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A pilot study on effect of feeding castor (*Ricinus communis*) oil on milk yield and composition in lactating Kankrej cows

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Abstract
Functional oils, such as castor oil are chemical substances extracted from various plants parts which provide health benefits besides their nutritive properties. A pilot study was conducted to assess the effect of feeding castor (*Ricinus communis*) oil on milk yield and composition in lactating Kankrej cows. Thirty two lactating Kankrej cows (21 days in milk; average 9.74 kg/d of milk yield) were assigned randomly into four treatments having 8 cows each. The four treatments were: T_1: control group (without castor oil); T_2: 5 ml/d castor oil; T_3: 10 ml/d castor oil and T_4: 15 ml/d castor oil supplementation for a period of 21 days. The average milk yield, 4% fat corrected milk (FCM) and energy corrected milk (ECM) yield was increased numerically by 7.6, 9.2 and 9.8%, respectively in T_4 group as compared to control. The percentage of milk fat and lactose were similar among the different treatments. Milk total solids, solid-not fat and protein were significantly ($P<0.05$) higher in group T_2 than the group T_1 and comparable to both in the groups T_3 and T_4. It is concluded that dietary inclusion of castor oil at the rate of 15 ml/d has improved milk yield and modified the milk composition in lactating Kankrej cows.

Keywords: Castor oil, feed additive, functional oil, Kankrej cow, milk yield

Introduction
India is the largest producer of milk in the world with the increase in production from 17.0 million tonnes in 1950-51 to 155.49 million tonnes in 2015-16 (BAHFS, 2015). Currently, the Indian dairy market is growing at an annual rate of 7%. Milk yield in diary animals can be improved by factors such as genetic selection of animals for traits like higher milk yield, balanced feeding and other management practices. However, after exploring genetic potential of animal, improved production can only be supported by use of balanced ration and feed supplements/additives such as functional oils.

Functional oils, such as castor oil are chemical substances extracted from various plants by distillation, compression or using solvents, providing health benefits besides their nutritive properties (Murakami *et al.*, 2014; Ferreira de Jesus *et al.*, 2016) [10, 5]. Data on effects of dietary functional oil supplementation in dairy cows performance are still scarce in literature. Seradj *et al.* (2017) [16] performed an *in vitro* evaluation with functional oil and reported an increase in the molar proportion of propionate. Propionate is the most important substrate for hepatic gluconeogenesis (accounting for 60–74% total substrate) which is highly associated with milk production in dairy cows (Aschenbach *et al.*, 2010; Hammon *et al.*, 2010) [3, 7]. India is known as the world leader in castor oil production and leads the international castor oil trade. Castor oil consists of 90% ricinoleic, 4% linoleic, 3% oleic, 1% stearic, and less than 1% linolenic fatty acids (Patel *et al.*, 2016) [14]. The main component of castor oil is ricinoleic acid (12-hydroxy-9-octadecenoic acid), which constitutes between 86% and 92% of the fatty acids found in the oil (Torrentes *et al.*, 2017) [18]. Inclusion of castor oil in diet of dairy cows has improved their performance without impairing nutrient intake and digestibility (Gandra *et al.*, 2014; Ferreira de Jesus *et al.*, 2016; Alves *et al.*, 2017) [6, 5, 1]. Moreover, castor oil is less prone to oxidative degradation than other vegetable oil ensuring longer conservation in tropical farm conditions (Medeiros *et al.*, 2013) [9]. Therefore, a pilot study was planned to evaluate the effect of feeding castor oil on milk yield and composition in lactating Kankrej cows.

Materials and Methods
Location of study
The experiment was carried out at Livestock Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. It is located in semi arid region of Banaskantha District of North Gujarat having latitude of 24.35˚North and longitude of 72.59˚ East and at an elevation of 189 meters above the mean sea level.

Experimental Animals and Design

Thirty two lactating Kankrej cows (21 days in milk; average 9.74 kg/d of milk yield) were assigned randomly into four treatments (8 cows per treatment) stratified on the basis of live body weight and milk production. The four treatments were: T_1: control group (without castor oil); T_2: 5 ml/d castor oil; T_3: 10 ml/d castor oil and T_4: 15 ml/d castor oil supplementation for a period of 21 days. Castor oil was mixed into a portion of the concentrate thoroughly and provided once daily during the experimental period. The animals were fed as per ICAR (2013) [8] feeding standards to meet the nutrient requirements. All the experimental animals were reared under standard management practices with free access to fresh and clean drinking water. The feeds and fodder used in the experiment were as analyzed for chemical composition *viz.* dry matter, crude protein, crude fibre, ether extract and total ash (AOAC, 2007) [2].

All cows were milked twice a day (morning 4:00 a.m. and evening 4:00 p.m.) and individual milk yield of each cow was recorded daily by using electronic weighing balance. For analysis of milk constituents, milk samples were collected at weekly interval. Milk fat, solid not fat (SNF), protein and lactose were determined by using EKOMILK Ultra Pro Milk Analyzer (Everest Instruments Pvt. Ltd.). The 4% fat corrected milk (FCM) and energy corrected milk (ECM) yield were calculated as:

$$4\%\ \mathrm{FCM} = \text{Milk yield (kg) x } 0.4 + \text{Fat yield (kg)x } 15$$

$$\mathrm{ECM} = 0.327 \text{ x Milk yield (kg) } + 12.95 \text{ x Fat yield (kg) } + 7.20 \text{ x Protein yield (kg)}$$

Statistical analysis

The data obtained was statistically analyzed as per the method of Snedecor and Cochran (1994) [17]. Analysis of variance of the data obtained in the experiment was conducted based on a completely randomized design (CRD) using the general linear model procedure of SPSS (SPSS 16.0). The differences in the means was compared by Least Significant Differences (LSD) at 5% level (P<0.05).

Results and Discussion

The chemical composition of feeds and fodders fed to experimental animals is given in Table 1. The crude protein content in concentrate mixture, green maize and jowar hay was 19.15, 6.16 and 3.29%, respectively.

Table 1: Chemical composition (on % DM basis) of feeds and fodders

Composition (%)	Concentrate mixture	Green maize	Jowar hay
Dry matter	94.92	15.64	89.73
Crude protein	19.15	6.16	3.29
Crude fibre	6.38	27.43	37.58
Ether extract	3.07	1.16	0.98
Total ash	7.88	8.56	10.51
Nitrogen free extract	63.52	56.69	47.64

The data of milk yield in lactating Kankrej cows fed graded levels of castor oil is presented in Table 2. Initial milk yield was similar among the different treatment groups. The average milk yield (kg/day) during experimental period was 9.58±0.69, 9.62±0.88, 9.43±0.72 and 10.31±1.19 in T_1, T_2, T_3 and T_4 groups, respectively, which was not significantly (P>0.05) affected by supplementation of castor oil among the treatments.

Table 2: Effect of feeding castor oil on milk yield in lactating Kankrej cows (n=32)

Milk yield (kg/d)	Treatments				P value
	T_1	T_2	T_3	T_4	
Initial	9.72±0.69	9.79±0.87	9.75±0.97	9.71±1.03	1.000
d-7	9.85±0.78	9.53±0.86	9.18±0.69	10.46±1.31	0.798
d-14	9.46±0.70	10.00±0.92	9.50±0.71	10.71±1.36	0.774
d-21	9.30±0.70	9.16±0.97	9.31±0.86	10.35±1.30	0.815
Average	9.58±0.69	9.62±0.88	9.43±0.72	10.31±1.19	0.901
4% FCM	10.39±0.77	10.55±0.92	10.23±0.77	11.34±1.28	0.850
ECM	11.16±0.79	11.50±1.01	11.10±0.82	12.25±1.37	0.847

FCM: Fat corrected milk; ECM: Energy corrected milk

The 4% FCM and ECM yield was not influenced significantly (P>0.05) by the dietary addition of different levels of castor oil. However, the average milk yield, 4% FCM and ECM yield were numerically improved in T_4 (15 ml/d castor oil) group as compared to the T_1 (control) group by 7.6, 9.2 and 9.8%, respectively. An increase in milk yield was expected as castor oil increase the molar proportion of propionate in rumen. Propionate is the most important substrate for hepatic gluconeogenesis (accounting for 60–74% total substrate), which is highly associated with milk yielding in cows. In line with our findings, Parente *et al.* (2018) [12] observed that addition 30 g FA/kg DM of castor oil in ewes had no effect on milk production. In contrast, Gandra *et al.* (2014) [6] observed significant (P<0.05) increase in milk yield (22.47 *vs.* 24.16 kg/d) in lactating Simmental dairy cows fed with 2 g of ricinoleic acid from castor oil/animal/day in an experiment carried out for 42 days divided into two trials of 21 days. Ferreira de Jesus *et al.* (2016) [5] also reported that feeding of 500 mg/kg DM of functional oil (cashew nut shell oil and castor oil) in lactating Holstein cows for 21 days increased (P<0.001) milk yield (25.9 *vs.* 27.1 kg/d), but the FCM yield was not affected (p = 0.188) by the treatments.

The data of milk composition in lactating Kankrej cows fed graded levels of castor oil is presented in Table 3. The average fat content in Kankrej milk was ranged from 4.55 to 4.69%. Earlier other authors were recorded similar range of fat percentage in Kankrej cows (Patel *et al.*, 2017; NBAGR, 2018) [13, 11].

Table 3: Effect of feeding castor oil milk composition in lactating Kankrej cows (n=32)

Milk composition (%)	Treatments				P value
	T_1	T_2	T_3	T_4	
Milk fat	4.55±0.06	4.66±0.08	4.58±0.09	4.69±0.08	0.544
Milk total solids	12.81^{a}±0.22	13.60^{b}±0.11	13.24^{ab}±0.19	13.34^{ab}±0.16	0.028
Milk SNF	8.26^{a}±0.21	8.94^{b}±0.09	8.66^{ab}±0.15	8.65^{ab}±0.14	0.036
Milk protein	3.25^{a}±0.08	3.50^{b}±0.03	3.40^{ab}±0.05	3.38^{ab}±0.05	0.035
Milk lactose	4.50±0.07	4.74±0.06	4.59±0.08	4.59±0.08	0.177

^{a,b}Means within a row bearing different superscripts differ significantly ($P<0.05$).

The percentage of milk fat and lactose were similar among the different treatment groups. The milk total solids, solid not fat and protein were significantly ($P<0.05$) higher in group T_2 than the group T_1 and comparable to both in the groups T3 and T4. Ferreira de Jesus *et al.* (2016) [5] found that feeding of 500 mg/kg DM of functional oil (cashew nut shell oil and castor oil) in lactating Holstein cows for 21 days did not have any influence on milk fat percentage, but milk protein and lactose level were increased ($P<0.05$). Parente *et al.* (2018) [12] reported that castor oil supplementation increased milk fat content, while Pereira *et al.* (2010) [15] reported decrease in milk fat level of goats supplemented with castor oil.

Conclusion

Based on the findings, it is concluded that dietary inclusion of castor oil at the rate of 15 ml/d improved milk yield and modified milk composition in lactating Kankrej cows. Further long term studies with castor oil supplementation in dairy cows could contribute to understanding its effect on milk yield and composition.

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