Biorefinery of coffee by-products to obtain a feed ingredient and briquettes as energy source

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Introduction

According to the International Coffee Organization (ICO), EU countries are the most important worldwide coffee consumers with more than 2.5 million tons per year and 21 billion/year of coffee capsules. Coffee consumption involves a ratio of generation of around 2 kg of wet Spent Coffee Ground (SCG) from 1 kg of coffee consumed and around 18 g of wet SCG and 3 g of plastics and aluminium waste per coffee capsule (CC) (1). Hotels, Restaurants and Caterings (HORECA) sector arises as one of the main responsible sectors for this generation.

Around half of this SCG is landfilled and almost all the CC are managed as waste with the subsequent soil, water, and air pollution. A solution for large SCG volumes sent to landfills is necessary. Several studies have demonstrated that SCG has high potential as secondary feedstuff for animal feed (2, 3, 4). However, the efficiency of the stabilization process is of utmost importance as its high moisture content makes them rapidly biodegradable due to the microbial activity. Traditional drying processes are energy intensive processes and most of them economically unfeasible at industrial level. Hence, low energy consumption drying emerges as an alternative.

In addition, it is necessary to use a cheap energy source to make the whole process more efficient and, therefore, profitable. In this sense, the SCG which comes from coffee capsules is not suitable for animal feeding due to the presence of undesirable substances and it is proposed to be used as the source of energy for making more efficient the drying of SCG. However, before producing pellets, the organic part of the coffee capsules must be removed from the inorganic part by applying a decapsulation process.

Within this framework, the present study proposes to valorise SCG to obtain an ingredient for animal feed, including the use of briquettes formed with SCG as an energy source.

Material and methods

The SCG and CC samples were collected in Basque Country region in Spain.

The decapsulation process of coffee capsules was performed by applying a process based on 3 phases: 1) Crushing 2) First sifting of coffee and coffee + packaging 3) Eddy. The organic part is used to produce briquettes that were used in the drying process, whereas the inorganic part of coffee capsules (aluminium and plastics) was recycled to produce new products such as containers or chairs.

The stabilization and adaptation of the SCG to the needs of the animal feed sector was performed using RINA-JET turbo-dryer (Figure 1). This technology is suitable for thermosensitive products.

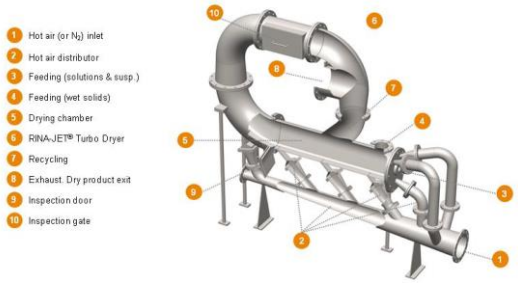

Figure 1. Diagram of the RINA-JET turbo-dryer.

The nutritional value of the ingredients prototypes was measured by applying the Association of Official Analytical Chemists (AOAC) Official Methods. Then, a digestibility test was carried out with the aim of determining its digestibility. Afterwards, feeding trials with animals have been performed to assess the suitability of these ingredients for animal feeding. Finally, sensory tests were performed to ensure the suitability of the obtained milk.

Results and discussion

The decapsulation process has been shown to be suitable for separating the organic part (SCG) from the inorganic part (aluminium and plastics). However, the separation does not meet the requirements of feed raw materials for the total absence of undesirable substances and therefore cannot be used for animal feed. As an alternative, the production of SCG briquettes from the decapsulation process is proposed.

SCG briquettes production has proven to be suitable, and the operational conditions have been defined. Obtained briquettes have been used in the drying of wet SCG as an energy source.

The wet SCG has been successfully dried in a RINA-JET turbo dryer and the operational conditions have been defined. Then, the nutritional composition of coffee grounds used for animal feed (Table 1), are characterized by their high-water content but also by their high fibre and fat content (between 5 and 9 %).

Table 1. Chemical composition of spent coffee ground-based ingredient obtained in different time points.

ID	DM %	Ashes %	Ca %	P %	K %	Mg %	Crude Fat %	Crude Protein %	ADF %	LIGNIN%	NDF %	ADFCP %	NDFCP %
1	90.77	1.25	0.14	0.10	0.32	0.13	8.05	15.17	47.16	19.85	70.92	3.71	6.69
2	93.15	2.57	0.14	0.14	0.73	0.13	8.19	14.90	40.84	17.59	71.30	2.59	6.53
3	94.17	1.62	0.14	0.10	0.50	0.13	8.55	15.07	43.00	19.72	69.55	3.27	6.48
4	91.48	2.25	0.14	0.12	0.55	0.13	7.59	15.13	45.14	18.32	71.55	3.23	6.69
5	93.33	3.06	0.14	0.15	0.82	0.13	8.03	14.94	41.49	17.36	69.88	2.63	6.30
6	91.76	2.51	0.14	0.13	0.64	0.13	7.50	15.10	44.77	18.35	71.42	3.26	6.74
7	94.25	2.18	0.14	0.07	0.24	0.14	9.48	15.08	44.85	23.18	70.96	4.19	7.05
8	91.90	1.32	0.14	0.10	0.39	0.13	7.05	15.21	45.39	19.15	69.60	3.52	6.69
9	92.75	1.24	0.14	0.08	0.46	0.13	5.97	14.73	44.07	24.66	80.97	4.80	9.72
10	90.77	1.61	0.14	0.03	0.36	0.13	6.88	14.57	37.34	29.54	84.31	3.73	9.75
11	93.58	1.15	0.14	0.08	0.49	0.13	6.33	14.87	42.87	24.13	74.54	4.51	9.03
12	93.29	1.01	0.14	0.07	0.36	0.13	7.14	14.76	45.81	25.27	75.22	4.83	9.45
13	94.44	2.77	0.14	0.05	0.35	0.13	6.24	14.62	38.57	29.07	79.57	4.37	8.31

The obtained ingredients have been tested in ruminants: dairy cattle and sheep, and the obtained results of growth performance have shown no statistical differences with the control at 10 % of inclusion level. Finally, sensory tests haven also developed with the obtained milk with the same results.

Conclusions

Spent Coffee Ground (SCG) are not currently valorised, and they are managed as a waste. This involves that they are an available and cheap raw material with high potential to be valorised.

The decapsulation process has been demonstrated suitable for separating the organic part from the inorganic part. The presence of undesirable substances limits the use of organic part in animal feed applications.

The production of briquettes with the SCG makes the drying process more efficient.

Flash drying is presented as a suitable technology to adequate them to the feed industry requirements.

Obtained results in the animal feeding trials and sensory tests have shown that SCG based ingredients are suitable for animal feeding.

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