Effect of Eucalyptus Leaves Supplementation in Ration on Lactating Buffaloes Performance

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Abstract. The present study was carried out to investigate the effect of fresh and dry eucalyptus leaves on feed intake, digestibility, rumen fermentation activity, blood serum biochemical, milk yield and composition, feed conversion and economic efficiency of lactating buffaloes. Twenty lactating multiparous Egyptian buffaloes in 3rd and 5th lactation seasons and weighed 550 kg on average were used in *complete randomized design* after 8 weeks of calving (peak period) and assigned into five similar groups of four buffaloes each according to milk yield and live body weight. Animals were individually fed on a basal ration (BR) consisted of 40% concentrate feed mixture (CFM), 30% fresh berseem (FB) and 30% rice straw (RS). The first group was un supplemented and served as a control group (G1). Those in the second and third groups were supplemented with 50 and 100 g of fresh eucalyptus leaves per head per day for low level (G2) and high level (G3). Animals in the fourth and fifth groups were supplemented with 15 and 30 g of dry eucalyptus leaves per head per day for low level (G4) and high level (G5). G3 recorded significantly the highest digestibility coefficients of all nutrients and feeding values followed by G2, G5 and G4, whereas control one (G1) had the lowest values. Ruminal pH value tended to decreased with Eucalyptus leaves additive. Group 3 showed significantly the highest TVFA's and the lowest NH_3-N concentration followed by G2, G5 and G4, while G1 had the opposite trend. Moreover, G3 revealed significantly the highest concentrations of total protein and globulin and the lowest urea, urea-N and creatinine and activity of SGOT and SGPT enzymes in blood serum followed by G2, G5 and G4, while G1 had reverse values. However, serum albumin concentration was nearly similar for the different groups. Group 3 recorded significantly the highest feed intake (DM, TDN and DCP), yield of actual milk and 7% FCM, milk composition (fat, protein, lactose, SNF, TS and ash) and milk constituents yield followed by G2, G5 and G4, while G1 had the lowest values. Also, G3 recorded significantly the lowest amounts of DM, TDN and DCP per 1 kg 7% FCM followed by G2, G5 and G4, while G1 had the highest amounts. At the same time, G3 recorded significantly the highest values of feed cost, output of 7% FCM yield, net revenue and economic efficiency and the lowest feed cost per kg 7% FCM followed by G2, G5 and G4, while G1 had the opposite values. In conclusion, addition of fresh eucalyptus leaves at the level of 100 g/head/day recorded the best improvements in feed intake, digestibility, rumen fermentation activity, some blood serum biochemical, milk yield and composition, feed conversion and economic efficiency of lactating buffaloes.

Keywords: Eucalyptus, buffaloes, digestibility, milk yield and composition, economic

Introduction

According to FAO statistics (FAO, 2015) in 2013 Egypt produced about 5.9 million liters/year fresh milk, consisted of 2.6 million liters of buffalo milk (44.1 %) and about 3.17 million liters of other cattle milk (53.73%) produced by 4.2 million buffalos and 4.95 million cattle. In Egypt, buffalo represents 47 % of the total livestock population and Egyptians prefer buffalo milk due to its high fat content, color, and flavor. This high demand and consumer preference provide a great opportunity for Egypt to produce buffalo milk. However, milk yield per dairy buffalo is still as low as 4-10 kg. Furthermore, despite the higher population of buffaloes in Egypt, the productive and reproductive performance are lower than those in Italy with a smaller buffalo population. This indicates that the dairy buffaloes are not fully utilized in Egypt so the current production potential needs improvement through capacity building, appropriate feeding strategies, health care, appropriate milking routine, use of milk storage and processing facilities and creating strong market linkage with dairy companies.

Also, proper recording of individual buffalo cow milk yield, selection based on pedigree information, accurate estrus detection and nucleus herd breeding strategies will bring sustainable improvement for efficient utilization of buffaloes in Egypt (Arefaine and Kashwa, 2015). On the other hand, buffaloes are sensitive to weather changes and adverse climatic conditions which are hazardous to buffalo milk productivity (Marai and Habeeb, 2010).

Increasing the productivity and decreasing the climatic stress of dairy buffalo can be done through various feeding management techniques. One way to increase it productivity is by supplementing eucalyptus leaves camaldulensis. Variation in the yield and chemical composition of essential oil obtained from the leaves of Eucalyptus camaldulensis from saline and non-saline provenances of Pakistan is presented. Eucalyptus camaldulensis leaves contained 0.98 and 0.96 % essential oils from saline and non-saline areas, respectively. GC-MS analysis of the E. camaldulensis leaves essential oil revealed the presence of 24 and 27 compounds from the saline and non-saline samples, respectively. The principal constituent in the essential oil from saline and non-saline provenances was 1,8-cineole 34.42 and 40.05 %, respectively. Other major constituents were: α-pinene (14.68 and 12.43 %), γ-terpinene (9.42 and 7.48 %), ledol (7.42 and 7.67 %) and t-pinocarveol (8.36 and 3.32 %), respectively. There were no significant differences in the yield of essential oil of E. camaldulensis from saline or non-saline habitats of Pakistan. However, the concentration of most of the chemical components varied significantly ($p < 0.05$) due to salt stress (Ashraf et al., 2010).

Essential oil from the leaves of Eucalyptus camaldulensis ranges from less than 1% to over 2%. As reported by Elaissi et al. (2012), eucalyptus contents several kinds of EO, the main components were 1,8-cineole (4.5% to 70.4%) followed by cryptone (0.0% to 20.9%), α-pinene (1.0% to 17.6%), ρcymene (0.8% to 16.7%), α-teprpineol (0.6% to 10.3%).

Steam distillation of Eucalyptus leaves yielded 0.93 % (v/w) of essential oil (EO). GC/MS Analysis revealed 39 compounds, essentially oxygenated monoterpenes (86.01%). The main constituents of the oil were 1,8-cineole (78.45 %), o-cymene (2.18 %), isopinocarveole (1.74 %), α-pinene (1.69 %), pinocarvone (1.34%) and veridiflorol (1.31%). The BSL assay revealed a highly toxic value of LC50 (67.55 μg/mL) (Atmani-Merabet et al., 2018).

Inclusion 3% of EG leaves in lactating buffaloes ration resulted in an increase ($P<0.05$) of milk yield, milk fat, protein, solid not fat, lactose content (Aboul-Fotouh et al., 2000) because eucalyptus leaves supplementation enhanced of milk production, milk protein, and milk fat and reduced milk non protein nitrogen of lactating cows (Shwerab et al., 2014).

The aim of the present study was to investigate the effect of fresh and dry eucalyptus leaves on feed intake, digestibility, rumen fermentation activity, blood serum biochemical, milk yield and composition, feed conversion and economic efficiency of lactating buffaloes.

Materials and Methods

This study was carried out at the Experimental Farm of Mehalet Mousa Animal Production Research Station, Kafr El-Sheikh Governorate, belonging to Animal Production Research Institute (APRI), Agricultural Research Center, Dokki, Giza, Egypt. The experiment lasted for 90 days.

Experimental Animals

Twenty lactating multiparous lactating buffaloes weighed 550 kg on average and in 3rd to 5th lactation seasons were used after eight weeks of calving (peak period) and assigned into five similar groups of 4 buffaloes according to milk yield and live body weight. Animals were used in a complete randomized design to study the effect of fresh and dry eucalyptus leaves additives on the productive performance of lactating buffaloes. Fresh and dry Eucalyptus leaves were chopped to about 1 cm in length before feeding to buffaloes.

Experimental Rations

All animals in the experimental groups were individually fed on basal ration (BR) consisted of 40% concentrate feed mixture (CFM), 30% fresh berseem (FB), and 30% rice straw (RS). The first group was unsupplemented and served as the control group (G1), the second (G2) and the third group (G3) were supplemented with fresh eucalyptus leaves at 50 and 100 g/head/day respectively, and the fourth (G4) and fifth (G5) groups were supplemented with dry eucalyptus leaves at 15 and 30 g/head/day, respectively. The chemical composition of different feedstuffs and basal ration is shown in Table 1.

Feeding Procedures

Animals were individually fed with basal ration to fulfill energy and protein requirements for lactating buffaloes according to Mudgal (1988). The allowance of different feedstuff was adjusted according to the changes in milk yield. The CFM was offered to all animals twice daily at milking time (7 am and 5 pm), fresh berseem once daily at 10 am, and rice straw at 1 pm. Animals were allowed to drink three times daily.

Digestibility Trials

Five digestibility trials were conducted at the end week of experiment to determine nutrients digestibility coefficients and nutritive values of experimental rations using Acid Insoluble Ash (AIA) technique as described by Van Keulen and Young (1977). Feces samples were collected from the rectum of each buffalo two times daily with 12 hours interval for 7 days collection period. The samples of used feedstuffs were collected at the beginning, middle and end of collection period. Feedstuff and feces samples were oven dried at 65°C for 48 hours, pulverized, sampled, and analyzed to determine CP, CF, EE, and ash following the AOAC method (2000). Digestibility coefficient of all nutrients was calculated from the equations given by Schneider and Flatt (1975). Total Digestible Nutrients (TDN) was calculated according to the classic equation of McDonald et al. (1995).

Rumen Liquor Samples

Rumen liquor samples were taken from all buffaloes during the collection period (3h after morning feeding) using stomach tube with a draw pulse power of the automatic milking machine. Every sample was strained through four layers of cheese cloth and rumen pH was determined immediately after straining the samples using Orian 680 digital PH meter. Ammonia nitrogen (NH_3-N) was determined using saturated solution of magnesium oxide distillation according to the method of AOAC (2000). Total volatile fatty acids (TVFA's) were determined by the steam distillation method described by (Warner, 1964).

Blood Samples

Blood samples were collected from all buffaloes at the same time of rumen samples. The blood samples were taken from the jugular vein in dry clean glasses tubes and left in refrigerator for 2 hours, then centrifuged for 15 min at 4000 rpm to obtain serum. Biochemical of blood serum constituents (total protein, albumin, creatinine, urea, urea nitrogen (BUN), SGOT and SGPT were determined calorimetrically using commercial diagnostic kits (test- Combination-Pasteur lap).

Table 1. Chemical composition of different feedstuffs and basal ration

Item	DM %	Composition of DM %					
		OM	CP	CF	EE	NFE	Ash
CFM	90.35	91.15	16.32	12.48	2.74	59.61	8.85
FB	16.60	88.51	16.59	29.25	2.87	39.80	11.49
RS	89.80	84.90	2.45	39.67	1.75	41.03	15.10
BR	68.06	88.48	12.24	25.67	2.48	48.09	11.52

CFM: concentrate feed mixture, FB: fresh berseem, RS: rice straw, BR: basal ration, DM: dry matter, OM: organic matter, CP: crude protein, CF: crude fiber, EE: ether extract, NFE: nitrogen free extract.

Milk Yield and Sampling

Buffaloes milk was obtained individually by hand milking twice daily at 7 am and 5 pm and the daily milk yield was recorded and was corrected to 7% FCM by the following equation according to Raafat and Saleh (1962): 7% FCM = 0.265*milk yield+0.5*fat yield. Milk samples were individually collected from each buffalo during the fourth week of each month, which two milk samples were taken at the morning and evening milking and were composite in proration to milk yield and representative sample was taken for chemical analysis. Milk samples were analyzed for fat, protein, solids not fat, total solids and ash using Milkoscan-130 apparatus.

Feed Conversion

Feed conversion was calculated as the amounts of DM, TDN and DCP required per 1 kg 7% FCM.

Economic Efficiency

Economic efficiency was expressed as feed cost, feed cost per 1 kg 7% FCM produced, the output of milk yield and net revenue on the following prices in Egyptian pounds were 5000 LE/ ton concentrate feed mixture, 420 LE/ ton fresh berseen, 450 LE/ ton rice straw, 10 LE/ kg fresh eucalyptus leaves, 20 LE/ kg dry eucalyptus leaves and 10 LE/ kg 7% FCM. Economic efficiency was expressed as the ratio between the output of milk yield and feed cost. Also, economic efficiency is expressed as the percentage of net revenue of feed cost.

Statistical Analysis

Data were statistically analyzed using the general linear models (GLM) procedure adapted by IBM SPSS Statistics (2014) for user's guide with one-way ANOVA. The differences among means were separated according to Duncan's New Multiple Range Test (Duncan, 1955).

Results and Discussion

Nutrient Digestibility

Nutrients digestibility as affected by eucalyptus leaves supplementation are presented in Table 2. Eucalyptus leaves showed significant (P<0.05) improvements in all nutrient digestibility. Fresh eucalyptus leaves had more effect than dry leaves on digestibility, which may be that some of the essential oils lost with drying leaves. Group 3 recorded significantly (P<0.05) the highest digestibility coefficients of DM, OM, CP, CF, EE and NFE followed by G2, G5 and G4, whereas G1 had the lowest values. Eucalyptus leaf meal could modify the rumen fermentation and potentially be used as a rumen enhancer in methane mitigation and rumen fermentation efficiency (Thao et al., 2015). The results of the present study are in accordance with those obtained by Hassan et al. (2011) who found that the quails fed diets supplemented with 0.5% Eucalyptus recorded the highest significant digestibility of DM, OM, CP, EE, NFE and nitrogen balance compared to those fed diets supplemented with the level of 0.25% Eucalyptus regardless of antibiotic supplementation.

Table 2. Nutrient digestibility coefficients and feeding values of experimental rations

Item	Experimental groups					SEM
	G1	G2	G3	G4	G5	
Digestibility coefficients, %						
DM	62.69^{d}	66.64^{ab}	67.28^{a}	64.63^{c}	65.32^{bc}	0.44
OM	63.52^{d}	67.52^{ab}	68.16^{a}	65.48^{c}	66.18^{bc}	0.46
CP	64.34^{d}	68.39^{ab}	69.05^{a}	66.33^{c}	67.04^{bc}	0.45
CF	61.87^{d}	65.76^{ab}	66.39^{a}	63.78^{c}	64.46^{bc}	0.41
EE	67.64^{d}	71.90^{ab}	72.59^{a}	69.73^{c}	70.47^{bc}	0.48
NFE	65.33^{d}	69.45^{ab}	70.11^{a}	67.35^{c}	68.07^{bc}	0.47
Feeding values, %						
TDN	58.95^{d}	62.66^{ab}	63.26^{a}	60.77^{c}	61.42^{bc}	0.41
DCP	7.88^{d}	8.37^{ab}	8.45^{a}	8.12^{c}	8.21^{bc}	0.05

Values bearing different superscripts within rows differ significantly at 5% level. DM: dry matter, OM: organic matter, CP: crude protein, CF: crude fiber, EE: ether extract, NFE: nitrogen free extract, TDN: total digestible nutrients, DCP: digestible crude protein.

Also, El-Bordeny et al. (2006) reported that incorporating Eucalyptus glopulus (EG) leaves at the recommended dose enhanced feed digestion of beef calves. Supplementing 3% EG leaves to Rahmany lambs ration could increase (P<0.05) CP digestibility (Aboul-Fotouh et al., 1999). The same rend was reported El-Bordeny (2011) that eucalyptus Globules leaves as natural feed additives in calves diet improve its digestibility. Meanwhile, Soltan (2009) found that essential oil mixture (EOM) addition (mixture of eucalyptus oil 7%; menthol crystal 6.6% and mint oil 2.0%) at 16 mg L-1 drinking water slightly improved digestibility of dry matter, organic matter and crude protein compared to control.

Feeding Values

Feeding values of different rations as affected by Eucalyptus leaves additive are shown in Table 2. There were significant (P<0.05) differences in the contents of TDN and DCP among the different groups. Group 3 recorded significantly (P<0.05) the highest percentages of TDN and DCP followed by G2, G5, G4, whereas G1 had the lowest values. These results could be attributed to the improvements of nutrients digestibility with Eucalyptus leaves supplementation. These results confirmed Aboul-Fotouh et al. (1999; 2000) that feeding values as TDN, DCP and DE kcal/100g were improved (P ≤0.05) by adding EG leaves compared to the other diets for growing Rahmany lambs and lactating buffaloes. El-Ashry et al. (2006) found that the TDN and DCP for group received EG, were higher (P≤0.01) than the other groups of buffalo calves.

Rumen Liquor Parameters

The effect of Eucalyptus leaves additive on rumen liquor parameters of lactating buffaloes are presented in Table 3. This study showed that ruminal pH value (6.60 – 6.80) tended to decreased insignificantly (P>0.05) with Eucalyptus leaves additive. Thao et al. (2015) reported that ruminal pH value was not affected by Eucalyptus leaf meal supplementation. Soltan (2009) found that addition of Essential Oil Mixture (EOM) addition (mixture of eucalyptus oil 7%; menthol crystal 6.6% and mint oil 2.0%) at 16 mg L-1 drinking water had no significant effect on ruminal pH. Van Soest (1994) suggested that the pH range for optimal microbial activity was 6.2 to 7.2.

The concentration of total VFA in rumen liquor increased significantly (P<0.05) with Eucalyptus leaves additive. Fresh Eucalyptus leaves revealed more increase in TVFA concentration than that of dry leaves.

Group 3 recorded significantly (P<0.05) the highest TVFA's concentration in rumen followed by G2, G5 and G4, whereas the lowest concentration was detected in G1. Volatile fatty acids (VFA) are produced in large amounts through ruminal fermentation and are a primary energy source for ruminants, volatile fatty acids (VFA) have been estimated to provide up to 75% of the total metabolizable energy (Bergman, 1990; Kolver and de Veth, 2002; Oba and Allen, 2003a,b). The values of TVFA obtained in this study are within normal range of 70 to 150 mM/L, confirming the result by McDonald et al. (2002).

However, ammonia nitrogen concentration in rumen liquor decreased significantly (P<0.05) with Eucalyptus leaves additives and fresh leaves had more decrease than that of dry leaves. Group 3 showed significantly (P<0.05) the lowest NH3-N concentration followed by G2, G5 and G4, while the highest concentration was done in G1. These results are in accordance with those obtained by Sallam et al. (2009) who found that ammonia-N concentration in rumen linearly decreased (P < 0.05) when the EuO was included. Thao et al. (2015) reported that Eucalyptus leaf meal supplementation resulted in lower concentration of ruminal ammonia nitrogen. Total volatile fatty acids concentration increased with the level of Eucalyptus leaf meal (P<0.05). Shwerab et al. (2014) stated that as Eucalyptus leaves supplementation improved rumen fermentation and VFA's production but decreased ammonia production. Soltan (2009) found that incorporating Essential Oil Mixture (EOM) (7% eucalyptus oil, 6.6% menthol crystal and 2.0% mint oil) at 16 mg L-1 drinking water had no significant effect on ruminal fluid ammonia concentration and increased total volatile fatty acid (VFA). The optimal ruminal NH3-N range from 12 to 17 mg/dL (Wanapat and Pimpa, 1999; Mapato et al., 2010 and Lunsin et al., 2012) for rumen ecology, fermentation and optimal microbial growth (Satter and Slyter, 2007 and Anantasook and Wanapat, 2012).

Blood Serum Biochemical

The effect of Eucalyptus leaves supplementation on blood serum biochemical of lactating buffaloes is presented in Table 3.

Table 3. Rumen liquor parameters and blood serum biochemical for lactating buffaloes fed the experimental rations

Item	Experimental groups					SEM
	G1	G2	G3	G4	G5	
Rumen liquor parameters						
pH value	6.80	6.65	6.60	6.76	6.71	0.04
TVFA's (mM/dL)	11.78^{d}	13.42^{b}	14.08^{a}	12.53^{c}	12.87^{bc}	0.20
NH_3-N (mg/dL)	16.46^{a}	13.54^{c}	12.35^{d}	15.13^{b}	14.52^{bc}	0.35
Blood serum biochemical						
Total protein (g/dl)	7.23^{d}	7.75^{b}	7.93^{a}	7.41^{c}	7.53^{c}	0.10
Albumin (g/dl)	3.65	3.65	3.60	3.60	3.61	0.03
Globulin (g/dl)	3.58^{d}	4.10^{b}	4.33^{a}	3.81^{c}	3.92^{c}	0.09
Albumin: globulin ratio	1.02^{a}	0.89^{ab}	0.84^{b}	0.94^{ab}	0.92^{ab}	0.02
Urea (mg/dl)	44.00^{a}	39.25^{ab}	35.00^{b}	40.25^{ab}	39.75^{ab}	1.51
Urea-N (mg/dl)	20.48^{a}	18.28^{ab}	16.28^{b}	18.75^{ab}	18.53^{ab}	0.71
Creatinine (mg/dl)	1.14^{a}	0.99^{b}	0.98^{b}	1.04^{ab}	1.01^{b}	0.03
SGOT (IU/L)	47^{a}	41^{ab}	38^{b}	45^{ab}	43^{ab}	2.19
SGPT (IU/L)	16^{a}	14^{c}	13^{d}	16^{a}	15^{b}	0.53

Values bearing different superscripts within rows differ significantly at 5% level. TVFA's: total volatile fatty acids, NH3-N: ammonia nitrogen, SGOT: serum glutamic-oxaloacetic transaminase, SGPT: serum glutamic-pyruvic transaminase.

There were significant (P<0.05) differences in blood serum parameters among the different experimental groups. Group 3 contained significantly (P<0.05) the highest concentrations of total protein and globulin in blood serum followed by G2, G5 and G4, while G1 had the lowest concentrations. Serum albumin concentration was nearly similar across groups. Most of the increase in serum total protein due to Eucalyptus leaves additive occurred in globulin. These increases in proteins in plasma may be due to an improvement in digestibility in digestion tract when compare with the control group. These values are within normal range in blood being 6-8 g/dL for total protein, 3.5-5.0 g/dL for albumin and 2.6-4.6 g/dL for globulin according to UCDAVIS (2001).

However, the concentrations of urea and urea-N in blood serum decreased significantly (P<0.05) in G3, whereas in G2, G4 and G5 decreased insignificantly (P>0.05) compared to those in control one (G1). Meanwhile, serum creatinine concentration decreased significantly (P<0.05) in G2, G3 and G5, whereas in G4 decreased insignificantly (P>0.05) than that of G1.

AST (SGOT) and ALT (SGPT) are reasonably sensitive indicators of liver damage or injury from different types of diseases or conditions, and collectively they are termed liver tests or liver blood tests. They may mean liver problems or they may not. For example, elevations of these enzymes can occur with muscle damage. The lowest activity of liver enzyme SGOT in serum was detected significantly (P<0.05) in G3 followed by G2 and G5, whereas G1 and G4 had the highest values. Meanwhile, serum SGPT activity decreased significantly (P<0.05) in G3 and insignificantly (P>0.05) in G2, G4 and G5 compared to G1. Adding eucalyptus and antibiotics increased plasma total protein, globulin, calcium, phosphorus and alkaline phosphates. However, the levels of plasma cholesterol, LDL, HDL, total lipids, AST, and ALT decreased compared to the control group (Hassan et al., 2011).

Feed Intake

Results of feed intake by buffaloes for different groups are presented in Table 4. Feed intake from concentrate feed mixture, fresh berseem and rice straw as well as DM, TDN and DCP intake increased significantly (P<0.05) with fresh and dry eucalyptus leaves additives. Buffaloes of G3 recorded significantly (P<0.05) the highest values of feed intake followed by G2, G5 and G4, while G1 had the lowest values. Results showed that fresh leaves were more effective on feed intake than that of dry leaves. These results confirmed El-Bordeny et al. (2005) who observed that supplementing calf starter by 100 mg Eucalypts globulus leaves/ kg live body weight improved (P<0.05) feed intake.

Table 4. Feed intake for lactating buffaloes fed the experimental rations

Item	Experimental groups					SEM
	G1	G2	G3	G4	G5	
As fed (kg/head/day)						
Concentrate feed mixture	7.30^{d}	7.76^{ab}	7.84^{a}	7.53^{c}	7.61^{bc}	0.05
Fresh berseem	29.82^{d}	31.69^{ab}	32.00^{a}	30.74^{c}	31.06^{bc}	0.21
Rice straw	5.51^{d}	5.86^{ab}	5.91^{a}	5.68^{c}	5.74^{bc}	0.04
Total feed	42.63^{d}	45.32^{ab}	45.75^{a}	43.95^{c}	44.42^{bc}	0.30
As DM (kg/head/day)						
DM	16.50^{d}	17.54^{ab}	17.70^{a}	17.01^{c}	17.19^{bc}	0.11
TDN	9.73^{d}	10.99^{ab}	11.20^{a}	10.34^{c}	10.56^{bc}	0.14
DCP	1.30^{d}	1.47^{ab}	1.50^{a}	1.38^{c}	1.41^{bc}	0.02

Values bearing different superscripts within rows differ significantly at 5% level. DM: dry matter, TDN: total digestible nutrients, DCP: digestible crude protein.

Milk Yield

The yield of actual milk and 7% fat corrected milk (FCM) across groups in Table 5 revealed significant (P<0.05) increase with eucalyptus leaves supplementation. Actual milk and 7% FCM yield during three-month experiment and the overall mean yield for the experimental period was significantly (P<0.05) the highest in G3 followed by G2, G5 and G4, while G1 had the lowest yield. Fresh eucalyptus leaves led to significant (P<0.05) increase in actual milk and 7% FCM yield more than dry leaves. The different responses to the herbs might be related to differences in the types of active components or their content as indicated by the higher total phenolic compounds in eucalyptus leaves. These results are in accordance with those obtained by Shwerab et al. (2014) who found that eucalyptus leaves supplementation was enhancing milk production of lactating cows. Also, Aboul-Fotouh et al. (2000) reported that incorporating 3% of eucalyptus leaves in lactating buffaloes ration resulted in an increase (P<0.05) of milk yield. Soltan (2009) found that essential oil mixture (EOM) addition (7% eucalyptus oil, 6.6% menthol crystal and 2.0% mint oil) at 16 mg L-1 drinking water improved (P>0.05) milk production across the whole experimental period.

Contents and Yields of Milk Constituents

Contents and yields of milk constituents of buffaloes for the different groups are presented in Table 5. Eucalyptus leaves supplementation led to significant (P<0.05) increase in the percentages and yields of fat, protein, lactose, SNF and TS in milk of lactating buffaloes and it was higher with fresh than that of dry leaves. Buffaloes in G3 recorded significantly (P<0.05) the highest percentages and yields of milk constituents followed by G2, G5 and G4, while the lowest values were detected in G1. These results agreed with Shwerab et al. (2014) who found that eucalyptus leaves supplementation enhanced milk fat, protein, lactose, SNF and TS of lactating cows.

Table 6. Milk yield, milk composition and milk constituents yield for lactating buffaloes fed the experimental rations

Month	Experimental groups					SEM
	G1	G2	G3	G4	G5	
Milk yield (kg/day)						
Actual milk	8.42^{d}	9.58^{b}	10.06^{a}	8.95^{c}	9.19^{bc}	0.14
7% FCM	8.86^{d}	10.54^{b}	11.38^{a}	9.56^{c}	9.89^{c}	0.21
Milk composition (%)						
Fat	7.50^{c}	7.95^{ab}	8.25^{a}	7.65^{c}	7.73^{bc}	0.07
Protein	4.05^{c}	4.29^{b}	4.46^{a}	4.13^{c}	4.17^{bc}	0.04
Lactose	5.03^{c}	5.33^{b}	5.53^{a}	5.13^{c}	5.18^{bc}	0.04
SNF	9.88^{c}	10.43^{b}	10.80^{a}	10.06^{c}	10.16^{bc}	0.09
TS	17.38^{c}	18.38^{b}	19.05^{a}	17.71^{c}	17.88^{bc}	0.16
Ash	0.80	0.81	0.82	0.81	0.81	0.001
Milk constituents yield (kg/day)						
Fat	0.63^{d}	0.76^{b}	0.83^{a}	0.68^{c}	0.71^{c}	0.02
Protein	0.34^{c}	0.41^{ab}	0.45^{a}	0.37^{bc}	0.38^{bc}	0.01
Lactose	0.42^{d}	0.51^{b}	0.56^{a}	0.46^{c}	0.48^{c}	0.01
SNF	0.83^{d}	1.00^{b}	1.09^{a}	0.90^{c}	0.93^{c}	0.02
TS	1.46^{d}	1.76^{b}	1.92^{a}	1.58^{c}	1.64^{c}	0.04
Ash	0.068^{c}	0.078^{ab}	0.082^{a}	0.072^{bc}	0.075^{ab}	0.001

Values bearing different superscripts within rows differ significantly at 5% level. FCM: fat corrected milk, SNF: solids not fat, TS: total solids.

Also, Aboul-Fotouh et al. (2000) reported that inclusion 3% of eucalyptus leaves in lactating buffaloes ration resulted in an increase (P<0.05) of milk fat, protein, lactose, SNF and TS contents. Soltan (2009) stated that incorporating essential oil mixture (EOM) that 7% eucalyptus oil at 16 mg L-1 drinking water improved (P>0.05) milk fat and protein. Meanwhile, Khattab et al. (2018) showed that chamomile flowers supplementation to the ration of Farafra ewes had no effect on ash content in milk.

Feed Conversion

The effect of eucalyptus leaves additives on feed conversion by lactating buffaloes fed the different experimental ratios are shown in Table 6. Eucalyptus leaves additives significantly (P<0.05) improved feed conversion expressed as kg DM and TDN or g DCP required for producing one kg 7% FCM. The amount of DM per kg 7% FCM was significantly (P<0.05) lower for G2 than G3, G3 lower than G4 and G5, G4 and G5 lower than G1. Meanwhile, the amount of TDN and DCP per kg 7% FCM were significantly (P<0.05) lower for G2 and G3 than G1, and non-significantly (P>0.05) lower in G4 and G5 than G1. These results agree with those obtained by Aboul-Fotouh et al. (2000) that incorporating 3% of EG leaves in lactating buffaloes ration resulted in improved feed conversion (P<0.05). Soltan (2009) reported that addition of essential oil mixture (EOM) (7% eucalyptus oil, 6.6% menthol crystal and 2.0% mint oil) at 16 mg L-1 drinking water improved milk to feed ratio. Also, some reported studies carried out on ruminant have shown that EuEO improved the efficiency of nutrient use at 200 g/head/day supplementation for Holstein Friesian cows (Manh et al., 2012). EOs may be used as feed additives in ruminant nutrition to improve feed efficiency and support health (Oussalah et al., 2007). Milk efficiency of Damascus goats as milk/DM intake (P= 0·011), and ECM/DM intake (P=0·003) was greater with mustard and cumin treatments than the control treatment, with no difference (P>0·05) between mustard and cumin treatments (Morsy et al., 2018).

Economic Efficiency

Economic efficiency as affected by eucalyptus leaves additive for the different experimental groups are presented in Table 6.

Table 6. Feed conversion and economic efficiency for lactating buffaloes fed the experimental rations.

Item	Experimental groups					SEM
	G1	G2	G3	G4	G5	
Feed conversion						
DM (kg/kg 7% FCM)	1.86^{a}	1.66^{c}	1.56^{d}	1.78^{b}	1.74^{b}	0.03
TDN (kg/kg 7% FCM)	1.10^{a}	1.04^{b}	0.98^{c}	1.08^{a}	1.07^{ab}	0.01
DCP (g/kg 7% FCM)	147^{a}	139^{b}	132^{c}	145^{a}	143^{ab}	1.36
Economic efficiency						
Feed cost (LE/day)	51.50^{d}	55.25^{ab}	56.30^{a}	53.42^{c}	54.28^{bc}	0.36
Feed cost (LE/ kg 7% FCM)	5.81^{a}	5.24^{c}	4.95^{d}	5.59^{b}	5.49^{b}	0.08
Output of 7% FCM (LE/day)	88.60^{d}	105.40^{b}	113.80^{a}	95.60^{c}	98.90^{c}	2.09
Net revenue (LE/day)	37.10^{d}	50.15^{b}	57.50^{a}	42.18^{c}	44.62^{c}	1.76
Economic efficiency[1]	1.72^{d}	1.91^{b}	2.02^{a}	1.79^{c}	1.82^{c}	0.03
Economic efficiency[2]	72.04^{d}	90.77^{b}	102.13^{a}	78.96^{c}	82.20^{c}	2.78

Values bearing different superscripts within rows shows significant difference at 5% level. DM: dry matter, TDN: total digestible nutrients, DCP: digestible crude protein.

Feed cost, output of 7% FCM yield, net revenue and economic efficiency increased significantly (P<0.05); however, feed cost per one kg 7% FCM yield decreased significantly (P<0.05) with eucalyptus leaves additive.G3 had significantly (P<0.05) the highest feed cost, output of 7% FCM yield, net revenue and economic efficiency, and the lowest feed cost/kg 7% FCM followed by G2, G5 and G4, while G1 had the opposite values. These results might be attributed to the improvements in milk yield and composition as shown previously. These results agreed with Salem et al. (2019) that essential oil supplementation to Friesian cow's improved economic efficiency.

Conclusions

Incorporating fresh eucalyptus leaves at the level of 100 g/head/day recorded the best improvements in feed intake, digestibility, rumen fermentation activity, some blood serum biochemical, milk yield and composition, feed conversion, and economic efficiency of lactating buffaloes.

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