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Effect of drying temperature on in vitro gas production and energy content of wheat dried distillers' grains using mixed rumen micro-biota obtained from Holstein steers

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***Abstract*—** The aim of the present study was to evaluate the effect of drying temperature on in vitro digestibility of organic matter (DOM), metabolizable energy (ME) and net energy for lactation (NEL) values, and drying efficiency of wheat dried distillers' grains (WDDG), applied a tower heat-dryer system, using mixed rumen micro-biota obtained from Holstein steers. The technology was developed to dry WDDG when it was flew constantly through a tower (10 m length) against a current of pressure of heated air at 185 °C (LAT) or 246 °C (HAT) with a pressure suction cooling. Dried samples were obtained from the lowest and the highest applied temperature, then ground to pass through a 1-mm screen and subjected to a gas production technique. Rumen content was collected from four ruminally fistulated steers (420±13 kg, body weight) and strained through 4 layers of cheesecloth. The laboratory handling of rumen fluid was carried out under a continuous flow of CO2. In vitro incubation of the samples was done using a manual pressure transducer technique. Approximately 200 mg of each sample was weighed into a 120 ml serum bottle (n= 8). The bottles were pre-warmed at 38.6 °C before the injection of 30 ml rumen fluid-buffer mixture (10 ml rumen fluid and 20 ml buffer solution) into each bottle followed by incubation in a water bath at 38.6 °C. Gas pressure was recorded after 2, 4, 8, 12 and 24 h of incubation and converted to gas volume using experimentally determined calibrated curve. Metabolizable energy, NEL and DOM values of the samples were calculated using following equations: ME (MJ/kg DM)= 1.56 +0.1390 GP +0.0074 XP +0.0178 XL; NEL (MJ/kg DM)= 0.1010 GP +0.0051 XP +0.011 XL; DOM (g/kg DM)= 14.88 +0.8893 GP +0.0448 XP +0.0651XA. Where GP is net gas produced after 24 h of incubation (ml/0.2 g DM), and XP, XL and XA are crude protein, crud fat and ash content of the feed (g/kg DM), respectively.

Data were analysed using the GLM procedure of SAS. Results indicated that air temperature of the new drying technique had a significant (P< 0.05) effect on ME (MJ/kg DM), NEL (MJ/kg DM) and DOM (LAT= 9.7, 5.7 and 610, HAT= 10.0, 5.8 and 640, respectively) of the WDDG samples evaluated. Results indicated that the drying process of the samples dried at the air temperature of 185 °C was less efficient than the highest applied temperature, as observed in 9.8% of more consumed drying time with similar moisture output compared with the HAT samples. Therefore, the highest air temperature used in present study was more the efficient and safe for drying and enhancing the nutritive values of the WDDG samples evaluated.

***Keywords*—** digestibiliy, metabolizable energy, net energy, wheat wheat dried distillers' grains.

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I. Introduction

NON-FORAGE sources of fiber have a low lignin content and large proportion of potentially digestible fiber that supply energy needed for lactation without the ruminal acid load caused by rapidly fermented starchy concentrates. Non-forage sources of fiber also may serve as partial replacements for forage fiber in those situations where forage availability is limited. Compared with most forages, non-forage sources of fiber typically have a smaller particle size and relatively high specific gravity which promote particle passage from the rumen.

Wheat dried distillers' grains (WDDG) have high moisture which caused to give problems associated with their mould contamination and conservation. Two methods exist to remove these problems, are ensiling and drying. The effect of heat drying on organic matter digestion in the rumen and small intestinal and energy availability depends on the feed moisture, applied temperature and time consumed to drying [1]. The in vitro gas production technique has proved to be a potentially useful technique for feed evaluation. It has been suggested that the gas volume after 24 h of incubation has a relationship with

metabolizable energy in feedstuffs [2]. It was reported that gas volume is a good parameter to predict digestibility, fermentation end-product and microbial protein synthesis of the substrate by rumen microbes in the in vitro system. Additionally, in vitro dry matter and organic matter digestibility were shown to have high correlation with gas volume [3].

The aim of the present study was to evaluate the effect of the air temperature on the digestibility of organic matter (DOM), metabolizable energy (ME) and net energy for lactation (NEL) values, and processing drying efficiency of wheat dried distillers' grains dried applied a tower heat-dryer system, using mixed rumen micro-biota obtained from Holstein steers.

II. Materials and Methods

A tower heat-dryer was developed to dry WDDG when it was flew constantly through a tower (10 m length) against a current of pressure heated air from 185 °C (LAT) to 246 °C (HAT) with a pressure suction cooling. Dried samples were obtained from the lowest and the highest applied temperature, then ground to pass through a 1-mm screen and subjected to a gas production technique [2].

Rumen content was collected from four ruminally fistulated steers (420±13 kg, body weight) and strained through 4 layers of cheesecloth. The laboratory handling of rumen fluid was carried out under a continuous flow of CO_2. In vitro incubation of the samples was done using a manual pressure transducer technique [4]. Approximately 200 mg of each sample was weighed into a 120 ml serum bottle (n= 4). The bottles were pre-warmed at 38.6 °C before the injection of 30 ml rumen fluid-buffer mixture (10 ml rumen fluid and 20 ml buffer solution) into each bottle followed by incubation in a water bath at 38.6 °C. Gas pressure was recorded after 2, 4, 8, 12 and 24 of incubation and converted to gas volume using experimentally determined calibration curve. Metabolizable energy, NEL and DOM values of the samples were calculated using the equations of [2]:

ME (MJ/kg DM) = 1.56 +0.1390 GP +0.0074 XP +0.0178 XL

NEL (MJ/kg DM) = 0.1010 GP +0.0051 XP +0.011 XL

DOM (%) = 14.88 +0.8893 GP +0.0448 XP +0.0651XA

Where GP is net gas produced after 24 h of incubation (ml/0.2 g DM), and XP, XL and XA are crude protein, crud fat and ash content of the feed (g/kg DM), respectively. Data were analyzed using the GLM procedure of SAS (SAS Institute, 1990). Tukey test was used to compare the means at $P < 0.05$.

II. Results and Discussion

Effect of air temperature on gas produced after 24 h incubation, ME, NEL and DOM of the samples are presented in Table 1. Results indicated that air temperature of the new drying technique had a non significant ($P< 0.05$) effect on ME, NEl and DOM of the WDDG samples evaluated in the present study.

The highest air temperature of the drying system used in this experiment did not result in energy value reduction, as measured by in vitro gas production technique. In the present drying system, a combination of high air temperature and high air flow was applied to dry the feed at the lowest consumed time while taking the moisture out and keeping safe the nutritional quality of the output. The established rule to be followed in any drying system is the highest water removal rate at the lowest consumed time.

Distiller's dried grains as non-forage sources of fiber are a co-product of bio-ethanol production from cereal grains. Due to the selective removal of starch during the production process, it has a high content of NDF and CP, allowed to use this by product as a good source of protein and energy in the diet of ruminants.This is mainly due to their high digestible fiber content and ruminal escape protein levels. Results of the present study indicated that the drying process of the samples dried at the air temperature of 185 °C was less efficient than the highest applied temperature, as observed in 9.8% of more consumed drying time with similar moisture output compared with the HAT samples. Therefore, the highest air temperature used in the present study was more efficient and safe for drying and preserving the nutritive values of WDDG samples evaluated.

Table 1 Effect of drying temperature applied in a tower heat-dryer on gas production after 24 h incubation, ME, NEL and DOM of wheat dried distillers' grains.

Items	Drying temperature		SEM	P-value
	LAT	HAT		
Gas produced after 24 h (ml/0.2 g DM)	34	37	0.8	<0.05
ME (MJ/kg DM)	9.7	10.0	0.2	<0.05
NEL (MJ/kg DM)	5.7	5.8	0.1	<0.05
DOM (g/100 g DM)	61	64	7.00	<0.05

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