# Assessment of a Big Square Baler Able to Reduce Soil Impurities During Baling Process. First Evaluations

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**Abstract** In animal husbandry, results optimization is largely dependent on how the animals are fed so fodder-crops have a fundamental role in this sector. Dried fodder production has relevance in Southern Italy, even if in this territory the agronomic and meteorological conditions generate physical and micro-biological problems in the production of fodder. Some of the fundamental complications are connected to the amount of soil inside the fodder, which often is the vehicle of a large number of CFUs (colony forming units) of Clostridium bacteria, that could have dangerous effects on the welfare of the cows.

The aim of this paper is the evaluation of the performance of a large square baler, manufactured in Southern Italy, equipped with innovative devices which should allow to make prismatic bales compact and with less impurities if compared with the bales produced by similar square presses, built by other manufacturers. The presence and the amount of soil and impurities was assessed through first comparative tests carried out, considering also other two similar square presses. The obtained results, even if have to be validated through other in-depth tests, seem to confirm the benefits of the adopted technical solutions of the analysed large square baler.

**Keywords** Big square baler · Straw · Hay · Zootechny

## 1 Introduction

Hay bales are fundamentally used within the zootechny for the feeding of the animals and in this connection the quality of the fodder-crops is basic in the Euro-pean agricultural and economic sector [1]. Several mechanical treatments are involved in the manufacturing of big bales in order to obtain hygiene nutritive forage, even if the

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drying of the forage is accompanied by a competing process of deterioration which can lead up to the loss of nutrients and toxic metabolic products [2]. Unfortunately, the production of fodder in Central and Southern Italy is affected by agronomic and meteorological conditions which generate physical and microbiological problems. Some of the fundamental complications are: (i) the high content of clostridia; (ii) the presence of terricolous anaerobic bacteria; (iii) the dried fodder bales high humidity rate [3]. The number of Clostridium genus bacteria colony forming units (CFU) is largely affected by the presence of soil residual inside the fodder; this event could have effects both for cow wellness and for the quality of milk and of its products [4, 5].

It's well know that balers pick up loose straw or hay and then the compress the picked product into same size and weight bales tying with twine [6–10]. Obviously, these machine have to be designed and set up in agreement with the safety laws in force, in order to carry out all the operation in compliance with the operators' safety [11–17]. The efficiency of a large square baler, produced by Southern Italy manufacturer, having the characteristic of an high cleanliness of the dried fodder is the final goal of this paper.

## 2 Cicoria HD 1270 Baler

The machine under test is the large square baler, Cicoria HD 1270 (hereinafter "Cicoria's machine") (Fig. 1).

This machine is equipped with a system that feeds from the top the pressing chamber, so allowing the baling to be optimized, making bales compact and with less impurities [18–21]. The feeding from the top greatly improves the cleaning of the product without damaging it, and without changing the nutritional level, thus obtaining a high-quality hay suitable for zootechnical feeding. The separation of soil and stone residues occurs by force of gravity without energy consumption during the quite long way carried out from the product before entering the compression chamber [22–25]. The thrust mechanism of the piston can produce a force of 18 ×


**Fig. 1** Cicoria HD 1270 baler under test

$10^3$ kg in the pressing chamber and the compression of the product does not take place with a rectilinear sliding of the piston in the chamber, but through a semi-circular movement caused by the action of a system of rocker levers [24–27]. This compression system, absolutely different from the solutions commonly adopted on the market, allows a considerable reduction in the energy absorption of the machine. The piston can perform up to 48 strokes/min, with a higher stroke of 76 cm and a lower stroke of 36 cm requiring a power of 50–60 kW at the PTO (1000 rpm) of the tractor, considerably lower than other machines on the market with the same operational capacity. The supply chamber volume ranges from 0.63 to 0.92 $m^3$, and the baling capacity in terms of bales density varies according to the material: a) density of 180 kg/$m^3$ for straws; b) density of 260 kg/$m^3$ for fodder [26–32].

## 3 Materials and Methods

The presence and the quantity of soil and impurities inside the straw bales set up by the large square baler Cicoria HD 1270 was assessed by experimental tests in which different samples of straw were collected from prismatic bales produced both by the Cicoria machine and by the other two producers' similar square presses that, in the following, are named "producer 1" and "producer 2". The samples were gathered according to a randomized block experimental scheme in order to statistically evaluate impurities and soil quantity. Therefore, three theses were considering, corresponding to the samples obtained from the bales obtained respectively by: the Cicoria machine (thesis 1), the machine "producer 1" (thesis 2) and the machine "producer 2" (thesis 3). For each thesis three repetitions were considered. The collected samples were then processed in Dept. of Agricultural and Environmental Sciences – University of Bari Aldo Moro laboratory, in agreement with the following phases: a) the samples were subjected to ventilated drying at 65 °C for 3 h in a forced air oven ARGOLAB model TCF 200 (Argolab-XS Instruments srl, Carpi – Italy), in order to remove the humidity and stand-ardize the initial conditions for all the samples object of the case study; b) the sample were ground by means a RETSCH model 5657 grinder (Retsch Italia-Verder Scientific srl Industria, Torre Boldone, Bergamo district, Italy), to have 2 mm fineness; c) with ABT model 220-5DM (KERN & SOHN GmbH Industry – Balingen – Germany) electronic analytical balance, has been used a quantity of 2 g from each ground sample and placed into an furnace heat-resistance cup. A number of nine cups (considering the theses and the repetitions) were prepared. The filled cups were put, for 24 h at a temperature 550 °C, inside a Zetalab ZA (Zetalab s.r.l. Industry – Padova – Italy) muffle furnace for drying purpose. At the end of drying, cups contents were weighed to evaluate the difference between the initial and dried state in order to calculate percentage of the ashes content.

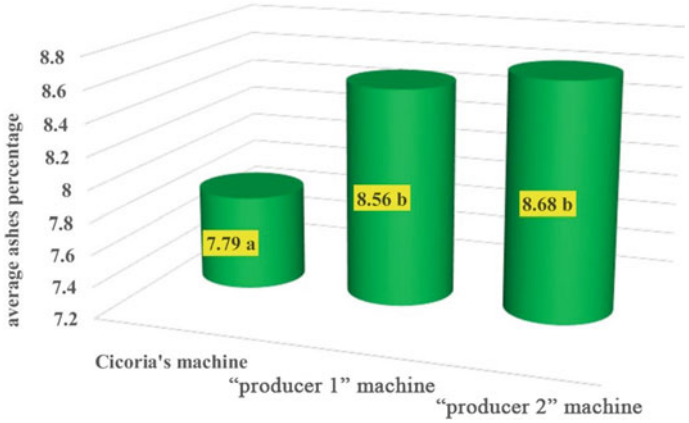


**Fig. 2** Statistical analysis results of straw from the three compared balers data

## 4 Results and Discussion

To statistically analyze the data related to the three theses straw samples was carried out a variance analysis and significance level of 0.05% "Duncan" tests were adopted to compare obtained average values [33, 34]. The results emphasize that the Cicoria's machine produced straw bales with an average value of 7.79% as content of impurities and soil. This value is about 10% lower than machine by "producer 1" average value and 11.4% lower than the machine by "producer 2". Furthermore, it is significant the difference among the ashes percentages for the samples obtained from, respectively, the Cicoria's machine (thesis 1) and the "producer 1" (thesis 2) and "producer 2" (thesis 3) machines. Finally, it is not significant the difference between the ash percentages concerning the "producer 1" (thesis 2) and "producer 2" (thesis 3) machines (Fig. 2).

## 5 Conclusions

First experimental evaluation of the performance of the "Cicoria Square Bales" HD 1270 large square baler were carried out. This machine is equipped with innovative devices, which improves the effectiveness in producing square bales using less energy despite other machines. The obtained results, even if have to be validated through other in-depth tests, seem to confirm the benefits of the adopted technical solutions. Further tests are in progress to better evaluate square bales content of impurities and soil, considering different operative conditions such as the type of swath, the harvesting height from soil and the soil texture and humidity.

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