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Research Article

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Texture properties of ruminal liquid obtained from Oat (*Avena sativa*) feed

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Abstract

Studies on quality aspect of rheological properties of ruminal fluid in goat analyzed from oat feed and oat and fermented feed. We studied the influence of shear rate on the experimental values of shear stress and apparent viscosity for ruminal fluid obtained from feed with 45% oat. Measurements were made at 37° C, with a TPA rheometer. From the experimental data it can be seen that the best overlaps between the experimental data and the calculated curves are obtained when using the completely randomized design, i.e. precisely the models that propose the existence of a flow effort.

Keywords: Goat, Ruminal Liquid, Texture.

Introduction

Rheological models describing the behavior of ruminal fluid in Goat obtained from oat feed. Here is the Cross Equation, giving viscosity as a function of shear rate. The pH of ruminal fluid in all the ruminal lactic acidotic cases was significantly ($p < 0.05$) lower than the normal range of healthy goats (7.05 ± 0.12). The mean values of rumen fluid pH were obtained 5.60 ± 0.07 , 5.10 ± 0.07 and 4.0 ± 0.17 for group I, II, and III respectively.

Goats were among the first animals to be domesticated. As the archaeological evidence indicates, they have been associated with man in a symbiotic relationship for upto 10 to 1000 years (Ensminger and Parker, 1986). India has the largest population of goats in the world. F.A.O. (2010) estimated that there are around 920 million goats in the world out of which 154 million goats are found in India and 150.7 million goats in China (Jindal, 2013). The erstwhile Andhra Pradesh contributes 9.629 million goats population according to animal husbandry annual report 2012-2013 (18th Livestock census, 2007). The goat is a multipurpose animal which provides meat, milk, fibers (pashmina, mohair and cashmere), skin, bones and manure. It is known as the 'poor man's cow' in India and as 'wet nurse of infants' in Europe. Goat can be kept with little expense. Marginal or undulating lands unsuitable

for other type of livestock may be used and inexpensive shelter will suffice. Of all the domestic animals, goats undoubtedly have the greatest range of adaptation. A goat thrives well on poor agricultural lands where they browse on incidental vegetations. Goat has ability to get acclimatized under diversified agro-climatic condition, unfastidious type in choosing of available forest and short generation period. Goat have a wide range of adaptive traits which enable them to survive and produce, including disease resistance, heat resistance, water tolerance, ability to cope with poor feed quality (Baker and Grey, 2004). Majority of health problems encountered in goats are rumen related. Rumen acidosis is abnormal fermentative disorder, a common ailment that was presented to peri-urban clinics. People living here rear goats in semi-intensive method are more susceptible to rumen lactic acidosis (Padmaja and Praveena, 2011).

Acidosis is also known as lactic acidosis, rumen acidosis or grain overload is a carbohydrate fermentation disorder of the rumen that can affect animals of all ages. As the name implies, acidosis results in acidic pH of rumen (normal being 6.2-6.8) which is caused by feeding of highly fermentable carbohydrates, feeding of low fiber diet, poor management practices or a combination of these. Degree of acidosis varies from seriousness, a slight drop in feed intake (mild) to death (severe). Acute form of the disease in ruminants is

characterized by indigestion, rumen stasis, toxemia, in coordination, collapse and frequently death (Tufani *et al.*, 2013). With acute acidosis, ruminal acidity and osmolality increase markedly as acids and glucose accumulate; these can damage the ruminal and intestinal wall, decrease blood pH, and cause dehydration that proves fatal. Laminitis, polioencephalomalacia and liver abscesses often accompany acidosis (Owens *et al.*, 1998). Lactic acidosis can also cause chemical ruminitis, metabolic acidosis, lameness, hepatic abscessation, pneumonia and death if untreated (Lean and Wade, 2000). The goats being reared under free grazing system are more vulnerable for accidental excessive ingestion of carbohydrate-rich diets. The majority of the goat population of the peri-urban area, Rajendranagar and Mylardevpally are free grazing; therefore, the possibility of accidental ingestion of carbohydrate products is more.

Where η_0 viscosity at zero shear rate (Pa.s), η_∞ viscosity at infinite shear rate (Pa.s), λ relaxation time (s) and n power index [5-11, 10-17].

Model Vocaldo:

$$\tau = \left[K \dot{\gamma}^{\frac{n-1}{n}} + \left(\frac{\tau_0}{\dot{\gamma}} \right)^{\frac{n}{1}} \right]^n \dot{\gamma}$$

(4)

Model Casson

$$\tau^{1/2} = \tau_0^{1/2} + \eta^{1/2} \dot{\gamma}^{1/2}$$

(5)

where τ is the shear stress, τ_0 – yield stress, η - viscosity, $\dot{\gamma}$ - shear rate, n – flow index and k – index of consistency.

Material and methods

The study of rheological behavior was done for ruminal fluid obtained from Goat feed with oat and feed with oat and yeast, fluid harvested after two diets: the classic diet (concentrated with 40% oats) and the classic diet with the addition of feed yeast [7-9]. Measurements were made at 39°C, with a TPA rheometer concentric cylinder measuring system.

Results and Discussion

From the experimental data it is found that the viscosity values decrease as the shear rate increases, it appears that the ruminal fluid has a pseudoplastic fluid behavior in both types of diet. The appearance of the rheograms in figure 1 confirms the pseudoplastic character of this fluid.

For the interpretation of the experimental data it was assumed that the experimental dependence $\tau = f(\dot{\gamma})$ can be described by the model of the law of power (relation 6).

$$\tau = K \cdot \dot{\gamma}^n$$

(6)

The expression of the law of power (relation 6) can be linearized by logarithm:

$$\ln \tau = \ln K + n \cdot \ln \dot{\gamma}$$

(7)

The graphical representation of this model, from the intersection to the ordinate the value of $\ln K$ is obtained, and from the slope the value of n, as can be seen from figure 2. For the two types of fluids the results from table 1 were obtained. for K and n, the calculated values for the dependencies were obtained $\tau = f(\dot{\gamma})$, respectively $\eta_a = f(\dot{\gamma})$.

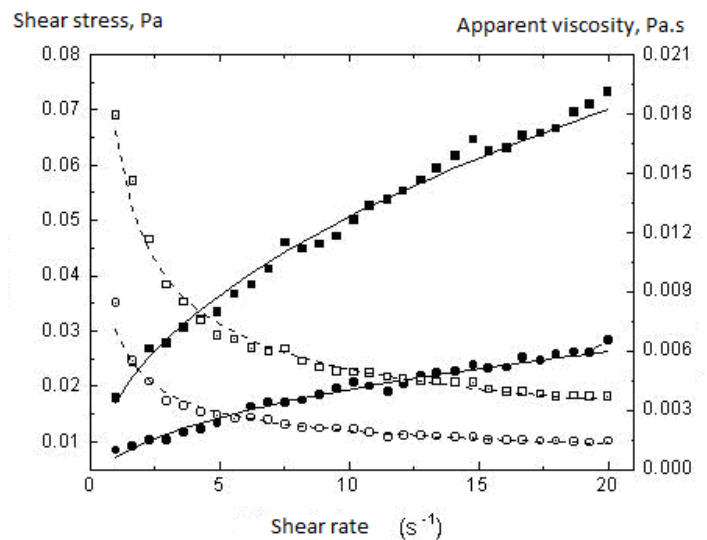


Figure 1. The influence of shear rate on the experimental values of shear stress and apparent viscosity for ruminal fluid obtained from feed with oat 40% (■ - shear stress; □ - apparent viscosity), respectively for ruminal fluid obtained from feed with 40% oat + yeast (●- shear stress; ○ - apparent viscosity), la 39° C

Continuous line - calculated dependency $\tau = f(\dot{\gamma})$, dotted line - calculated dependency $\eta = f(\dot{\gamma})$

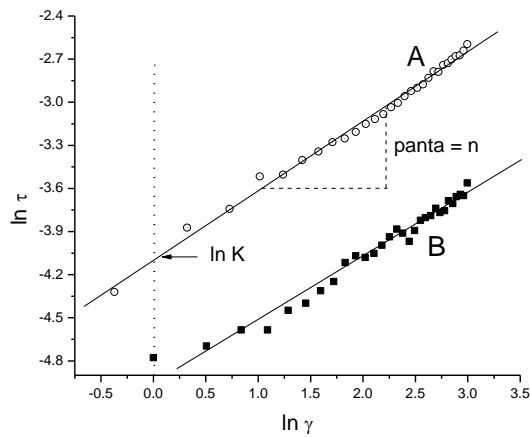


Fig. 2 Linearization of experimental dependence $\tau = f(\dot{\gamma})$ for the two ruminal fluids

A - ruminal fluid obtained from feed with 40% oat; B - ruminal feed fluid with 40% oat + yeast; O, ■ - experimental values; solid line - linear regression curves

As can be seen from Figure 1, the calculated dependencies overlap very well over the experimental values, which confirms that the power law model can be used to interpret the rheological behavior of ruminal fluid.

Table 1. Rheological characteristics of ruminal fluids obtained by linear regression applied to the linearized form of experimental dependence $\tau = f(\dot{\gamma})$

Rheological characteristics	The classic diet	The classic diet with the addition of feed yeast
n	0.483±0.008	0.436±0.013
K (mPa · s)	16.59±0.28	7.12±0.22
R	0.9966	0.9873

For a more complete characterization, the data obtained were interpreted using the following rheological models: power law (Figure 3), Cross (Figure 4), Carreau (Figure 5), Herschel-Bulkley (figure 6), Vocadlo (figure 7), and Casson (figure 8). It should be noted that in the mathematical expression of three models, namely Herschel-Bulkley, Casson and Vocadlo is found the flow effort σ_o .

The nonlinear regression method was used, using the Table Curve program. The Table Curve program allows the user to define a maximum of 50 nonlinear functions. A user-defined nonlinear function contains all the information needed to fit the function: the function name, the fitted parameters (constants), the function formula, the initial parameter estimates, the constraints for each parameter.

It is possible to graphically adjust the initial estimates to ensure better fit convergence. The model allows the introduction and adjustment of a maximum of 10 parameters, presented either as A, B, C, ..., or in the form A0, A1, A2,

The purpose of the graphical adjustment is to set the parameters in such a way that the start of fitting nonlinear to start with data closer to the values obtained. Partial derivatives of defined functions can be used to find insignificant parameters. If a partial derivative is constant, it must have the value 1, which means that it is a real constant (parameter) in the defined function. If a parameter has no significant contribution, this is a first indication that this parameter does not belong to the defined model.

The values of the rheological characteristics of the models used are those in table 2, and the curves calculated with the models used are presented graphically in figures 3-8.

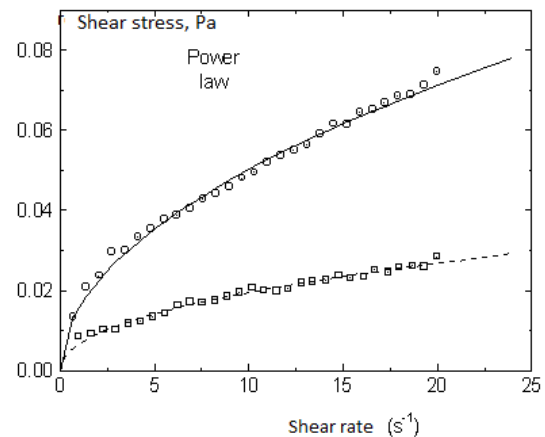


Fig. 3 Modeling of experimental data by nonlinear regression using the power law model for ruminal fluid obtained from feed with 40% oat (O), respectively for ruminal fluid obtained from feed with 40% oat + yeast (□).

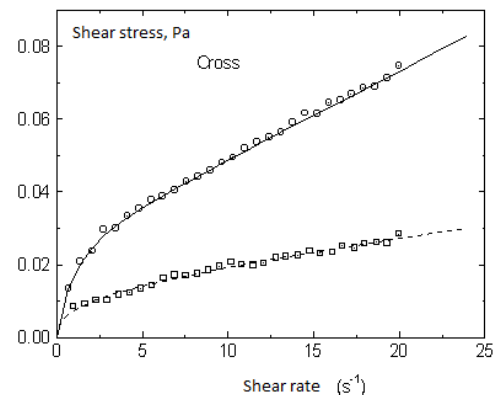


Fig. 4 Modeling of experimental data by nonlinear regression using the Cross model for ruminal fluid obtained from feed with 40% oat (O), respectively for ruminal fluid obtained from feed with 40% oat + yeast (□)

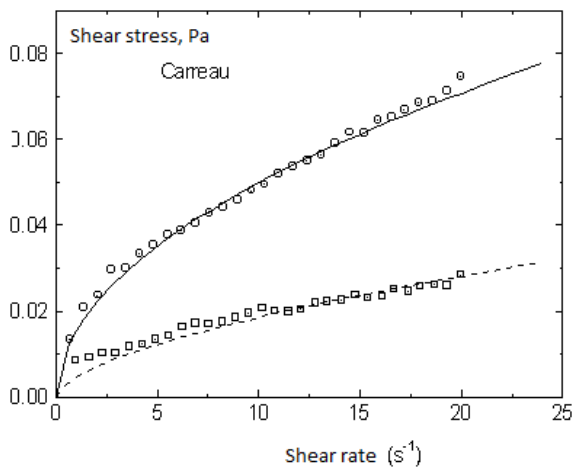


Fig. 5 Modeling of experimental data by nonlinear regression using the Carreau model for ruminal fluid obtained from feed with 40% oat (O), respectively for ruminal fluid obtained from feed with 40% oat + yeast (□)

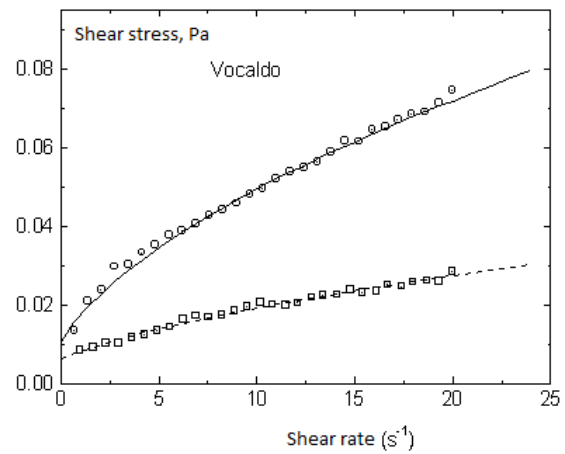


Fig. 7 Modeling of experimental data by nonlinear regression using the Vocadlo model for ruminal fluid obtained from feed with 40% oat (O), respectively for ruminal fluid obtained from feed with 40% oat + yeast (□)

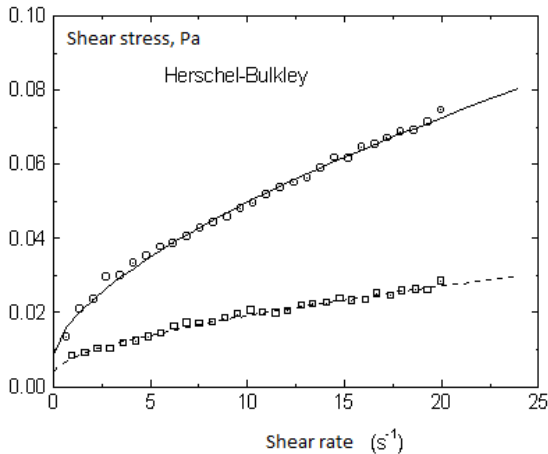


Fig. 6 Modeling of experimental data by nonlinear regression using the Herschel-Bulkley model for ruminal fluid obtained from feed with 40% oat (O), respectively for ruminal fluid obtained from feed with 40% oat + yeast (□)

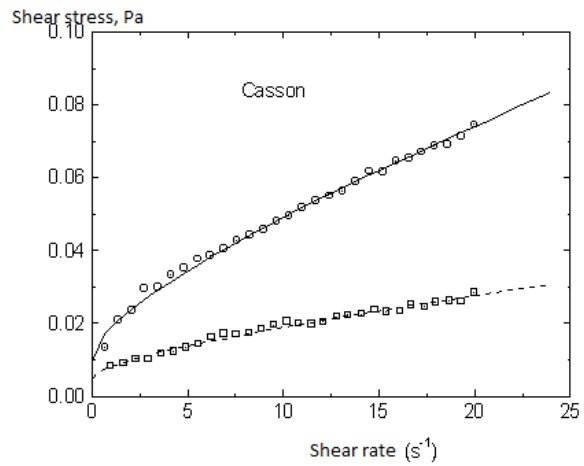


Fig. 8 Modeling of experimental data by nonlinear regression using the Casson model for ruminal fluid obtained from feed with 40% oat (O), respectively for ruminal fluid obtained from feed with 40% oat + yeast (□)

It can be seen that the best overlaps between the experimental data and the calculated curves are obtained when using the Herschel-Bulkley, Casson and Vocadlo models, ie precisely the models that propose the existence of a flow effort. It appears from table 2 that for each of the two studied fluids, the flow effort has similar values, regardless of the rheological model used.

Table 2. The values of the rheological characteristics obtained by nonlinear regression from the rheological models used

Models rheological	Rheological characteristics	
	The classic diet	The classic diet with the addition of feed yeast
The law of power	$K = 17.16 \text{ mPa} \cdot \text{s}^n$ $n = 0.470$	$K = 7.12 \text{ mPa} \cdot \text{s}^n$ $n = 0.436$
Cross	$\square_o = 28.3 \text{ mPa}$ $\square_\infty = 2.5 \text{ mPa}$ $k = 0.775 \text{ s}^n$ $n = 1.106$	$\square_o = 688.4 \text{ mPa}$ $\square_\infty = 0.43 \text{ mPa}$ $k = 97.17 \text{ s}^n$ $n = 0.677$
Carreau	$\square_o = 34.0 \text{ mPa}$ $k = 4.31 \text{ s}$ $s = 0.495$	$\square_o = 8.17 \text{ mPa}$ $k = 4.85 \text{ s}$ $s = 0.395$
Herschel-Bulkley	$\square_o = 8.5 \text{ mPa}$ $K = 9.5 \text{ mPa} \cdot \text{s}^n$ $n = 0.637$	$\square_o = 3.9 \text{ mPa}$ $K = 3.8 \text{ mPa} \cdot \text{s}^n$ $n = 0.605$
Vocaldo	$\square_o = 10.6 \text{ mPa}$ $k = 4.8 \text{ mPa}^{-n} \cdot \text{s}$ $n = 0.571$	$\square_o = 6.3 \text{ mPa}$ $k = 0.11 \text{ mPa}^{-n} \cdot \text{s}$ $n = 0.587$
Casson	$\square_o = 9.91 \text{ mPa}$ $k = 38.7 \text{ mPa} \cdot \text{s}^{-0.5}$	$\square_o = 6.86 \text{ mPa}$ $k = 21.8 \text{ mPa} \cdot \text{s}^{-0.5}$

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Conclusions

The following conclusions can be drawn from the experimental data. The graphs show that the best overlaps between the experimental data and the calculated curves are obtained when using the Herschel-Bulkley, Casson and Vocaldo models, ie, the models that propose a flow effort. It appears from Table 2 that for each of the two studied fluids, the flow effort has similar values, regardless of the rheological model used.

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