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## RESEARCH ARTICLE

# MECHANIZED UREA TREATMENT OF WHEAT STRAW (PART II: MODIFICATION OF SMALL RECTANGULAR BALER AND EVALUATION OF TREATED STRAW)

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**ABSTRACT**

The conventional urea treatment of cereal straw process is a laborious, tedious and time-consuming task. It is essential to facilitate or eliminate some of these operations by using machine. For this purpose, the small rectangular baler model 349-T was selected for optimizing and setting up the mechanical urea treatment systems. Based on the calculation, the required mechanisms were made and installed. The machine performance was evaluated in the farm condition by treating the straw mechanically. The nutritional value of treated straw was measured and compared with the straw that treated in conventional method. The experiments showed that there is no significant difference between two methods of treatment. Machine capacity is about 2 ton/hr and the usual (medium) tractors can be used for this purpose.



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## INTRODUCTION

Straw is the most abundant of all agricultural residues. In general, straw is used for burning, composting, papermaking and animal husbandry. The main component of straw is fiber, including cellulose and hemicelluloses. Some cellulose and hemicelluloses are bound to lignin and resistant to microbial attack. Cereal straws are an important feed resource in Iran and many developing countries and despite of its low digestibility, a significant amount is fed to ruminants. Treating consists of physical, chemical or biological processes which allow modification of the physical and chemical properties of the lignified walls of the forages so as to render them more accessible to the rumen's microorganisms and hence, more digestible (Guo *et al*., 2002). There are three broad categories of treatment: physical, biological and chemical. In fact, except for mowing, physical treatments are too onerous and their execution requires availability of complex machinery. As regards biological treatments, these still remain technically delicate to put into practice (Chenost and Kayouli, 1997).

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Chemical treatment using Naoh and ammonia either in anhydrous or aqueous forms has been practiced in developed countries to improve the nutritive value of straws (Han *et al*., 1983 and Sundstol and Coxworth, 1984). Ammonia treatment improves the digestibility of straw and low quality forages. Ammoniation usually increases digestibility by 20 percent and CP content up to 1-2 times. It can also improve palatability and consumption rate. The total nutritional value can be doubled. The sources of ammonia to treat straw include anhydrous ammonia, urea, ammonium bicarbonate and aqueous ammonia. Straw treatment with anhydrous ammonia is requires some expensive equipment. Furthermore, anhydrous ammonia is not well suited for private farmers because of its dangers (Guo *et al*., 2002). Urea can be an inexpensive source of ammonia for the treatment of straws. Treating straw with urea does not need complex equipment and the sealing conditions are not as strict as with anhydrous ammonia. Urea can be transported conveniently at normal temperature and pressure and it is harmless to humans. The use of urea as a source of ammonia is one of the best alternatives for treating straw in developing countries. Urea dosage needed to treat straw may vary a lot. The recommended dosage is 4-5 percent urea on DM basis (Jackson, 1978; Dolberg *et al.,* 1981; Jayasuriya and Perera, 1982; Imbrahim and Pearce, 1983).

Conventional urea treatment consists of spraying urea solution onto the dry mass of forage and covering the treated straw with materials available locally, so as to form a hermetic seal. Practical conditions affecting successful treatment include the presence of ureas, the application rate of urea, moisture content, ambient temperature and the length of the treatment period, sealing condition and the quality of the forage to be treated. In practice 50 liters of water added to every 100 kg of forage. There is no problem if the amount of water added varies within the range of 40 to 80 liters. The final moisture content should never be greater than 50%. Treatment time varies inversely with temperature. More than four weeks are needed at a temperature of 5-15°C, but only one week at >30°C (Chenost and Kayouli, 1997).

At present, the conventional methods that used for ammonia treatment of straw in Iran, includes stack and silo methods and has done on the straw that collected form the field (Raisianzade *et al*. 2005). The procedure for the stack method is as follows: First, an area is selected with an elevated, dry and even surface. This area is covered with plastic sheet and loose straw is stacked on it. About 5 kg of urea are dissolved in 50 liters of water for every 100 kg of dry straw. The urea solution is sprayed into straw layer by layer, whilst the stack is constructed. Then the whole stack will be cover with a second and much wider plastic sheet, making sure that coverage is the best possible. Surface silo constructed with cement (Figure 1), also has been used for urea treatment of straw (loose form of chopped or long straw).

**Figure 1. A kind of silo which used for urea treatment (Iran)**

The size of silo is depended on animal type and quantity. One Silo of 2 $m^3$ can hold 300 kg of wheat straw. In this method, straw is chopped and then urea is added to water and stirred to completely dissolve it. Normally, 5 kg urea and 40-60 kg water is used for 100 kg dry matter of straw. Next, the urea solution is sprayed repeatedly over the straw. Before loading the silo, straw can be spread in an open area to facilitate uniformity in spray application. While straw is added to the silo, each layer will be compacted till the silo is full, and then it is covered with plastic film.

At present a substantial quantity of straws is wasted or poorly utilized in Iran. The conventional urea treatment process is a laborious, tedious and time-consuming task and is not used by farmer. The treatment process involves a number of laborious and tedious tasks such as handling and mixing of large quantities of straw. It is essential to facilitate or eliminate some of these operations by using machine (Raisianzade *et al*. 2005). Low-density (<100 kg/$m^3$) cube baler is used to collect and compress hay or straw in Iran. It makes bales from the straw windrow left by the combine and it is powered from the power take-off shaft (P.T.O.) of the tractor. The straw windrow is lifted from the ground by a pick-up reel having spring teeth and transferred continuously to a conveying and feeding mechanism as the baler moves forward along the windrow. Therefore, one possible way for mechanized urea treatments of straw in this condition is, to spray the urea solution on straw when it is harvested from the field.

The objectives of this research are: 1) modification and installation of spraying systems on small rectangular baler on the base of former studies (part I) and 2) evaluating the modified baler by comparing the mechanized urea treated straw with conventional method and determining the machine capacity for this method.

## MATERIALS AND METHODS

The small rectangular baler model 349-T was selected for installing the spraying systems and making baler as a Cereal Straw Urea Treatment Machine (CSUTM). Modification and installation of spraying systems on small rectangular baler has done on the base of former studies (Part I: Determination of Wetting Properties of Wheat Straw). The systems consist of: a pump, a urea solution tank, a regulator and 20 flat fan nozzles. Then the required power, required flaw rates and pump type, frame and tank (container) capacity were selected in the basis of former studies (Part I). By installing these parts on baler, the Cereal Straw Urea Treatment Machine (CSUTM) was formed (Figure 2). The CSUTM performance was checked in the farm condition and malfunction was corrected. The feed (amount of straw per meter) and baling rate (tractor speed) were measured in order to find an optimal urea solution that should be sprayed. Five percent of urea solution was obtained and the tank filled with it. The nozzles flow rates were adjusted and CSUTM connected to the power take-off shaft of tractor (P.T.O.), for preparing Mechanized Urea Treated Straw (MUTS). The tractor moved in windrow straw (pishtaz variety) left by the combine and the MUTS bales were formed. After initial 5 bales, 3 MUTS bales were collected for determination of moisture content and some nutritional value.

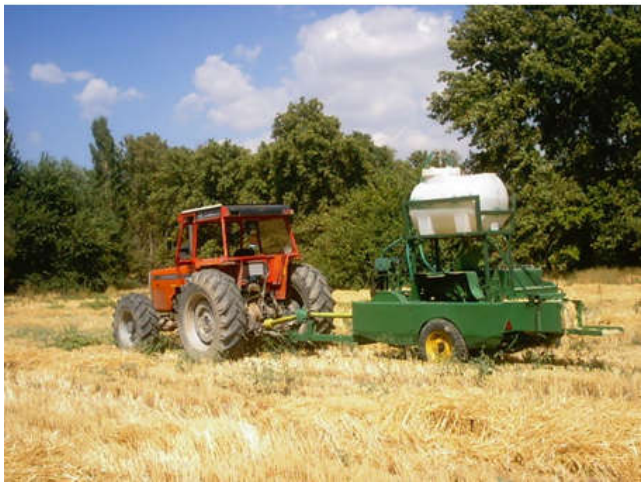

**Figure 2. Cereal Straw Urea Treatment Machine (CSUTM)**

The later three selected MUTS were lie under plastic film in farm condition for one month in summer (Figure 4). At the same time the conventional method was used for treating chopped straw with 100 cc water and 5 g urea for every 100 g dry straw. The straw was chopped to about 2 cm long and then the urea solution applied on it and was fully stirred. Treated straw, then placed in PVC bags and put it under plastic sheet near the MUTS bale stack for one month (Figure 3 and 4). Dry matter (DM), ash, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), dry matter digestibility (DMD), crude protein (CP), organic matter digestibility (OMD) of treated and untreated straw samples have been determined and the obtained data were analyzed.

**Figure 3. Conventional method which used for urea treatment of chopped straw**

**Figure 4. Mechanized treated straw in plastic sheet**

## RESULTS

The nutritional values and digestibility of straw samples were showed in Table 1 and 2. The dry matter content of untreated straw was 92.03, which reached to 49.93 and 47.25 in two methods. Also, the value of DMD changed from 30.00 in untreated straws increased to 44.63 and 42.29 in conventional and mechanized methods respectively (Table 1). The differences between two methods were not significant ($P<0.05$). The mean value of crude protein of untreated straws was 1.52, which increased to 4.53 and 3.81 percentages in two methods.

## DISCUSSION

Spray uniformity were checked by inspecting the moisture content of treated straw. Mean value of moisture content of the treated straw in the side and center of the bales were 52.53 and 48.40%, respectively. In spite of the higher moisture content in the side of the bales, the differences were not significant. Effective field capacity and effective material capacity of mechanical urea treatment (CSUTM) were 0.41 ha/h and 2.05 t/h respectively. The maximum required power for running the installed systems (SUTM), was about 5.07 kW, 3.3 kW of which was attributed to the weight of spraying systems on the baler and the rest to the running of the pump. The experiments result of using the STUM in the actual field showed that the designed machine could treat and baled the cereal straw in the field condition. The additional required power for running the installed systems is about 5 hp. Mechanized urea treatment improved the dry matter digestibility (DMD) of wheat straw and made it at least equivalent to conventional methods (Table 2). The differences between nutritional values in two methods of treatment could be produced because of unequal conditions of treating. In mechanized methods dusts and additional materials could be entered to baling system, whereas in conventional method the unfavorable conditions were more controlled. Beside in mechanized method uniformity of moisture was less than conventional method. The reason is that mechanized treatments were done in field and large scale, but

**Table 1. Comparing nutritional values of wheat straw with treated straw**

| Methods of treatment | DM | Ash | CP | CF | NDF | ADF | ADL |
|---|---|---|---|---|---|---|---|
| Untreated straw | 92.03 $^{a}$ | 7.03 $^{a}$ | 1.52 $^{a}$ | 43.53 $^{b}$ | 79.66 $^{b}$ | 47.93 $^{c}$ | 6.06 $^{b}$ |
| Conventional | 49.93 $^{b}$ | 6.30 $^{a}$ | 4.53 $^{c}$ | 47.03 $^{a}$ | 80.93 $^{b}$ | 50.80 $^{b}$ | 7.66 $^{a}$ |
| Mechanized (CSUTM) | 47.25 $^{b}$ | 6.40 $^{a}$ | 3.81 $^{b}$ | 47.09 $^{a}$ | 82.00 $^{a}$ | 53.40 $^{a}$ | 7.46 $^{a}$ |

**Table 2. Comparing digestibility of wheat straw with treated straw**

| Methods of treatment | DMD | OMD | DOMD |
|---|---|---|---|
| Untreated straw | 30.00 $^{b}$ | 27.64 $^{c}$ | 25.92 $^{c}$ |
| Conventional | 42.29 $^{a}$ | 43.84 $^{a}$ | 41.08 $^{a}$ |
| Mechanized (CSUTM) | 44.63 $^{a}$ | 40.15 $^{b}$ | 37.68 $^{b}$ |

conventional method is done by hand in laboratory and small scale (Figure 3).

**Conclusions**

- There is no significant difference between DMD of treated straw in two methods (conventional and mechanized) treatment.
- The system (CSUTM) has the capabilities of work in farm condition.
- The current tractor (medium tractors) can be used for making nutrition and baling the straw with CSUTM.

These data analyzed from the results of this experiment and more research and details are required to evaluate the performance of machine and this method of treatment. With Installing spray systems on a conveying and feeding mechanism of cube baler, straw can be collected, treated and compressed simultaneously. The handling task could be minimized substantially, and the mixing task could be eliminated altogether if urea solution were applied into the straw in this method. For this purpose, the rectangular baler model 349-T was selected to optimize and setup the mechanical treatment systems. The objective of this paper is: Treating straw with urea solution by Cereal Straw Urea Treatment Machine (CSUTM) and evaluating the system by comparing the treated straw with conventional methods (Figure 3).

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