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Research Article

Effect of Different Levels of Organic Acids Supplementation on Feed Intake, Milk Yield and Milk Composition of Dairy Cows during Thermal Stress

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ABSTRACT

In many developing countries in the tropics, thermal stress results in lower feed intake, changes in energy metabolism, alterations in endocrine profiles of dairy cows which lead to animal health problems and production losses. Supplementation of organic acids can reduce the toxic metabolites and endocrine changes in the cow's body during thermal stress. The present study was conducted at University Dairy Farm, The University of Agriculture, Peshawar to determine the effect of supplementing different levels of organic acids solution in drinking water on the milk yield, milk composition, milk somatic cell count (SCC), blood haemoglobin (Hb) and packed cell volume (PCV) of dairy cows during thermal stress. The solution of organic acids was prepared by dissolving 80g citric acid, 90g phosphoric acid, 50g lactic acid and 10g copper sulphate in one litre of distilled water. Twelve Holstein Friesian dairy cows (mid-lactation, 3 to 4 years old) having average body weight of 400kg were blocked into four groups on the basis of parity and milk yield. The cows were offered water without (group A) or with organic acids solution at the rate of 0.5, 1 or 1.5ml per litre of drinking water. The experiment was continued for 30 days along with two weeks adaptation period during the summer months of July and August, 2012. The addition of organic acids to the drinking water increased ($P<0.05$) feed intake and milk yield. The addition of organic acids significantly increased ($P<0.05$) the percentage of fat, protein, lactose, solids not fat and total solids in milk, whereas, the SCC decreased. The blood Hb and PCV increased ($P<0.05$) with the use of organic acids in the drinking water. The results of present research demonstrate that the using organic acids solution in the drinking water of dairy cows can maintain animal health and production during thermal stress and thereby minimizing the production losses and improve the profitability of the dairy farms.

Abbreviation: DMI, dry matter intake; Hb, haemoglobin; PCV, packed cell volume; SNF, solid not fat; TS, total solids; THI, Temperature Humidity Index.

INTRODUCTION

Thermal stress is the sum of external forces to a homoeothermic animal that acts to shift body temperature from the resting state. Thermal stress reduces feed intake, milk yield, growth rate and reproductive performance which lead to major economic losses to the dairy farmers especially in tropical countries. It also affects cellular physiology and systemic metabolism leading to reduction in dry matter intake (DMI) and milk production due to changes in the physiology, energy metabolism and endocrine profiles of dairy cows (Yousef, 1985; Baumgard and Rhoads, 2007; Collier *et al*., 2008). Sanchez *et al*. (1994) reported 20 to 40% decrease in DMI at 40℃ compared to cows in a thermo neutral comfortable environment. Thermal stress depresses digestion of dietary nutrients reducing the effectiveness of converting feed energy units into production energy units (Fuquay, 1981). The lactating dairy cows are more sensitive to thermal stress because they produce much more metabolic heat and accumulate the additional heat from radiant energy than the non-lactating ones (Blackshaw and Blackshaw, 1994; West, 2003). The cow's comfort zone is between -0.5 to 20℃, however it varies between the breeds (Prasad *et al*., 2012). The upper critical limit temperature limit can reach up to 25 to 26℃ (West, 2003). The environmental temperature is not the only factor, relative humidity is also important to describe the cow's comfort zone. The combined effect of temperature and humidity is quantified as Temperature Humidity Index (THI). The normal THI level of 72 is optimal to maintain the milk production of dairy animals (Prasad *et al*., 2012).

In the tropics, green fodder is not available during the prolonged summer period, and cows are mostly fed on low quality dry roughages, crop residues and agro industrial by products (Khan *et al*., 2009, 2012; Habib *et al*., 2013). These feeds are higher in ligno-cellulose content and lower in fermentable carbohydrates resulting in lower production of volatile fatty acids and rumen fermentation efficiency. Organic acids supplementation improves the utilization of dietary nutrients in the gastrointestinal tract of dairy cows. Moreover, organic acids can reduce the toxic metabolites, colonization of pathogens and endocrine changes in the cow's body during heat stress. The supplementation of organic acids improves the bioavailability of protein and uptake of minerals like magnesium, calcium, phosphorus and zinc (Hinton *et al*., 1988; Thompson and Hinton, 1997). Organic acids such as fumeric acid, citric acid, formic acid etc. have been used as growth promoters to enhance the digestibility of feed. Supplementation of organic acid can also improve milk quality. Feeding of orange extract reduced somatic cell count in high producing cows during moderately to hot summer season (Soderstrom, 2012).

During summer months (June to August), the temperature in most parts of South Asian Countries such as Pakistan increases above 40ºC, due to which the productivity of imported Holstein Frisians and their cross breeds reduces significantly due to less feed intake and changes in the metabolism. Moreover, most of the dairy animals are raised under small holder production systems. Because of these smaller production systems, the environmental interventions are very limited due to high cost involved.

The present study was therefore designed to investigate the effect of different levels of organic acids solution in the drinking water on the feed intake, milk yield, milk composition and the somatic cell count (SSC) of milk of dairy cows during thermal stress conditions. In addition, effect of different levels of organic acids on the blood haemoglobin (Hb) and packed cell volume (PCV) of heat-stressed dairy cows was also investigated.

MATERIALS AND METHODS

Experimental design and measurements

The solution of organic acids was prepared by dissolving 80g citric acid, 90g phosphoric acid, 50g lactic acid and 10g copper sulphate in one litre of distilled water. Copper sulphate was used for stability and preservation of the solution. Twelve Holstein Friesian cows (mid-lactation, 3 to 4 years old, average body weight of (400±50kg) were used in the present study. The cows were blocked on the basis of parity and milk production into four groups (three cows per group), and offered water without (control) or with organic acids solution at the rate of 0.5, 1 and 1.5 ml per litre of drinking water. The experiment was continued for 45 days including two weeks adaptation period. The study was conducted during the summer months of July and August, 2012. The rations for the experimental animals were formulated according to the guide lines of NRC (2001) for dairy cows. The cows were offered maize fodder (dry matter, 18%; crude protein, 9%) as a basal diet, and 10 kg/animal dry ration (60% concentrate+40% wheat straw). The concentrate was consisting of cottonseed cake (25%), maize gluten (20%), mustard seed cake (8%), wheat bran (45%) and di-calcium phosphate (2%). For record keeping, separate feeding and water troughs were provided for each animal. Feed intake, temperature and relative humidity of the farm were recorded on daily basis. The cows were milked twice daily (morning and evening) and daily milk yield per cow was recorded.

Sample collection

For analysis of milk composition and SCC, milk samples were taken weekly from 4 consecutive milking. The morning and evening milk samples were pooled (1:1 ratio) separately to obtain two composite milk samples. Blood samples from the experimental animals were taken weekly to study the effect of different levels of organic acids solution on the blood Hb and PCV of dairy cows.

Chemical Analysis

The milk samples were mixed thoroughly and were analyzed for lactose, fat, protein, ash, solid not fat (SNF) and total solids (TS) according to the method of AOAC (1990). The SSC in the milk samples was checked according to the method described by Sears *et al*. (1993). Blood PCV and Hb were determined through Micro-capillary method and Sahli's haemometer procedure, respectively.

Statistical analysis

The effect of organic acids addition on milk yield, composition and the SSC, and on the blood Hb and PCV was determined using PROC MIXED procedure of statistical analysis (SAS, 2009) using the following model.

$$Y_{ijk} = \mu + B_i + O_j + e_{ijk}$$

where, Y_{ijk}, is the depended variable; μ, is the overall mean; B_i, is the random effect of block/replication, O_j, is the fixed effect organic acids; e_{ijk} is the random error. Values are presented as least square means with the standard error of the means.

RESULTS AND DISCUSSION

Feed intake

Data on feed intake of the dairy cows supplemented with different levels of organic acids solution are summarized in Table 1. The supplementation of organic acids in the drinking water significantly increased (P<0.05) feed intake of dairy cows. Higher feed intake was recorded for cows offered with 1.5ml organic acids solution per litre of water, while lowered feed intake was recorded in cows offered with plain water (control), during the thermal stress conditions. The increase in feed intake with the addition of organic acids in the present study was similar to the findings of Wing *et al.* (1988). Moreover, a parallel increase in feed intake was observed with the increasing dose of organic acids solution (Wing *et al*., 1988; Castillo *et al*., 2004; Bampidas and Robinson, 2006). During thermal stress, the feed intake of dairy cows decreases, and the extent of reduction depends on the period of thermal stress. The production of volatile fatty acids especially acetic acid reduces during heat stress which results in less feed intake and feed efficiency (Prasad *et al*., 2012). In contrast, Emery *et al.* (1961) reported that lactic acid supplementation to the diet reduced feed intake. Lactic acid makes rations less palatable which result in low feed intake. The higher feed intake in the present study could be related to the use of lactic acid in combination with other organic acids (citric acid, phosphoric acid and copper sulphate) and to the use in the drinking water instead of feed. The higher feed intake could also be related to the positive effect of the mixed organic acids solution on the ruminal fermentation and metabolism of dairy cows. Similarly, Castillo *et al*. (2004) stated that high levels of organic acids may be beneficial as feed additives for ruminants because they have effects on ruminal fermentation analogous to ionophores.

Table 1: Feed intake and milk yield of dairy cows supplemented with different levels of organic acids during summer heat stress

Organic acids[1] (ml/litre of water)	Feed intake (kg/day)		Milk yield (kg/day)	
	Mean	SEM[2]	Mean	SEM
0	31.3b	0.94	10.4c	0.99
0.5	35.4a	2.71	11.8b	0.98
1.0	36.0a	2.38	12.5b	0.81
1.5	37.3a	2.84	13.4a	0.30

Mean values of feed intake and milk yield with different superscripts (a-c) are significantly (P<0.05) differed.
[1] Mixed solution of organic acids: containing 80g citric acid, 90g phosphoric acid, and 50g of lactic acid and 10g of copper sulphate per litre of distilled water.

Milk yield

During thermal stress, the constant exposure of dairy cattle to high temperature causes high body temperature, reduction in feed intake, alterations in endocrine profiles which ultimately lead to decrease in milk production (Prasad *et al*., 2012). In the tropical countries, thermal stress is considered as a main factor which causes decline in milk production during summer months (Prasad *et al*., 2012). Milk production can decrease between 10 to 35% during prolonged thermal stress period (Schneider *et al*., 1984; St-Pierre *et al*., 2003). Collier *et al*. (2008) reported reduction in milk yields due to decrease in energy metabolism. The utilization of digestible energy in dairy cows was 60% at 21℃ but it decreased to 40% after 7 days exposure to 32℃. During heat stress period, a negative

correlation was found between milk production and THI (Linville and Pardue 1992).

Data on milk yield of the dairy cows supplemented with different levels of organic acids solution are summarized in Table 1. The results show that the milk yield significantly (P<0.05) increased with the use of the organic acids solution in the drinking water during thermal stress. The higher level (1.5ml) of organic acids solution results in higher milk production (Table 1). The increase in the milk yield might be due to increase in microbial efficiency and microbial nitrogen production, and the less methane production the rumen (Newbold *et al*., 2005; Sniffen *et al*. 2006; Khampa and Wanapat, 2007). Wing *et al*. (1988) evaluated the possible use of citrus molasses distillers as a source of organic acids for dairy cows and found increase in DMI and milk yield without any negative effect on the milk composition and body weight of the cows.

Milk composition

Thermal stress not only decreases the milk production but also causes negative influence on the milk composition (Prasad *et al*., 2012). The different levels of organic acids supplementation affected the composition of milk. In the present study, the use of organic acids solution in the drinking water significantly (P<0.001) increased the contents of fat, protein, lactose, SNF and total solids in milk (Table 2). In contrast, Piquer *et al*. (2009) and Ebtehag *et al*. (2011) reported a decline in milk fat content by the inclusion of whole citric fruits and organic acids, respectively compared to the control ration. However, Wang *et al*. (2009) observed that dairy cows supplemented with organic acids showed no effect on milk composition. The significant (P<0.05) increase in the milk fat content in the present study might be due to the supplementation of organic acids in the drinking water instead of using in the feeds which can depress feed intake due to lower palatability. In the present study, the milk protein increased at high level of organic acids used in the drinking water (Table 2). El-Nour *et al*. (2009) and Piquer *et al*. (2009) also found that organic acid supplementation increased milk protein. However, this increase was quantitatively very small. In the present study, the high protein content might be attributed to high feed intake and the beneficial effect of the mixture of organic acids. The increase in lactose content in milk with organic acid supplementation is consistent with the findings of El-Nour *et al*. (2009). The content of SNF in milk increased (P<0.05) with the use of organic acids in the drinking water. In the present study, the total solids content in milk increased with supplementation of organic acids. The results of present study are supported by Piquer *et al*. (2009) reported that the total solids content of milk was significantly (P<0.05) increased by the use of organic acids.

Somatic cell count

Data on the SCC of milk from cows offered with various level of organic acids solution is summarized in Table 3. The SCC significantly (P<0.05) decreased in cows supplemented with organic acids as compared to cows offered with plain water. The decrease in milk SSC content is consistent with the findings of Soderstrom (2012). These findings suggest that organic acids can be used as preventive measures against mastitis infection which cause major economic losses to dairy business.

Table 3 : Effect of different levels of organic acids[1] supplementation on blood haematology of dairy cows during summer stress.

Organic acids(ml/litre of water	Haemoglobin (g/dl)		Packed cell volume (%)	
	Mean	SEM[2]	Mean	SEM
0	10.5[c]	0.43	32.4[c]	0.27
0.5	11.3[b]	0.25	32.7[b]	0.28
1.0	11.4[b]	0.34	33.1[a]	0.43
1.5	12.1[a]	0.71	33.2[a]	0.45

Mean values within the same column with different superscripts (a-c) are significantly (P<0.05) differed.

[1] Mix solution of organic acids: citric acid (80g), phosphoric acid (90g), lactic acid (50g) and copper sulphate (10g) were solved in one L distilled water.

[2] Standard error of the mean.

Table 2: Effect of different levels of organic acids[1] supplementation on milk composition (%) and somatic cell count of dairy cows during summer stress

Organic acids (ml/litre of water)	Ash	Fat	Protein	Lactose	Solid not fat	Total solids	Somatic cell count per ml
0	4.92	3.79[c]	3.32[c]	4.50[c]	8.54[c]	12.34[c]	220000
0.5	4.92	3.83[b]	3.35[b]	4.56[b]	8.62[b]	12.45[b]	202083
1.0	4.92	3.83[ab]	3.36[b]	4.57[b]	8.64[b]	12.48[b]	179583
1.5	4.92	3.84[a]	3.39[a]	4.59[a]	8.69[a]	12.54[a]	174583
Pooled SEM[3]	0.71	0.025	0.028	0.031	0.030	0.041	4083

Mean values within the same column with different superscripts (a-c) are significantly ($P<0.05$) differed.
[1] Mix solution of organic acids: citric acid (80g), phosphoric acid (90g), lactic acid (50g) and copper sulphate (10g) were solved in 1L distilled water. [2] Standard error of the mean. [3] Estimated for the least square mean values of milk composition across all groups

Blood haemoglobin and packed cell volume

Data of the effect of different levels of organic acids on blood Hb and PCV is summarized in Table 3. The Hb content and PCV of blood significantly (P<0.05) increased with the use of organic acid in water during the thermal stress conditions. The results shows that the use of organic acids solution in the drinking water not only improve milk production and milk quality but also beneficial for the health of dairy cows.

CONCLUSIONS

The results of present study show that the supplementation of the organic acids solution in the drinking water improves the performance of dairy cows during thermal stress conditions. Feed intake and milk yield of dairy cows were significantly (P<0.05) increased with the addition of organic acids mixture in the drinking water. The use of organic acids mixture during thermal stress also shows positive effects on milk composition during thermal stress. Moreover, the use of organic acids increased Blood Hb concentration and decreased the SCC in milk of dairy cows. The results of this study suggest using organic acids solution in the drinking water of dairy cows to minimize the production losses and to improve the health of dairy cows during prolonged thermal stress conditions in the tropics.

LITERATURE CITED

AOAC. 1990. Association of Analytical Chemists, Official Methods of Analysis, Arlington, Virginia, USA.

Baumgard, L.H., Rhoads, R.P. 2007. The effects of hyperthermia on nutrient partitioning. In proceeding of Cornell nutritional conference for feed manufacturers, pp. 93-104.

Blackshaw, J.K. and Blackshaw, A.W. 1994. Heat stress in cattle and the effect of shade on production and behaviour. Australian Journal of Experimental Agriculture, 34, 285-295.

Castillo, C., Benedito, J.L., Mendez, J., Pereira, V., Lopez-Alonso, M., Miranda, M. and Hernandez, J. 2004. Organic acids as a substitute for monensin in diets for beef cattle. Animal Feed Science and Technology, 115, 101-116.

Collier, R.J., Collier, J.L., Rhoads, R.P. and Baumgard, L.H. 2008. Invited review: Genes involved in the bovine heat stress response. Journal of Dairy Science, 91, 445-454.

Ebtehag, I.M.A.E., Hoda, M.E. and El-Shabrawy, H.M. 2011. Comparing effects of organic acid (malate) and yeast culture as feed supplement on dairy cows performance. In proceedings of the 4th Scientific Conference of Animal Wealth Research in the Middle East and North Africa, Foreign Agricultural Relations (FAR), Egypt, pp. 340-353.

El-Nour, H.H.M., Rahman, H.M.A. and Safaa, A. 2009. Effect of supplementation with malate on some metabolites, reproductive performance and milk constituents in early lactating Egyptian buffaloes. Global Veterinaria, 3, 369-376.

Emery, R.S., Thomas, J.W. and Brown, L.D. 1966. Fermentation, absorption and feeding results with L (+) lactic acid monomer and polymer and DL-lactate salts. Journal of Animal Science, 25, 397-40.

Fuquay, J.W. 1981. Heat stress as it affects animal production. Journal of Animal Science, 52, 164-174.

Habib G, Khan, N.A., Ali, M., Bezabih, M. 2013. In situ ruminal crude protein degradability of cereal grains, oilseeds and animal by-product based protein feedstuffs. Livestock Science, 153: 81-87.

Hinton, M. and Linton, A.H. 1988. Control of salmonella infections in broiler chickens by the acid treatment of their feed. Veterinary Record, 123, 416-421.

Khampa, S. and Wanapat, M. 2007. Manipulation of rumen fermentation with organic acids supplementation in ruminants raised in the tropics. Pakistan Journal of Nutrition, 6, 20-27.

Khan, N.A. and Habib, G. 2012. Assessment of Grewia oppositifolia leaves as crude protein supplement to low-quality forage diets of sheep. Tropical Animal Health and Production, 44, 1375–1381.

Khan, N.A., Habib G., Ullah G. 2009. Chemical composition, rumen degradability, protein utilization and lactation response to selected tree leaves as substitute of cottonseed cake in the diet of dairy goats. Animal Feed Science and Technology, 154: 160-168.

Linvill, D.E. and Pardue, F.E. 1992. Heat stress and milk production in the South Carolina coastal plains. Journal of Dairy Science, 75, 2598-2604.

Newbold, C.J., López, S., Nelson, N., Ouda, J.O., Wallace, R.J. and Moss, A.R. 2005. Propionate precursors and other metabolic intermediates as possible alternative electron acceptors to methanogenesis in ruminal fermentation *in vitro*. British Journal of Nutrition, 94, 27-35.

Piquer, O., Ródenas, L., Casado, C., Blas, E. and Pascual, J.J. 2009. Whole citrus fruits as an alternative to wheat grain or citrus pulp in sheep diet: effect on the evolution of ruminal parameters. Small Ruminant Research, 83, 14-21.

Prasad, A., Muhammed, E., Kannan, A. and Aravindakshan, T. 2012. Thermal stress in dairy cattle. Journal of Indian Veterinary Association, 10, 45-51.

Sanchez, W.C., McGuire, M.A. and Beede, D.K. 1994. Macromineral nutrition by heat stress interactions in dairy cattle: review and original research. Journal of Dairy Science, 77, 2051-2079.

SAS, 2009. Statistical Analysis System, User's Guide: Statistics, Version 9.2. SAS Institute, Inc., Cary, NC, USA.

Sears, P.M., Gonzalez, R.L.N., Wilson, D.J. and Han, H.R. 1993. Procedures for mastitis diagnosis and

control. The Veterinary clinics of North America. Food Animal Practice, 9 (3), 445.

Schneider, P.L., Beede, D.K., Wilcox, C.J. and Collier, R.J. 1984. Influence of dietary sodium and potassium bicarbonate and total potassium on heat-stressed lactating dairy cows. Journal of Dairy Science, 67, 2546-2553.

Sniffen, C.J., Ballard, C.S., Carter, M.P., Cotanch, K.W., Dann, H.M., Grant, R.J., Mandebvu, P., Suekawa, M. and Martin, S.A. 2006. Effects of malic acid on microbial efficiency and metabolism in continuous culture of rumen contents and on performance of mid-lactation dairy cows. Animal Feed Science and Technology, 127, 13-31.

Soderstrom, J.M. 2012. Impacts of feeding a citrus extract on measures of heat stress and productive performance of high producing dairy cows during summer heat. MS thesis, University of California, Davis.

St-Pierre, N.R., Cobanov, B. and Schnitkey, G. 2003. Economic losses from heat stress by US livestock industries. Journal of Dairy Science, 86, E52-E77.

Thompson, J.L. and Hinton, M. 1997. Antibacterial activity of formic and propionic acids in the diet of hens on Salmonellas in the crop. British Journal of Nutrition, 38, 59-65.

Wang, C., Liu, Q., Yang, W.Z., Dong, Q., Yang, X.M., He, D.C., Dong, K.H. and Huang, Y.X. 2009. Effects of malic acid on feed intake, milk yield, milk components and metabolites in early lactation Holstein dairy cows. Livestock Science, 124, 182-188.

West, J.W., 2003. Effects of heat-stress on production in dairy cattle. Journal of Dairy Science, 86, 2131-2144.

Wing, J.M., Van Horn, H.H., Sklare, S.D. and Harris Jr, B. 1988. Effects of citrus molasses, distillers solubles and molasses on rumen parameters and lactation. Journal of Dairy Science, 71, 414-420.

Yousef, MK. 1980. Stress physiology: definition and terminology. CRC Press, Boca Raton, Fla., USA.

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