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The effect of heat or heat-xylose processing on chemical composition and in vitro first order dry matter and crude protein disappearance kinetics of guar meal

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***Abstract*—**The effect of overheat or overheat-xylose processing on chemical composition and in vitro non-linear first order matter (DM) and crude protein (CP) disappearance of three samples of guar meal (GM) was evaluated. Samples were intact GM, overheat processed GM (GM_{hp}, GM was heated at 100 °C for 45 minute using air-forced oven) and overheat-xylose processed GM (GM_{hx}, xylose was included in GM to give a final concentration of 10 g/kg DM, then was heat processed at 100 °C for 45 minute using air-forced oven). The model was: $D_{(t)}= D_{(i)}.exp(-kd.\ time)+ I$; Where, $D_{(t)}$ is residual DM at any time, , $D_{(i)}$ potentially digestible fraction , *kd* is fractional rate constant of digestion (h^{-1}) and, *I* is indigestible fraction. Results of the non-linear first order disappearance kinetic of DM indicated that the DM of GM and GM_{hp} was completely degradable after 24 h of incubation. The fractional rate constant (*kd*) of DM disappearance was significantly ($P< 0.05$) influenced by overheat or overheat-xylose processing.

***Keywords*—** Guar meal, Digestion, Processing, Heat, Xylose.

I. INTRODUCTION

Guar (Cyamopsis Tetragonoloba) is a sub-tropic resistant legume that mostly is cultivated in India peninsula and grown to the guar bean's gum that has many food and industrial application. Guar bean consist of hull (14-17% of bean), endosperm (35-42% of bean) and germ (43-47% of bean). This seed has a large endosperm which contains a significant amount of mannogalactan that is called gum(Rahman and Leighton, 1968) .Isolation of gum (a galactomannan) from guar seed led to yield a high protein by-product containing 55 to 60 percent crude protein (CP), which has been used as a protein sources in ruminant and non-ruminants livestock feeding (Conner, 2002). However, information about kinetic of guar meal nutrient disappearances in ruminants is very low. Non-linear first order disappearance kinetic parameters of DM and CP of the samples were determined using an in vitro culture inoculated by mixed rumen microbes.

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The aim of the present study was to evaluate an in vitro first order dry matter (DM) and crude protein (CP) disappearance kinetics of guar meal samples as intact or over-heated alone or combined with xylose.

II. MATERIALS AND METHOD

Commercial production of guar gum is normally undertaken by using the process of roasting, differential attrition, sieving and polishing. Selected guar split is screened to clean and then soaked to prehydrate in a double cone mixer. Pre-hydrating stage is very important in the process as it derives the rate of hydration of the final product. Soaked splits, which have reasonably high moisture content, are passed through a flakers. The flaked guar split is ground to the desired particle size, followed by drying of the material. The powder is then screened through rotary screens to deliver required particle size. Using heating, grinding and polishing process, the husk is separated from the endosperm halves and the refined guar gum split is obtained. This isolation from the bean yields a by-product named guar meal.

Experimental samples were intact GM, heat processed GM (GM_{hp}, GM was processed at 100 °C for 45 minute using industrial heater) and heat-xylose processed GM (GM_{hx}, xylose was included in GM to give a final concentration of 10 g/kg DM and heat processed as 100 °C for 45 minute using industrial heater). Samples were ground to pass through a 2-mm screen, and then analyzed for organic matter (OM), crude protein (CP) and ash (AOAC, 2000). Neutral detergent fiber exclusive of residual ash (NDF) and acid detergent fiber exclusive of residual ash (ADF) were determined using the method of Van Soest et al. (1991). Acid detergent insoluble nitrogen (ADIN) was determined as proposed by Licitra et al. (1996).

Experimental samples were incubated in a medium prepared as described by Arroquy *et al*. (2005). Fifty-five ml of medium were supplied into 100 ml bottles that approximately containing 0.45 g of feed (15 replicate for each feed). Then, each bottle was inoculated under carbon dioxide with 5 ml of mixed rumen microbes. Rumen fluid was obtained from three sheep (49.5 ± 2.5 kg) fitted by rumen fistulae, before the morning feeding, and immediately strained through four layers of cheesecloth. The animals fed 1 kg d^{-1} of DM of alfalfa hay and 0.3 kg d^{-1} of DM concentrates (165 g CP/ kg of DM). The bottles were incubated for 4, 8, 16 and 24 h at 39 ºC. Then, each bottle content was filtered through a 42 µm filter, and CP of the unfiltered medium was determined using Kjeldahl method (Kjeltec 2300 Auto analyzer, Foss Tecator AB, Hoganas, Sweden). Non-linear

first order model was used to estimate the digestion kinetic parameters of DM. The model was: $D_{(t)}= D_{(i)}.exp\ (-kd.\ time)+ I$; Where, $D_{(t)}$ is residual DM at any time, , $D_{(i)}$ potentially digestible fraction , *kd* is fractional rate constant of digestion (h^{-1}) and, *I* is indigestible fraction.

III. RESULTS AND DISCUTION

Chemical compassion of the samples is shown in Table 1. Non-linear first order parameters of in vitro DM and CP digestion kinetics of the sample are presented in Table 2 and 3, respectively. Overheat processed GM and GM_{hx} had higher EE (75.2 and 71.9 g/kg DM, respectively) and CP (580 and 594 g/kg DM, respectively) than those of GM (36.4 and 556 g/kg DM, respectively).

Table 1: Chemical compassion of guar meal samples (g/ kg)

	Feed samples*		
Nutrients	GM	GM_{hp}	GM_{hx}
Organic matter	948.0	948.5	948.5
Crude protein	566	580	594
Ether extract	36.1	71.9	71.9
ADIN¥	10	11	18
NDF- NDIP ŧ	218	238	238
ADF ŧŧ	131	140	140
Ash	52	50.9	51.7

* GM= intact guar meal; GM_{hp}= overheat processed GM; GM_{hx}= overheat-xylose processed GM
ŧ NDF- NDIP= neutral detergent fiber expressed exclusive of residual ash which corrected for neutral detergent insoluble crude protein.
¥ ADIN= Acid detergent insoluble nitrogen.
ŧŧ ADF= acid detergent fiber expressed exclusive of residual ash.

Approximately 35-42% of guar beans are mannogalactan gum while the germ concentration is 43-45% (Conner, 2002). In contrast to the other compartments of guar bean, germ has a high CP and EE concentration (0.55 and 0.052 per kg DM, respectively). In gum production industry, mannogalactan residual is extracted from guar meal by subjecting it to steam and dry heating over than initial heat process (Rahman and Leighton, 1968). Therefore, steam and dry heat processing of guar meal tended to increase the proportion of germ in the residual.

The results of the present experiment concluded that DM of GM and GM_{hp} was completely digestible after 24 h of incubation, while about 7% of the DM of GM_{hx} remained. The fractional rate constant (*kd*) of DM digestion was significantly ($P< 0.05$) influenced by overheat and overheat-xylose processing. It was concluded that in vitro *kd* of DM disappearance of GM was higher than those of the other samples. It has been indicated that the protein content in guar meal is well digested under present experimental condition.

Table 2: In vitro first order DM disappearance kinetics parameters of guar meal

	Parameter			
Feed*	*Kd*	*I*	*Di*	R^2
GM	0.13± 0.007	0.0	1.0±0.02	0.99
GM_{hp}	0.11± 0.005	0.0	1.0± 0.02	0.99
GM_{hx}	0.10± 0.011	0.07± 0.03	0.91± 0.04	0.95

* GM= intact guar meal; GM_{hp}= overheat processed GM; GM_{hx}= overheat-xylose processed GM
$D_{(i)}$ = potentially degradable fraction, *kd* = fractional rate constant of digestion (h^{-1}), *I* = indigestible fraction.

Table 3: In vitro first order CP disappearance kinetic parameters of guar meal

	Parameter			
Feed*	*Kd*	*I*	*Di*	R^2
GM	0.58± 0.04	0.0	0.99± 0.01	0.99
GM_{hp}	0.59± 0.03	0.0	0.99± 0.02	0.99
GM_{hx}	0.62± 0.04	0.04± 0.007	0.95± 0.01	0.99

* GM= intact guar meal; GM_{hp}= overheat processed GM; GM_{hx}= overheat-xylose processed GM
$D_{(i)}$ = potentially degradable fraction, *kd* = fractional rate constant of digestion (h^{-1}), *I* = indigestible fraction.

However, overheat and overheat-xylose processing had not significant effect on D_i and *kd* of CP digestion of the guar meal samples. Results of the present experiment showed that guar meal might be use as an appropriate source of protein for ruminant.

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