained from bran reaches a value of 1,07 UFL/kg DM (Tab. 3), comparable to that of wheat and barley flour. Likewise, the finest fraction obtained from straw reaches 0.64 UFL/kg DM (Tab. 4), as that of a common grass hay.
The HYST processing improves the overall NDF digestibility by 2.4% for straw and >7% for bran, when compared to the starting raw materials.

Tab.1: Chemical analysis of Bran before (sample B) and after (samples G, M, F4) Hyst processing (results in % dry matter)

Sample	Yield	CP	Starch	EE	NDF	ADF	ADL	Ash
B bran	-	17,5	15,5	3,4	44,9	14,6	6,8	6,4
G bran	0,4	18,0	17,0	4,0	48,9	15,2	8,4	7,2
M bran	0,4	18,4	16,8	3,9	48,0	15,4	8,3	7,1
F4 bran	0,2	18,8	37,7	3,6	17,6	6,3	2,5	3,5

Tab. 3: Nutritional value of HYST fractions (samples G, M, F4) from wheat bran (sample B)

Sample	GP24 (% DM)	DSS (%)	NDFD (%)	UFL/kg DM
B bran	48,9	80,6	59,8	0,89
G bran	48,9	81,2	66,4	0,89
M bran	48,5	81,9	66,3	0,89
F4 bran	57,8	89,2	69,4	1,07

Tab.2: Chemical analysis of Straw before (sample B) and after (samples G, M, F4) Hyst processing (results in % dry matter)

Sample	Yield	CP	Starch	EE	NDF	ADF	ADL	Ash
B straw	-	4,4	4,8	1,3	71,3	50,9	8,2	9,5
G straw	0,4	3,6	4,8	0,9	73,8	52,7	7,9	8,0
M straw	0,5	5,1	5,3	1,4	66,7	44,5	9,2	12,7
F4 straw	0,1	4,7	11,9	2,9	47,2	32,5	11,0	17,2

Tab. 4: Nutritional value of HYST fractions (samples G, M, F4) from mais straw (sample B)

Sample	GP24 (% DM)	DSS (%)	NDFD (%)	UFL/kg DM
B straw	28,3	55,5	44,9	0,48
G straw	25,4	51,3	41,6	0,44
M straw	32,6	61,2	48,4	0,55
F4 straw	37,1	72,8	56,7	0,64

Moreover, the lignocellulosic biomass (corn straw), once pre-treated with the HYST system, shows high biogas yield (2.5 to 2.8 times that from corn silage, Fig. 3) when submitted to anaerobic digestion for biogas production, also due to the good miscibility of the treated material in the digester sludge. The digestion rate is comparable to that of high starch-containing biomass, such as corn silage; moreover the F4 fraction shows a better biogas yield yet at 16 days of digestion (Fig. 4) (Adani et al. 2008).

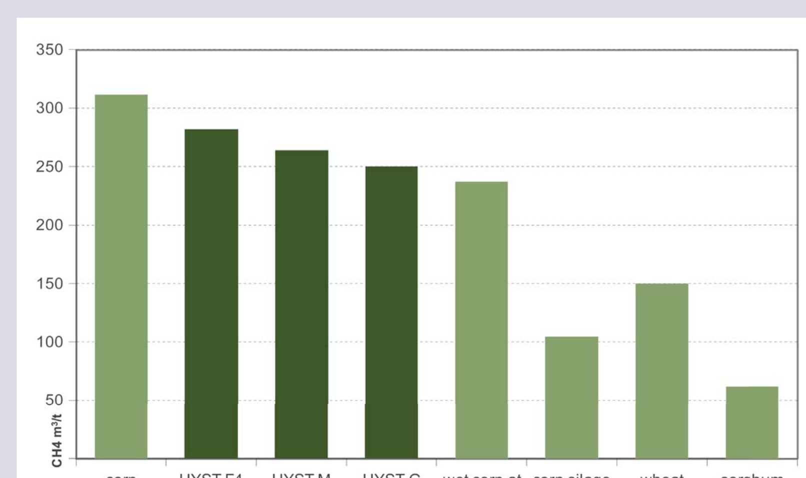

Figure 3: Production of biomethane from the HYST processed corn straw, as compared to other biomass matrices

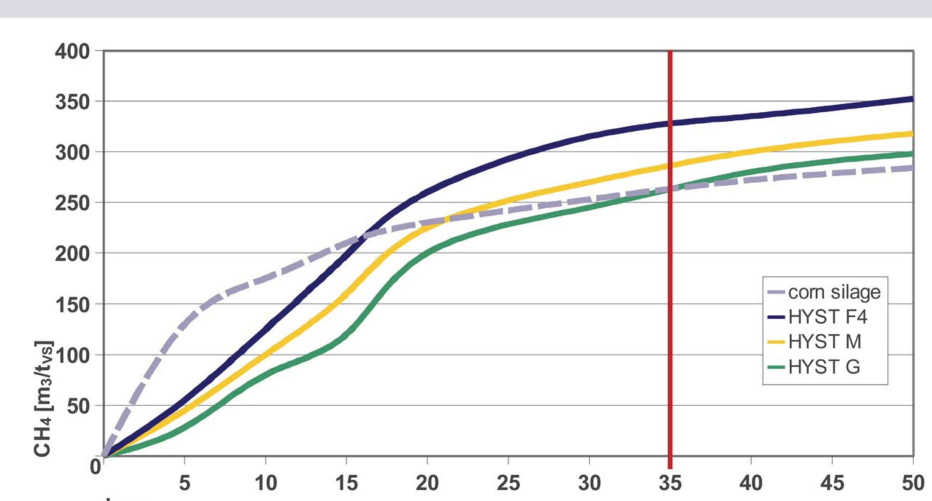

Figure 4: Methane production kinetics from corn silage as compared to HYST matrices obtained by corn straw processing

Conclusions

The above results, along with the reduced working costs, suggest that the HYST process is a valuable technology for resources optimization. In fact, the HYST processing allows to improve the yield and quality of biomass intended for animal feeding and to solve the waste biomass disposal problems, making biomass such as straws 100% usable for feeding or bioenergy production purposes.

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