EFFECT OF FEEDING ADDITIVES ON TOTAL SOLIDS OF COWS' MILK

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **EFFECT OF FEEDING ADDITIVES ON TOTAL SOLIDS OF COWS' MILK** is a bonafide record of research work and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other university or society.

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Introduction

1. INTRODUCTION

In recent years India made a remarkable achievement in dairying by implementation of Operation Flood programmes. The Anand pattern co-operatives have changed the scene of dairy farming in this country.

Cross-breeding of local cattle with their exotic counterparts is one innovation that dramatically improved the productive performance of our animals. With increase in milk yield, composition of milk also underwent changes. Solids content of milk lowered which was more marked in Holstein-Friesian crosses. Pruthi et al. (1987) estimated solids content of milk of cross-bred cows maintained at four military farms in India. They found that levels of milk solids in these samples were lower than PFA standards.

In Kerala milk samples from cross-bred cows are often rejected by the co-operatives because these samples do not conform to Prevention of Food Adulteration Act (PFA) limits. Co-operatives pay premiums for high fat/high solids-not fat (SNF) milk above a set standard and pay a flat price below that standard. More tragic part of the problem is that these innocent farmers are often convicted for adulterating milk with water because the samples do not conform to PFA standards.

A recent symposium stressed feeding additives as a principal means for modifying milk composition (Ferris and Vasavada, 1989).

In this country fat is the costliest milk constituent and fat-rich milk products still dominate the market. From the part of producer he gets more value for fat content of the milk produced when compared to SNF portion, under two-axis pricing system. So problem of low-fat milk should be given more attention compared to other milk solids. Moreover, among milk constituents greatest change is possible in fat content (Sutton, 1989). For these reasons in this study cows with low-milk fat content was used.

There are reports about different substances used as feed additives for altering milk composition. But all these compounds cannot be tried in our situation for limitations in the cost of the material, low productivity of animals, nature of feeding and utility of milk.

The present study was undertaken with the following objectives.

1. To find out the effect of feeding certain additives on solids content of cow milk

2. To recommend a feed additive for improving the solids content of milk in low solids producing cows.

Review of Literature

2. REVIEW OF LITERATURE

Extensive studies have been undertaken to modify the composition of the milk of the cow by feeding different chemicals as well as natural feed ingredients. In this review effects of feeding four compounds namely acetic acid, sodium bicarbonate, potassium carbonate and magnesium oxide are mainly dealt with.

Works on other substances, more or less popular, and used for modifying milk composition are discussed together.

2.1. Acetic Acid

The effect of acetic acid supplementation on composition of cow's milk was studied by Rook and Balch (1961); Rook *et al.* (1965); Storry and Rook (1966); Orskov *et al.* (1969) and Omel'yanenko and Shliko (1982).

Some workers used a normal ration supplemented with acetic acid (Rook and Balch, 1961; Rook *et al.*, 1965; Omel'yanenko and Shliko, 1982). But Storry and Rook (1966) and Orskov *et al.*, (1969) used acetic acid with high concentrate-low roughage ration which depressed milk fat content.

Omel'yanenko and Shliko (1982) fed cows with roughage ensiled with acetic acid or green fodder treated with acetic acid while other workers directly infused aqueous solution of acetic acid into rumen (Rook and Balch, 1961; Rook *et al.*, 1965; Storry and Rook, 1966; Orskov *et al.*, 1969).

Acetic acid could increase milk yield from cows (Rook and Balch, 1961; Rook *et al.*, 1965; Omel'yanenko and Shliko, 1982).

In normally fed cows milk fat content was increased with acetic acid (Rook and Balch, 1961; Rook *et al.*, 1965; Omel'yanenko and Shliko, 1982). Acetic acid could increase the lowered fat percentage resulted from high concentrate-low roughage ration (Storry and Rook, 1966; Orskov *et al.*, 1969).

Acetic acid could increase fat yield, protein yield and lactose yield from cows (Rook and Balch, 1961). Rook *et al.* (1965) reported a non significant decrease in SNF content, lactose content and protein content of milk on infusion of acetic acid into rumen.

Effect of other rumen volatile fatty acids on milk composition was also studied. Intra-ruminal infusion of other rumen VFA like propionic acid depressed milk fat content and fat yield (Rook and Balch, 1961; Orskov *et al*., 1969). But propionic acid infusion increased content of SNF including protein in milk and their yields (Rook and Balch, 1961).

Similar infusion with butyric acid increased milk fat percentage and fat yield (Rook and Balch, 1961) while Storry and Rook (1966) could not notice such effect.

Milk yield from supplemented cows was not affected by both propionic and butyric acids (Rook and Balch, 1961).

Feeding of sodium acetate for modifying milk composition was tried by different scientists (Balch and Rowland, 1959; Van soest and Allen, 1959; Stanley *et al*., 1964; Kvitko and Li, 1985).

Sodium acetate also could improve milk fat content of supplemented cows, (Balch and Rowland, 1959; Vansoest and Allen, 1959; Stanley *et al*., 1964).

Stanley *et al*.(1964) and Kvitko and Li (1985) observed an increase in fat corrected milk (FCM) yield and percentage of total solids in milk on feeding sodium acetate.

Balch and Rowland (1959) fed sodium butyrate and sodium propionate to cows. Sodium butyrate increased milk fat content while sodium propionate had no effect on fat content (Balch and Rowland, 1959). Sodium propionate was tried by Vansoest and Allen (1959). Sodium propionate lowered milk fat percentage of supplemented cows (Vansoest and Allen, 1959).

2.2. Sodium Bicarbonate

Sodium bicarbonate remains as one of the most popular feed additive in dairy cow ration for modifying yield and composition of milk. Apart from cows it has been tried in feeding other species for modifying milk composition. Studies were conducted with sodium bicarbonate in the concentrate portion of high concentrate low roughage ration to modify milk composition, but ingredients of the ration differed. Emery and Brown (1961) used grain and hay. Pelleted concentrate and hay was used by Schultz et al. (1965). Concentrate and maize silage was the ration used by Erdman et al. (1982a); Erdman et al. (1982b) Synder et al. (1983) and Vandersall et al. (1989). Concentrate and hay was used by Rogers et al. (1985). Level of inclusion of sodium bicarbonate differed between authors from 1.2 per cent to three per cent of concentrate allowance.

In an experiment Dutton (1981) sprinkled sodium bicarbonate on silage portion of diet at the rate of two ounce per cow.

The influence of feeding sodium bicarbonate on milk fat content varied between reports. Increases in milk fat per cent, as reported by different workers (Emery and Brown 1961 - 0.8% ; Emery et al., 1965a - 0.44%; Schultz et al., 1965 - 1.5%; Dutton 1981 - 0.8%; Erdman et al.,1982a - 0.5%; Erdman et al., 1982b - 0.5%).

An increase in milk fat per cent by feeding sodium bicarbonate was also reported by Thomas and Emery (1969); Synder et al. (1983) and Erdman (1988).

According to some authors feeding sodium bicarbonate did not affect milk fat content (Donker and Marx, 1985; Rogers et al., 1985; ST. Laurent and Block, 1989; Erdman and Sharma, 1989).

Milk protein content as well as solids-not-fat (SNF) content of cow milk was not affected by feeding sodium bicarbonate (Emery et al., 1965a; Ghorbani et al., 1989).

Staples and Lough (1989) reported an increased milk yield on supplementation with sodium bicarbonate. Reduction in milk yield was observed by Emery _et al_. (1965a) and Erdman _et al_. (1982a). No change in milk yield was recorded by Emery and Brown, (1961); Synder _et al_. (1983); Donker and Marx, 1985; Rogers _et al_. (1985); Erdman and Sharma, (1989); Ghorbani _et al_.(1989).

On feeding Sodium bicarbonate, FCM yield from experimental cows were higher in most of the reports (Schultz _et al_., 1965; Synder _et al_., 1983; Erdman, 1988; Staples and Lough, 1989; Erasmus and Prinsloo, 1989; Schriker, 1989). A reduction in FCM yield was reported by ST.laurent and Block (1989), while no change in FCM yield was noticed by Ghorbani _et al_. (1989).

Introduction of sodium bicarbonate into the ration reduced feed intake by experimental animals (Emery _et al_., 1965a). Erdman _et al_. (1982b) reported that this drop in feed intake was temporary and could be avoided by gradual introduction of the additive over a period of three weeks.

Sodium bicarbonate improved feed intake of a ration containing maize silage (Erdman, 1988) and consumption of poor quality silage was increased on its addition (Dutton, 1981).

Dry matter intake by cows was not at all affected by feeding sodium bicarbonate (Schultz et al., 1965; Erdman et al., 1982a; Donker and Marx, 1985; Rogers et al., 1985).

Feeding of sodium bicarbonate improved digestion of nutrients in general (Rogers et al., 1985) and that of acid detergent fibre (ADF) in particular (Synder et al., 1983).

Change of pH of rumen contents from feeding sodium bicarbonate was a topic for study. An increase in rumen pH was noted by Emery et al. (1965a); Thomas and Emery (1969); Synder et al. (1983); Erdman (1988) and Erasmus and Prinsloo, (1989).

There are reports indicating no change in rumen pH (Schultz et al., 1965; Rogers et al., 1985).

Changes in proportion of volatile fatty acids (VFA) in rumen resulting from feeding of sodium bicarbonate showed an increase in the proportion of acetic acid and reduction in that of propionic acid (Emery et al., 1965a; Schultz et al., 1965; Thomas and Emery, 1969; Synder et al., 1983; Erdman, 1988; Erasmus and Prinsloo, 1989). Synder et al. (1983) recorded an increase in the proportion of butyrate and iso-valerate while Schultz et al. (1965) reported increased proportion of valerate in the rumen on feeding sodium bicarbonate. In some experiments there was no change in the proportion of VFA in the rumen (Emery and Brown, 1961; Rogers et al., 1985; Ghorbani et al., 1989).

Comparative studies were conducted between sodium bicarbonate and other feed additives for their effect on milk composition.

Emery et al. (1965a) compared sodium bicarbonate and Magnesium oxide in which he observed increased fat content of milk for magnesium oxide. Milk yield/day and ruminal pH was higher for cows fed with sodium bicarbonate. There was no difference in grain intake and SNF content of milk between two groups.

Sodium bicarbonate was found to be superior than a Phyllosilicate (Palabora vermiculite) in increasing milk fat production in a study conducted by Erasmus and Prinsloo (1989).

A comparative study was conducted between sodium bicarbonate and yeast culture by Erdman and Sharma (1989) which indicated superiority of yeast culture in improving milk fat and protein content.

Feeding sodium sesquicarbonate increased milk fat percent to a higher level than with feeding sodium bicarbonate (Ghorbani et al., 1989).

Even though there is much debate on benefits of inclusion of sodium bicarbonate in dairy cow ration, Shricker (1989) reported about a commercial preparation patented in USA, containing sodium bicarbonate which was effective in increasing milk fat yield.

Reports about the use of sodium bicarbonate in the ration of other species were also available. Jalora and Yadava (1979) and Garg and Nangia (1991) included sodium bicarbonate in buffalo ration while Hadjipanayiotou (1988) reported about its use in feeding milch goats.

Jalora and Yadava (1979) reported a decreasing trend in milk production of buffaloes on feeding sodium bicarbonate. They could not observe any change in milk protein content. Milk yield of buffaloes were not affected in this experiment.

Garg and Nangia (1991) reported an increase in voluntary water consumption by buffaloes supplemented with sodium bicarbonate. The rumen pH increased and microbial protein synthesis was improved in this experiment. They also noted that sodium bicarbonate increased rumen dilution rate and ruminal outflow rate. The proportion of acetic acid in the rumen was higher in buffaloes fed with sodium bicarbonate.

Hadjipanayiotou (1988) reported a decrease in milk protein content for goats fed with sodium bicarbonate. FCM yield increased but there was no change in milk yield from goats.

Erdman (1988) in a detailed review about buffering agents in rumen described mechanism of action of sodium bicarbonate. It increased ruminal pH; compensated inadequate salivary buffering; and increased acetate:propionate ratio in rumen. He stated that 44 g sodium bicarbonate in the ration was equal to one per cent fibre in the ration.

2.3. Potassium Carbonate

West et al. (1986a) included 1.85 per cent of potassium carbonate in a high concentrate - low roughage ration. Supplementation increased digestibility of dry matter consumed and fat content of milk. They noticed a reduction in milk yield.

Comparative studies were conducted between potassium carbonate and sodium bicarbonate by West et al. (1986b) and West et al. (1987).

West et al. (1986b) tried 1.2 per cent potassium carbonate in comparison with 1.5 per cent sodium bicarbonate on two types of diets. The experimental cows were first fed with concentrates and roughages separately and later fed with a complete diet (A mixture of feed ingredients designed to be sole source of food and precludes selection). Potassium carbonate caused highest forage DM intake during first period and highest total DM intake during second period. The values for milk yield and milk fat content, were higher for feeding potassium carbonate, while milk protein content was higher on feeding sodium bicarbonate. None of these buffers influenced rumen pH, or VFA proportion in the rumen.

In the study by West et al.(1987) potassium carbonate caused greater intake and digestibility of dry matter. The ratio of acetic acid to propionic acid in the rumen and milk fat content was higher with feeding potassium carbonate and it did not affect milk yield.

2.4. Magnesium Oxide

Studies were conducted with different levels of magnesium oxide in a high concentrate-low roughage rations.

Emery *et al*. (1965a) used 0.4 lb magnesium oxide in a ration composed of grains, hay and alfalfa pellets.

Thomas and Emery (1969) fed magnesium oxide at two levels (136 g or 181 g). Erdman (1980) tried 0.8 per cent magnesium oxide in a ration of concentrates and maize silage. Teh *et al*. (1985) included 0.4 per cent or 0.8 per cent magnesium oxide in a ration containing 50:50 concentrate and silage on DM basis. Lough *et al*. (1990) formulated a diet using corn silage, cottonseed hulls and concentrates including magnesium oxide so as to supply 0.32 to 0.43 per cent of total dietary magnesium.

Reports indicated increase in milk fat percentage from feeding magnesium oxide. Emery *et al*. (1965a) reported an increase of 0.45 percentage units while Erdman (1980) recorded 0.75 percentage unit increase.

Increase in fat content of milk on feeding magnesium oxide was also reported by Thomas and Emery (1969) and

Erdman (1988). Teh et al. (1985) could observe only a non significant increase in fat percentage.

Lough et al. (1990) could not observe any effect on milk fat percentage from feeding magnesium oxide.

No change was noticed in milk SNF content or in protein content (Emery et al., 1965a; Lough et al., 1990).

A reduction in milk yield on feeding magnesium oxide was reported by Emery et al. (1965a) and Thomas and Emery (1969).

Erdman et al. (1980) and Erdman et al. (1982b) could not observe any change in milk yield on feeding magnesium oxide.

An increase in milk yield was reported by Teh et al. (1985) and Lough et al. (1990) from cows fed with magnesium oxide.

Feeding magnesium oxide depressed feed intake by cows (Emery et al., 1965a; Thomas and Emery, 1969). But supplementation increased dry matter intake by cows without any effect on grain intake (Erdman, 1980; Lough et al., 1990).

After feeding magnesium oxide rumen pH showed an increase in experimental cows (Thomas and Emery, 1969; Erdman, 1980). No change in rumen pH was noted by Emery et al. (1965a).

Emery et al. (1965a) reported a decrease in the proportion of propionate in the rumen of supplemented cows. Decrease in the proportion of propionate and valerate was reported by Thomas and Emery (1969).

Comparative studies were conducted between sodium bicarbonate and magnesium oxide. Emery et al. (1965a) and Erdman (1980) reported that magnesium oxide was superior in increasing milk fat percentage. Milk production was lower with magnesium oxide than with sodium bicarbonate (Emery et al., 1965a; Thomas and Emery, 1969). Rumen pH and propionate content was lower for magnesium oxide when compared with sodium bicarbonate (Emery et al., 1965a).

Combination of magnesium oxide and sodium bicarbonate in a ratio of 1:2 was tried in dairy cow ration by Thomas and Emery (1967); Thomas and Emery (1969); Vandersall et al. (1989).

Thomas and Emery (1969) tried three combinations of magnesium oxide and sodium bicarbonate (91 g + 45 g), (182 g + 91 g) and (272 g + 136 g) respectively. They got fat percentages +0.44, +0.58 and +0.85 and fat yields (kg/day) + 0.1, +0.12 and +0.08 over control values respectively for these combinations.

Similar studies by Thomas and Emery (1969) proved that combination of these two supplements was advantageous.

Vandersall et al. (1989) recommended this combination as specially useful when included in concentrates containing fish-meal.

Mechanism of action of magnesium oxide was explained as extra ruminal by Emery and Thomas (1967). They proved this fact by noting an increase in milk fat production by parenteral injections of magnesium ions.

According to Teh et al. (1985) magnesium oxide increased milk yield by improving the digestibility of ration.

Erdman (1988) pointed out that magnesium oxide is not a true buffer, but it has got maximum acid consuming capacity among additives. He stated that 20 g magnesium oxide in ration was equivalent to one per cent fibre in the ration.

2.5. Other Factors Modifying Milk Composition

Studies were coducted with different levels of Bentonite, a compound composed of inert clay particles (aluminium silicate) in dairy ration (Bringe and Schultz, 1969; Rindsig _et al._, 1969; Zalewska _et al._, 1985). They reported an increase in milk fat percentage in cows fed with Bentonite. Milk yield was also increased in the experiments of Rindsig _et al._ (1969) and Zalewska _et al._ (1985).

The action of Bentonite on milk composition was by increasing acetate:pripionate ratio in rumen, increasing mammary uptake of acetate and by supplying some trace elements (Bringe and Schultz, 1969; Rindsig _et al._, 1969; Zalewska _et al._, 1985).

Whole cotton seed (WCS), an ingredient in cattlefeed proved to be having definite effects on milk composition (Depeters _et al._, 1985; Coppock, 1988).

WCS had no effect on milk yield in any of these works. All the reports showed an increase in milk fat percentage. An increase in total solid content of milk (Depeters _et al._, 1985) and an increase in fat corrected milk yield

(Depters *et al*., 1985; Coppock, 1988) was observed on feeding WCS. Protein content of milk reduced (Depeters *et al*., 1985) but it was not affected in the report of Bartocci *et al*. (1988).

Cotton seed products namely, cotton seed meal and cottonseed hulls which were good protein sources, could not modify milk composition when included in dairy ration (Coppock, 1988).

Incorporation of fats and fatty acids in dairy cow ration for modifying milk composition has been extensively tried. Banks *et al*. (1984) tried saturated free fatty acids, saturated free (unprotected) fats and protected triglycerides. All these supplements increased milk yield from cows. Milk fat percentage was increased by saturated free fatty acids, but feeding of free fats did not affect fat content of milk. Protein content of milk was increased by feeding free fatty acids. Lactose yield from experimental animals increased on feeding free and protected fats.

Pierce-Sandner *et al*. (1985) fed cows with Ammonium salts of isobutyric, isovaleric and valeric acids. These supplements increased milk yield. Fat percentage was not affected by ammonium salts of VFA but they lowered protein content of milk.

Kankare *et al*. (1989) reported that calcium salts of fatty acids improved milk yield from cows on feeding.

Klein *et al*. (1989) fed cows with crystalline fat. This supplement increased milk yield from cows, but there was no effect on milk fat percentage.

Feeding free fats from oil seeds improved milk yield and persistency of milk production (Schingoethe and Casper, 1989).

Abidur Reza (1988) economically used water hyacinth (*Eichhornia crossipes*) along with rice straw in dairy ration to improve milk yield as well as fat content. Fodder sugar beet is another plant which can improve protein percentage of milk (Jambor *et al*., 1988).

A report from France indicated use of protected amino acids in dairy cow ration for improving milk protein percentage (Anon., 1989).

Beauchemin and Buchanan-Smith (1989) used diets differing in neutral detergent fibre (NDF) for feeding cattle. They concluded that increasing levels of NDF decreased milk yield.

High energy-high fibre by-products like soybean hulls increased fat content of milk while wheat middlings improved SNF content when included in cow ration (Bernard et al., 1989).

Cocoa shell meal when included in cattle feed from zero to nine per cent, milk fat percentage proportionately improved from 3.17 per cent to 3.69 per cent without any off-flavour (Chase, 1989).

Silage ensiled with formic acid at the rate of 2.2 litre/MT. on subsequent feeding to milch cows increased milk fat per cent at the expense of milk yield (Gordon, 1989).

Yeast culture has emerged as a feed additive in ruminant ration with beneficial results. It increased milk fat content (Gunther, 1990) and fat corrected milk yield (Williams, 1989; Erdman and Sharma, 1989; Gunther, 1990). Feeding yeast culture increased milk yield (Gunther, 1990) and milk protein yield (Erdman and Sharma, 1989; Williams, 1989; Gunther, 1990).

Mechanisms by which yeast culture influenced milk production were described by Lyons (1989). Yeast culture utilised simple sugars and avoided depression of ruminal pH. It increased acetate:propionate ratio and stimulated cellulose digestion.

Simkins and Rock (1989) reported about a commercial product capable of improving milk yield and milk fat content. The preparation contained a glycopeptide antibiotic and bovine somatotropin injection.

Vitamin D, Niacin and Vitamin E are described as capable of improving milk quality and milk yield when included in cow ration (Barbuat, 1989).

Hermansen (1990) observed increased milk fat yield and milk protein yield when rolled barley was fed to the cows at the rate of two kilogram per day.

2.6. Reasons for Variation in Milk Composition

The relation between low roughage-high grain ration and secretion of low-fat milk was explained by the changes in the proportion of VFA in rumen leading to decrease in fat content of milk (Vansoest and Allen, 1959; Storry and Rook, 1966; Sutton and Morant, 1989).

High grain rations caused some endocrinological disturbances leading to secretion of low-fat milk (Van-Soest, 1963).

High grain-low roughage rations affected microbial population and efficiency of microbial digestion by changing ruminal environment (Knezo and Hlinka, 1988).

Such rations caused incomplete biohydrogenation of poly-unsaturated fatty acids (Teter *et al*., 1989).

Stott (1960) stated that low roughage, highly digestible rations produced more fat corrected milk under high climatic temperatures because such rations reduced heat stress and lowered body temperature and respiration rate. He got only lower milk fat content with low roughage ration. The proportion of different VFA in the rumen of low fat milk producing cows were examined in detail.

Vansoest and Allen (1959) observed lower level of acetic acid and higher level of propionic acid in the rumen of low-fat milk secreting cows. similar reports were made by Storry and Rook (1966); Woodford and Murphy (1988); Erdman (1988) and Klusmeyer et al. (1990).

Changes in proportion of rumen VFA resulted in decreased ketone bodies in blood lowering milk fat synthesis in mammary gland (Vansoest and Allen, 1959). This finding was supported by noticing lower content of Beta hydroxybutyric acid in the mammary gland of such animals (VanSoest, 1963).

Decreased acetate propionate ratio in rumen improved SNF content of milk by increasing alpha amino acids and glucose in blood (Huber and Boman, 1965).

Maintenance of normal ruminal pH was found to be necessary for normal milk composition. Woodford and Murphy (1988) and Klusmeyer et al. (1990) observed a direct correlation between ruminal pH and proportion and type of roughage. Bringe and Schultz (1969) pointed out that maintenance of higher pH in rumen by feeding Bentonite resulted in higher milk fat content. The microbial activity inside rumen is directly correlated with ruminal pH (Knezo and Hlinka, 1988).

Buffers, on using as feed additives increased ruminal pH increasing digestion of dietary ADF (Erdman, 1988).

Particle size of the forage influenced milk composition as reported by Woodford et al. (1986). They suggested that a minimum particle length of 0.64 cm for chopped forage to prevent depression in milk fat content. The minimum size recommended by Knezo and Hlinka (1988) was 0.8 to 1 cm which was termed 'structural fibre' necessary for stimulating mechanoreceptors of rumen mucosa. The same phenomena was noticed by Sutton and Morant (1989).

Studies also indicated that the physical form in which roughage is fed to animals is important in relation to their milk composition. Feeding of pelleted or ground roughages produced low milk fat syndrome (Woodford and Murphy, 1988; Knezo and Hlinka, 1988). Cubing of alfalfa forage after cutting and pressing lowered milk fat per cent on subsequent feeding to cows (Klusmeyer et al., 1990).

Rumen volume, dilution rate and total ruminal outflow are factors influencing composition of milk (Woodford and Murphy, 1988; Garg and Nangia, 1991).

There are reports relating salivary secretion and milk composition. Erdman (1988) described saliva as the major buffering agent in rumen. Bailey and Balch (1961) pointed out that a secretion rate of below 30 ml/min. will change the composition of saliva, reducing concentration of bicarbonates. Rate of secretion of saliva has a relation to DM content of feed and it influenced microbial activity in rumen (Knezo and Hlinka, 1988).

Time spent on chewing increased with roughage content of ration and has a positive correlation with milk fat percentage (Woodford et al., 1986; Woodford and Murphy, 1988).

Milk fat depression resulting from a high concentrate-low roughage diet could be avoided to certain extent, if frequency of feeding total quantity of that diet was increased (Sutton et al., 1988; Sutton and Morant, 1989).

Dietary energy intake and SNF content of milk were directly correlated (Huber and Boman, 1965). A similar relationship was reported between metabolizable energy and protein content of milk (Sporndly, 1989).

For maximum production of milk fat, diet should contain optimum quantity of neutral detergent fibre (NDF) and Acid detergent fibre (ADF). Woodford et al. (1986) recommended an NDF level of 27 per cent and an ADF level of 18 per cent in dairy ration. Erdman (1988) noticed that lower dietary ADF decreased rumen pH and in turn lowered ADF digestion in the rumen.

Stott (1960) stated that the rations should be formulated taking into account of the climatic temperature. He also recommended low roughage rations for tropical climate. Under such climate low roughage rations lowered milk yield from cows (Higginbotham et al., 1989).

Atwal and Erfle (1990) stated that the day-to-day variations in fat percentage resulted from metabolic regulations of lipolysis in adipose tissue.

Some minor factors influencing fat content of milk suggested by different authors were secretion of hormones like insulin, fat mobilizing factor (Vansoest, 1963), stage of lactation and completeness of milking (Schmidt et al, 1988) and stress or ketosis (Vansoest, 1963).

Materials and Methods

3. MATERIALS AND METHODS

An experiment was conducted to find out the effect of feeding certain additives on milk yield as well as some of the major constituents of milk in cross-bred cows.

Milch cows at University Livestock Farm, Mannuthy were used for this study. Cows between 60 and 160 days of lactation were selected for the study. Milk samples of all these animals were collected in the morning and analysed for fat percentage. Samples from cows giving low-fat were re-tested on subsequent days.

Cows giving milk samples with fat content between three and four per cent were noted and six animals from this group with uniform age and parity as far as possible were finally selected for feeding each additive.

The animals were fed with concentrate mixture (APCO's special, KCMMF) having following composition.

Moisture	8.6%
Crude protein	16.8%
Crude fibre	12.4%
Ether extract	2.1%
Acid insoluble ash	6.0%

Concentrate allowance was calculated according to the body weight of the animal and the milk production as per Package of practices Pushkaram (1987). Total concentrate allowance was divided into two equal portions and fed in the morning and evening.

Each cow was fed with *ad libitum* green grass. The animals were watered from buckets thrice daily.

Treatments

Treatments consisted feeding of following additives at given levels.

a) Acetic acid - five per cent solution - 200 ml/day

b) Sodium bicarbonate - 1.5 per cent of concentrate feed.

c) Potassium carbonate - 1.2 per cent of concentrate feed.

d) Magnesium oxide - 0.8 per cent of concentrate feed.

Additives were fed along with concentrate which was made into a gruel with water. Calculated quantity of additive was mixed with part of the concentrate and was fed in the morning. Acetic acid solution was mixed with water used for preparing the concentrate gruel. Sodium bicarbonate and potassium carbonate were dissolved in the water used for the preparation of gruel. Magnesium oxide being insoluble was mixed well with gruel.

Fodder consumption by animals were recorded in terms of weight of green grass consumed per day during each period.

A total period of forty days was alloted for each additive. This period was again divided into

1. Pre-treatment period of first five days in which no additives were fed to the animals.

2. Adaptation period of next twenty days in which additives were fed to the experimental animals for making animals adapted with the additive.

3. Experimental period of next five days in which additives feeding was continued.

4. Post feeding period of last ten days in which additives were not fed.

Collection and Analysis of milk samples

Milk samples from experimental animals were collected after proper mixing of morning milk during each period.

Twelve milk samples were collected from each animal at the rate of three samples during each of the four priods. The frequency of collection was at equal intervals. The samples were brought immediately to the laboratory and kept under refrigeration at 5 ± 1°C.

Observations on different parameters during pre-treatment period served as the control.

Milk yield of animals were noticed throughout the periods. At the time of analysis sample bottles were transferred into a tempering water bath maintained at 40°C and kept for five minutes. Then samples were mixed pouring repeatedly from one container to another.

The milk samples were analysed for the following parameters.

Fat

Fat percentage in milk was estimated by Gerber method as per the procedure described in IS 1224 - Part I (1977).

In a clean, dry butyrometer 10 ml of Gerber's sulphuric acid was taken. To this exactly 10.75 ml of well mixed sample of milk was added followed by 1 ml of amyl alcohol. Contents of butyrometer were mixed well and maintained at a temperature of 65±2°C. Butyrometers were centrifuged for four minutes at maximum speed in a Gerber's centrifuge. Then fat column was read after adjusting it into a main graduation.

Total solids

Total solids percentage of milk was estimated by Gravimetric method (IS: 1479-Part II, 1961). Clean dry empty stainless steel dishes were weighed with their lids. About five ml of milk was pipetted into dish and again weighed with lid. Milk was dried by placing the open dish on a boiling water bath for 30 minutes. Then it was transferred to a well ventilated oven maintained at 99 to 100°C. After three hours the dish was covered and transferred immediately to a desiccator. Weighed the dish after 30 minutes. Procedure was repeated until loss of weight between successive weighings did not exceed 0.5 mg. Lowest weight was noted. Percentage of total solids was calculated.

Solids-not-fat

Solids-not-fat (SNF) content of milk was determined by finding the difference between total solids content and fat content of milk.

Protein

Protein content was estimated by Dye-binding method (Dolby, 1961).

A dye solution was prepared by dissolving 0.6165 g of Amido black 10B in one litre of 0.3M citric acid. Five ml of milk sample was diluted to 100 ml, five ml of diluted milk was mixed with 10 ml of dye solution in a 15 ml centrifuge tube. Tubes were centrifuged for five minutes at 2500 rpm. A three ml portion of the supernatant liquid was diluted to 100 ml and the optical density was measured at 615 mμ. Blanks with 5 ml of water to 10 ml of dye solution were included in each batch and was diluted in the same manner. The difference in optical density (D) between blank (DO) and sample (DX) was recorded.

The protein content was arrived at from a standard curve (Fig.1) relating (DO-DX) found out by above procedure and total protein of eight milk samples containing a wide range of protein determined by Kjeldahl method (AOAC 1980).

Fat yield

Average fat yield/day from each animal was calculated from average milk yield and mean fat percentage during each period.

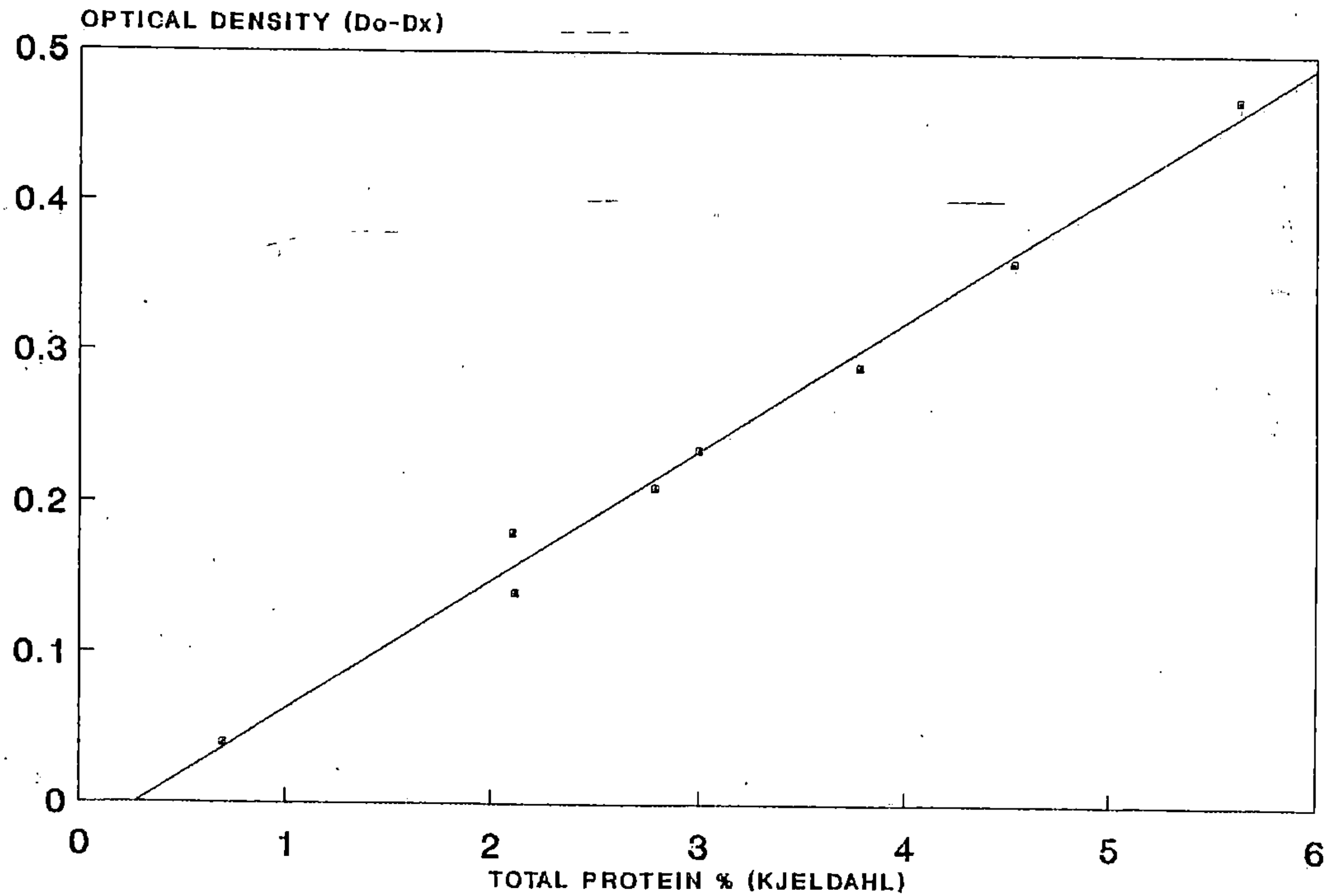
Protein yield

Average protein yield/day was calculated from average milk yield and mean protein percentage during each period.

Data were analysed statistically. Data collected during the adaptation period were not subjected to statistical analysis.

Effect of each treatment on different parameters was found out by pairwise comparison between means of observations during pre-treatment, experimental and post-feeding periods under that treatment using Student's t-test (Snedecor and Cochran, 1967).

Fig. 1 STANDARD CURVE FOR DETERMINATION OF PROTEIN PERCENTAGE



For comparing efficiency of additives two type of effects were estimated for each additive in the following manner.

Experimental period mean - Pre-treatment period mean
(Treatment effect)

Post-feeding period mean - Experimental period mean
(Carry-over effect)

Pair-wise comparison was made between additives for Treatment effect and Carry-over effect using Student's t-test (Snedecor and Cochran, 1967).

Results

4. RESULTS

An experiment was conducted for studying the effect of acetic acid, Sodium bicarbonate, Potassium carbonate and magnesium oxide on milk yield and composition. Results of this study are presented as two major sections. First section contains effects of individual additives on milk fat per cent, milk protein per cent, total solids per cent, solids-not-fat per cent, milk yield, milk fat yield and milk protein yield. For this purpose pairwise comparison was done beteween mean of observations noted during pre-treatment, experimental and post-feeding periods under each additive. The minimum and maximum values as well as the mean and standard error obtained during each period with different additives are presented in Tables 1 to 7. The results of pairwise comparison using t-test are also given along with each table. Those t-values which were found significant at five per cent level on statistical analysis are marked with an asterisk. The effects of different additives on fat per cent, protein per cent, total solids per cent and solids-not-fat per cent are graphically depicted in Figures 2 to 5.

Second section includes a comparative study between different additives for their effects on each parameter. For this purpose treatment effect and carry over effect of each additive were estimated for individual parameters under study. Pairwise comparison was done between additives for treatment effect and carry over effect. Minimum and maximum values obtained for each effect and their mean by feeding different additives are presented in Tables 8 to 14. The results of pairwise comparison of means are presented along with each table. Those effects which differed significantly between the additives were marked with an asterisk.

Graphical representations of comparative study between different additives for their effects on fat percentage, protein percentage, total solids percentages and solids-not-fat percentage are given in figs. 6 to 9.

Data on feed consumption by experimental cows during different periods on feeding acetic acid, sodium bicarbonate, potassium carbonate and magnesium oxide are presented in Tables 15, 16, 17 and 18 respectively.

Effect of Individual Additives on Composition and Yield of Milk

1. Milk fat percentage

Mean fat percentages obtained during different periods on feeding the four additives under study are presented in

Table 1(a). The results of the pairwise comparison between period means are presented in Table 1(b).

On feeding acetic acid the mean values of milk fat percentage were 3.73±0.09, 4.06±0.24 and 4.08±0.09 during pre-treatment, experimental and post-feeding periods respectively. On statistical analysis, pre-treatment and post-feeding means differed significantly ($P < 0.05$).

The average percentages of fat noted on feeding sodium bicarbonate were 3.51±0.06, 3.91±0.14 and 3.81±0.070 respectively during pre-treatment, experimental and post-feeding periods. The differences between pre-treatment mean and experimental period mean as well as that between pre-treatment period mean and post-feeding period mean were significant statistically ($P < 0.05$). The experimental period mean and post-feeding period mean did not differ significantly.

In response to feeding potassium carbonate the average fat percentage during pre-treatment period was 3.57±0.09. This value differed significantly ($P < 0.05$) from average during experimental period, 3.92±0.07. During post-feeding period average fat percentage was 4.06±0.07 which was significantly different from pre-treatment period value

Table 1(a). Range and mean* values of MILK FAT PERCENTAGE

Treatments		Pre-tre-atment period	Experi-mental period	Post-feeding period
	Min.	3.40	3.65	3.70
Acetic Acid	Max.	4.16	4.60	4.50
	Mean	3.73±0.09	4.06±0.14	4.08±0.09
	Min.	3.20	3.40	3.46
Sodium bicarbonate	Max.	3.80	4.85	4.30
	Mean	3.51±0.06	3.91±0.14	3.81±0.07
	Min.	3.10	3.60	3.66
Potassium Carbonate	Max.	4.20	4.25	4.36
	Mean	3.57±0.09	3.92±0.07	4.06±0.07
	Min.	3.20	3.00	2.86
Magnesium Oxide	Max.	4.03	4.40	4.36
	Mean	3.68±0.10	3.72±0.15	3.64±0.18

* Mean of 18 observations (6 animals x 3 samples)

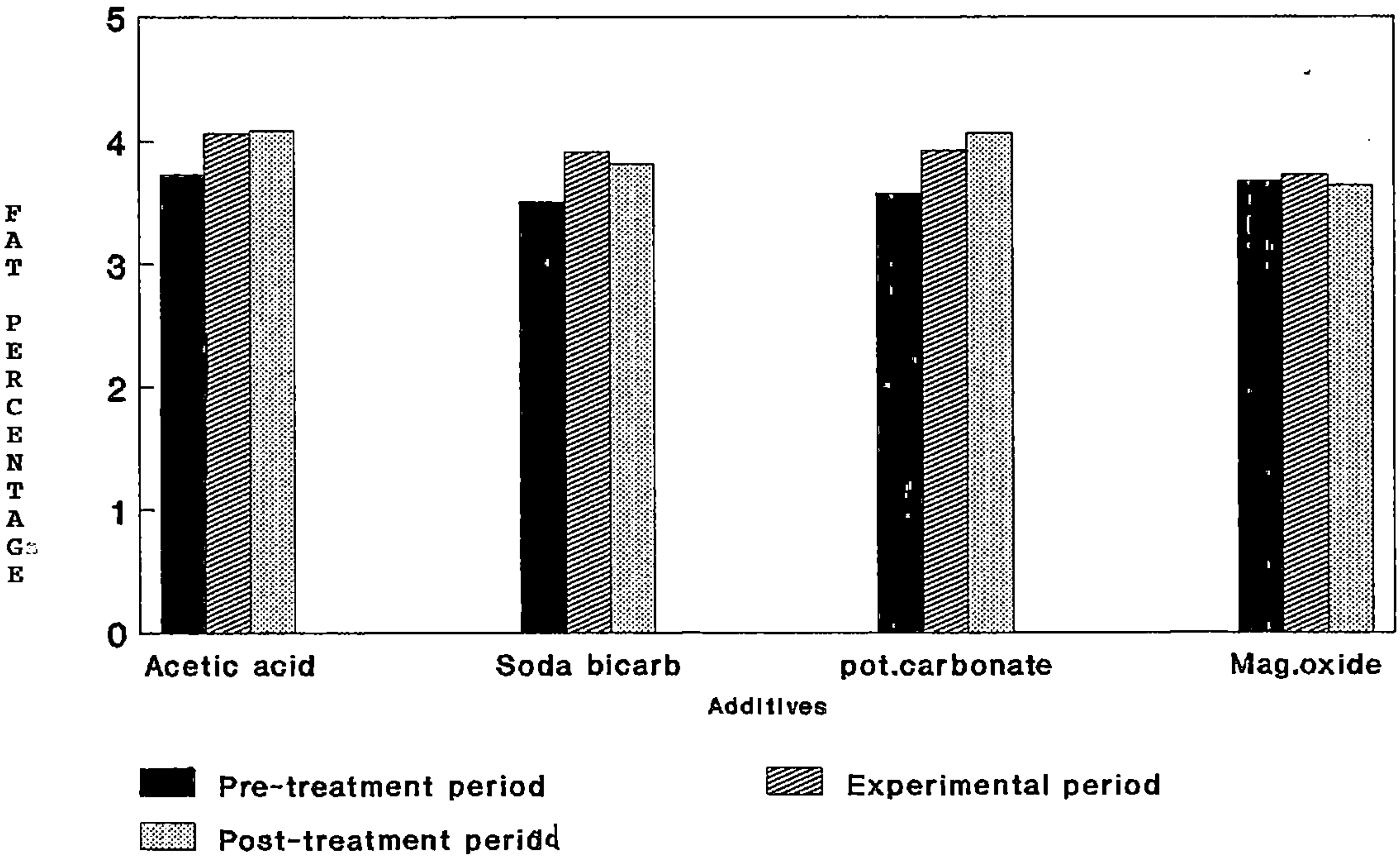
Table 1(b). Results of t-test

Treatments	Pre-treatment x Experimental	Pre-treatment x post-feeding	Experimental x post-feeding
Acetic Acid	-2.04	-2.86*	-0.11
Sodium bicarbonate	-2.57*	-3.08*	0.65
Potassium Carbonate	-2.73*	-3.84*	-1.42
Magnesium Oxide	-0.22	0.18	0.33

* t-values significant at five percent level.

Fig. 2

EFFECT OF FEEDING DIFFERENT ADDITIVES ON MILK FAT PERCENTAGE



($P<0.05$) but did not show any significant difference from experimental period mean.

The average fat percentages with feeding magnesium oxide were 3.68 ± 0.10, 3.72 ± 0.15 and 3.64 ± 0.18 during pre-treatment, experimental and post-feeding periods respectively. Pair-wise comparison showed no significant difference between any of these values.

The effects of different additives on milk fat percentage during the three periods are summarised in Fig.2.

2. Milk protein percentage

The mean of protein percentages obtained during the three periods along with the minimum and maximum values are presented for different additives in Table 2(a). The results of pair-wise comparison using 't-test' are given in Table 2(b).

The average of protein contents of milk recorded on feeding acetic acid were 2.89 ± 0.1, 2.96 ± 0.09 and 2.98 ± 0.1 during pre-treatment, experimental and post-feeding periods respectively. On statistical analysis differences between these means were not significant.

Table 2(a). Range and mean* values of MILK PROTEIN PERCENTAGE

Treatments		Pre-tre-atment period	Experi-mental period	Post-feeding period
	Min.	2.33	2.53	2.52
Acetic Acid	Max.	3.49	3.49	3.63
	Mean	2.89±0.10	2.96±0.09	2.98±0.10
	Min.	2.65	2.48	2.47
Sodium bicarbonate	Max.	3.15	3.35	3.21
	Mean	2.97±0.07	2.96±0.09	2.81±0.08
	Min.	2.30	2.75	2.67
Potassium Carbonate	Max.	2.92	3.45	3.38
	Mean	2.64±0.08	3.06±0.08	3.04±0.08
	Min.	2.65	2.67	2.41
Magnesium Oxide	Max.	3.50	3.35	3.20
	Mean	3.09±0.08	3.04±0.09	2.89±0.08

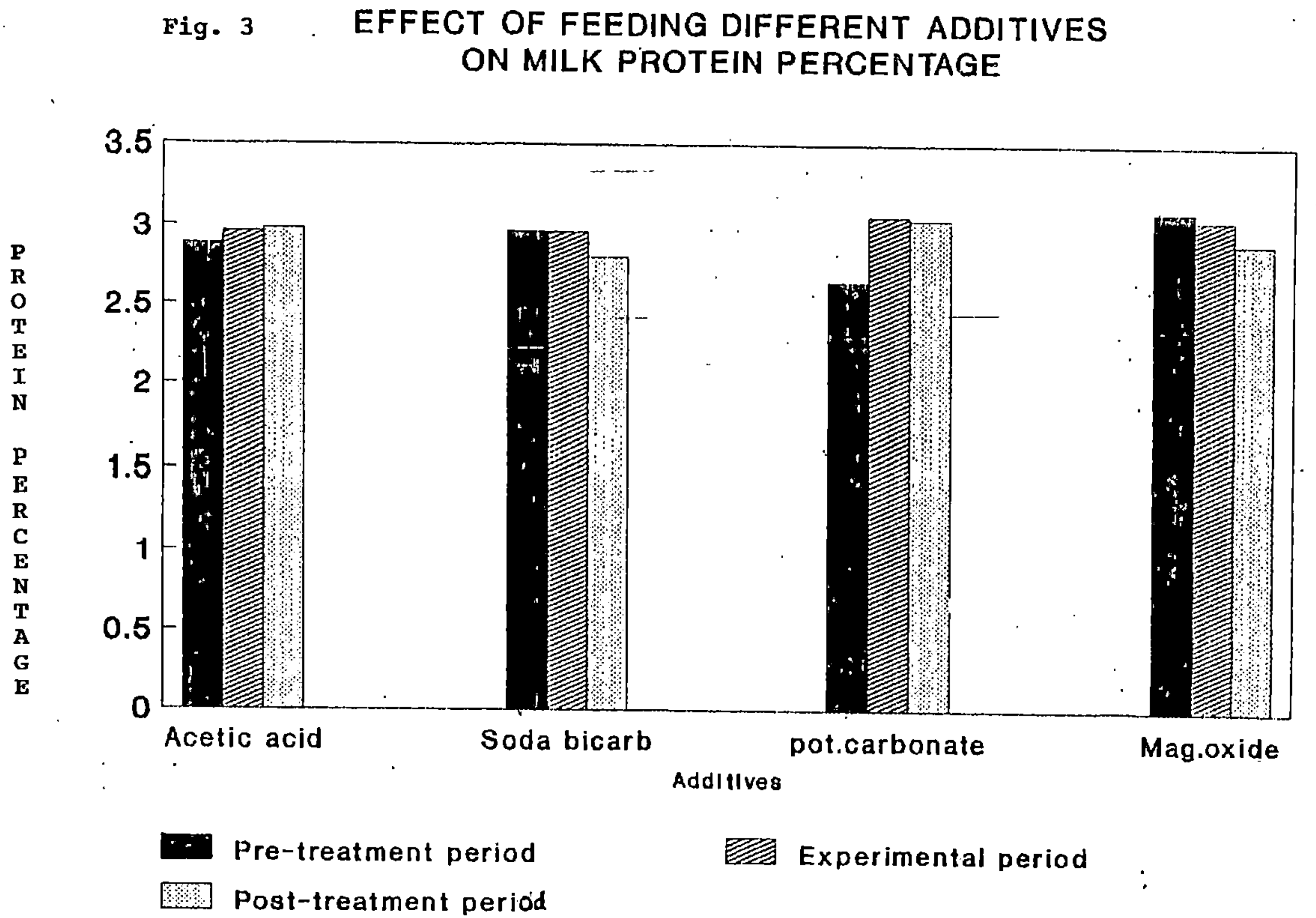
* Mean of 18 observations (6 animals x 3 samples)

Table 2(b). Results of t-test

Treatments	Pre-treatment x Experimental	Pre-treatment x post-feeding	Experimental x post-feeding
Acetic Acid	-0.48	-0.66	-2.09
Sodium bicarbonate	0.13	1.55	1.20
Potassium Carbonate	-3.55*	-3.34*	0.19
Magnesium Oxide	0.49	1.79	1.25

* t-values significant at five percent level.

Fig. 3


EFFECT OF FEEDING DIFFERENT ADDITIVES
ON MILK PROTEIN PERCENTAGE
PROTEIN PERCENTAGE
3.5
3
2.5
2
1.5
1
0.5
0
Acetic acid
Soda bicarb
pot.carbonate
Mag.oxide
Additives
Pre-treatment period
Experimental period
Post-treatment period

Feeding of sodium bicarbonate resulted in average protein percentage 2.97±0.07, 2.96±0.09 and 2.81±0.08 during pre-treatment, experimental and post-feeding periods respectively. The differences among these periods means were not significant.

In response to feeding potassium carbonate the average protein percentages during pre-treatment, experimental and post-feeding periods were 2.64±0.08, 3.06±0.08 and 3.04±0.08 respectively. Both experimental period mean and post-feeding period mean differed significantly from pre-treatment period mean ($P < 0.05$). But there was no significant difference between average protein percentages for experimental and post-feeding periods.

The pre-treatment period average for milk protein percentage was 3.09±0.08 while averages during experimental and post-feeding periods were 3.04±0.09 and 2.89±0.08 respectively on feeding magnesium oxide. On staistical analysis these mean values did not differ significantly between them. Fig. 3 represents effects of different additives on milk protein percentages during pre-treatment, experimental and post-feeding periods.

3. Total solids percentage

Maximum and minimum values along with the mean of total solids content recorded during three periods under each additive are presented in Table 3(a). The results of comparison between mean values under each additive are given in Table 3(b). The results obtained for average total solids contents of milk on feeding acetic acid were 12.93±0.14, 13.05±0.19 and 13.25±0.17 during pre-treatment, experimental and post-feeding periods. On statistical analysis no significant difference was noticed among mean values of total solids content.

On feeding sodium bicarbonate the average total solids contents during pre-treatment, experimental and post-feeding periods were 12.30±0.15, 12.52±0.13 and 12.61±0.11 respectively. The differences between these values were statistically not significant.

In response to feeding potassium carbonate the mean total solids content of milk during pre-treatment period was 12.26±0.09, while the value during experimental period was 12.68±0.14. The difference between these values were statistically significant (P <0.05). The mean total solids content was 12.46±0.11 during post-feeding period which was not significantly different from two other period means.

Table 3(a). Range and mean* values of TOTAL SOLIDS PERCENTAGE OF MILK

Treatments		Pre-treatment period	Experimental period	Post-feeding period
	Min.	12.47	12.27	12.73
Acetic Acid	Max.	13.78	14.40	14.38
	Mean	12.93±0.14	13.05±0.19	13.25±0.17
	Min.	11.75	12.04	12.05
Sodium bicarbonate	Max.	13.27	13.21	13.27
	Mean	12.30±0.15	12.52±0.13	12.61±0.11
	Min.	11.77	12.00	11.96
Potassium Carbonate	Max.	12.73	13.55	12.88
	Mean	12.26±0.09	12.68±0.14	12.46±0.11
	Min.	11.47	11.21	11.01
Magnesium Oxide	Max.	12.81	13.11	13.24
	Mean	12.19±0.15	12.38±0.21	12.42±0.24

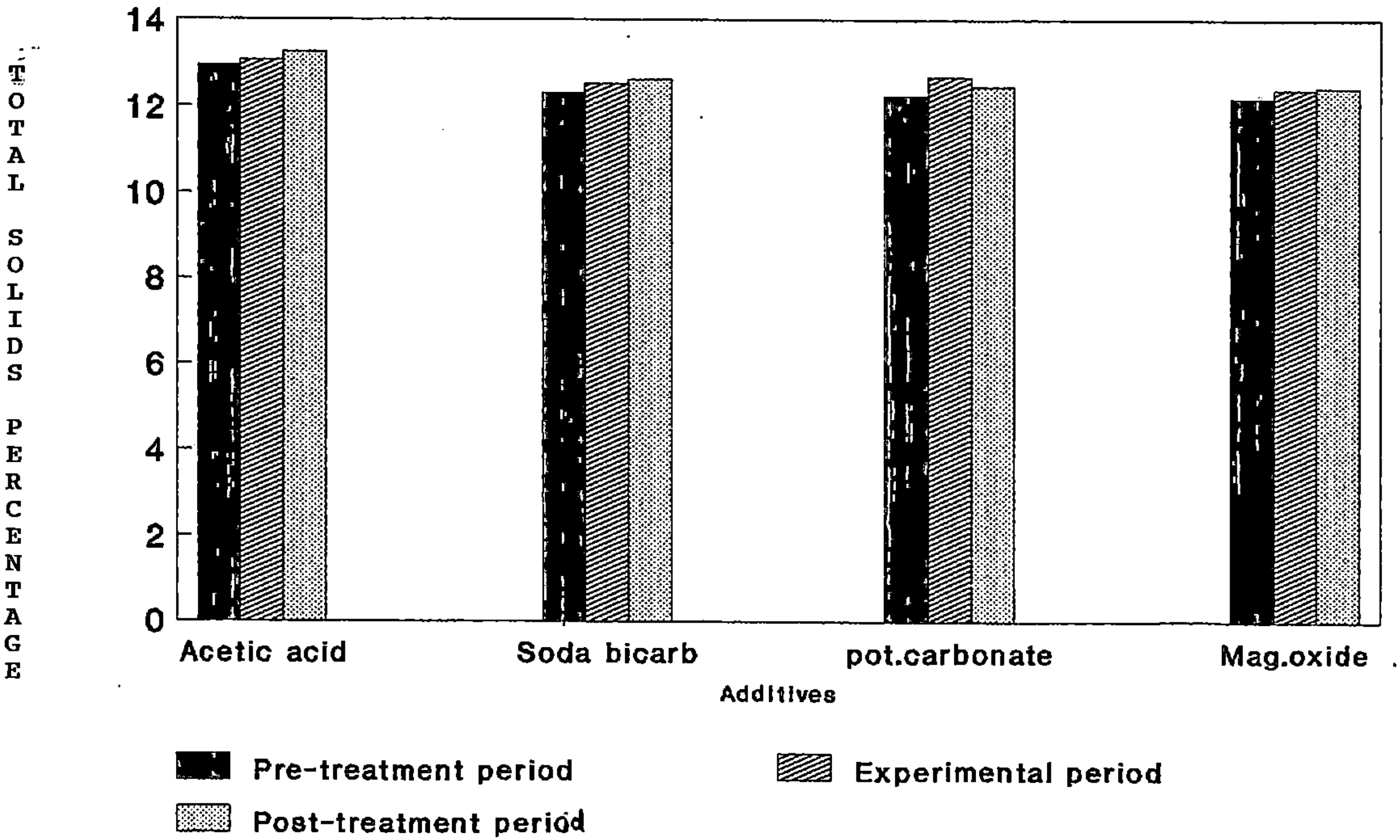
* Mean of 18 observations (6 animals x 3 samples)

Table 3(b). Results of t-test

Treatments	Pre-treatment x Experimental	Pre-treatment x post-feeding	Experimental x post-feeding
Acetic Acid	-0.52	-1.47	-0.76
Sodium bicarbonate	-1.11	-1.61	-0.50
Potassium Carbonate	-2.44*	-1.36	1.17
Magnesium Oxide	-0.74	0.81	0.13

* t-values significant at five percent level.

Fig. 4 EFFECT OF FEEDING DIFFERENT ADDITIVES ON TOTAL SOLIDS PERCENTAGE OF MILK



The mean values of total solids content were 12.19±0.15, 12.38±0.21 and 12.42±0.24 during pre-treatment, experimental and post-feeding periods respectively, when magnesium oxide was fed to cows. These values did not differ significantly between them.

Fig. 4 shows effect of different additives on total solids per cent during the three periods involved with feeding each additive.

4. Solids-not-fat (SNF) percentage

The minimum and maximum values as well as mean SNF percentage recorded during the three periods of feeding under each additive are presented in Table 4(a). The results of t-test for pair-wise comparison of above means are given in Table 4(b).

On feeding acetic acid the mean values obtained for SNF per cent were 9.22±0.11, 9.02±0.09 and 9.02±0.13 during pre-treatment, experimental and post-feeding periods respectively. There was no significant difference between these mean values on statistical analysis.

Feeding of sodium bicarbonate resulted in mean percentages of SNF 8.76±0.13, 8.62±0.12 and 8.93±0.09 during pre-treatment, experimental and post-feeding periods respectively. On statistical analysis these mean values did not differ significantly.

Table 4(a). Range and mean* values of SOLIDS-NOT-FAT PERCENTAGE OF MILK

Treatments		Pre-tre-atment period	Experi-mental period	Post-feeding period
	Min.	8.56	8.51	8.81
Acetic Acid	Max.	9.71	9.36	9.88
	Mean	9.22±0.11	9.02±0.09	9.02±0.13
	Min.	8.05	8.17	8.46
Sodium bicarbonate	Max.	9.48	9.41	9.47
	Mean	8.76±0.13	8.62±0.12	8.93±0.09
	Min.	8.17	8.20	8.00
Potassium Carbonate	Max.	9.03	9.30	8.78
	Mean	8.65±0.09	8.78±0.10	8.47±0.08
	Min.	8.27	8.21	8.15
Magnesium Oxide	Max.	8.92	8.95	8.94
	Mean	8.60±0.07	8.66±0.07	8.78±0.08

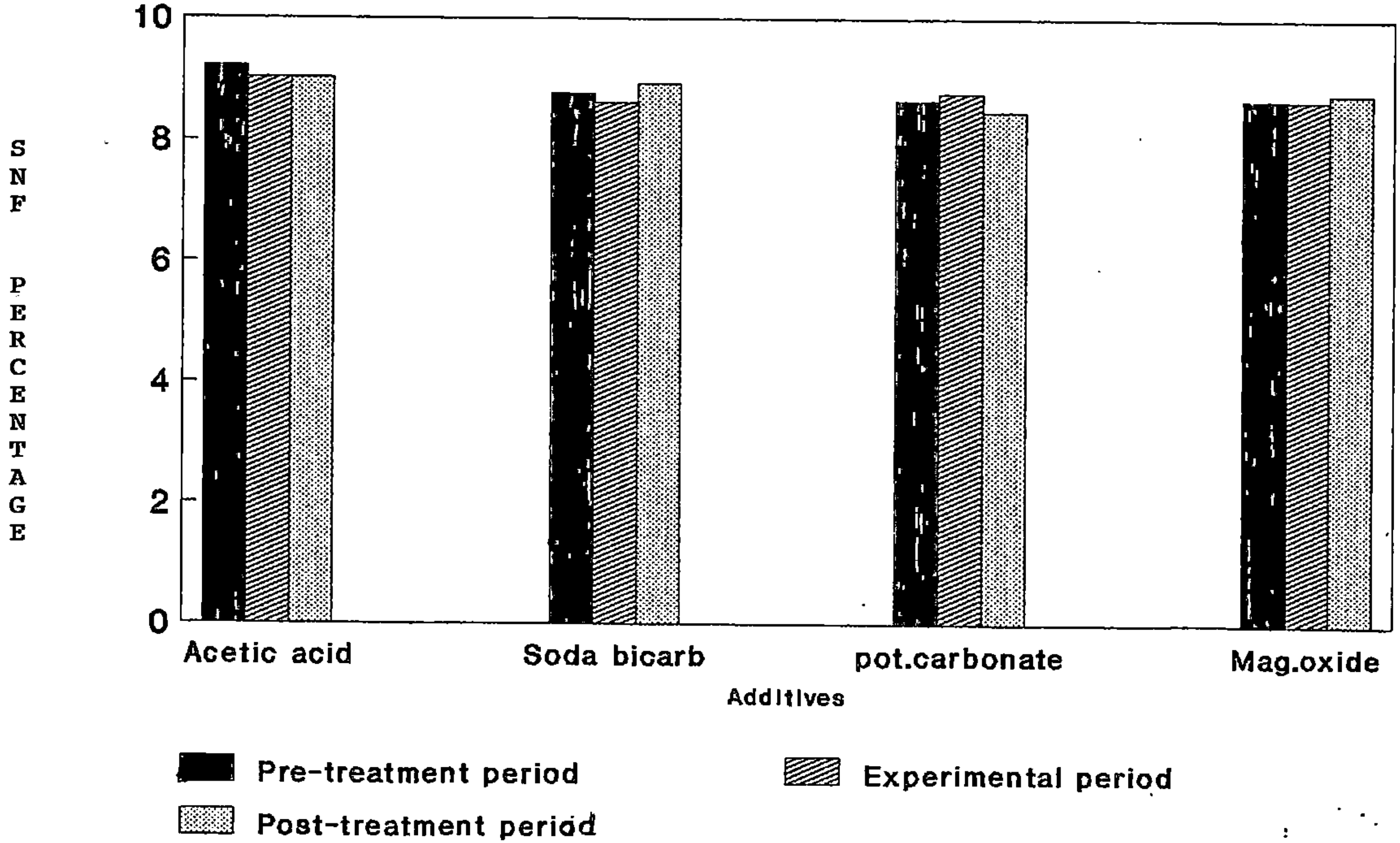
* Mean of 18 observations (6 animals x 3 samples)

Table 4(b). Results of t-test

Treatments	Pre-treatment x Experimental	Pre-treatment x post-feeding	Experimental x post-feeding
Acetic Acid	1.38	1.15	0.00
Sodium bicarbonate	0.81	-1.00	-1.96
Potassium Carbonate	-0.92	1.29	2.29*
Magnesium Oxide	-0.51	-1.59	-1.13

* t-values significant at five percent level.

Fig. 5 EFFECT OF FEEDING DIFFERENT ADDITIVES ON SNF PERCENTAGE OF MILK



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In response to feeding potassium carbonate the average SNF per cent recorded during pre-treatment period was 8.65±0.09. This value did not differ significantly from mean SNF per cent recorded during experimental period (8.78±0.1) and that during post-feeding period (8.47±0.08). But, there was a significant difference between average SNF per cent during experimental and post-feeding periods ($P<0.05$).

There was no significant difference between average SNF per cent recorded on feeding magnesium oxide which were 8.60±0.07, 8.66±0.07 and 8.78±0.08 during pre-treatment, experimental and post-feeding periods respectively.

Fig. 5 shows effect of different additives on SNF per cent during the three periods involved with feeding each additive.

5. Milk yield

The average yields of milk during different periods along with minimum and maximum values recorded on feeding each additive are presented in Table 5(a). The results of t-test are given in Table 5(b). The average milk yields obtained with feeding acetic acid were 6.03±0.41, 6.32±0.55

Table 5(a). Range and mean* values of MILK YIELD (kg/d)

Treatments		Pre-treatment period	Experimental period	Post-feeding period
	Min.	3.46	3.20	3.25
Acetic Acid	Max.	7.52	7.86	7.40
	Mean	6.03±0.41	6.32±0.55	6.03±0.46
	Min.	5.08	4.16	4.17
Sodium bicarbonate	Max.	8.80	7.33	7.40
	Mean	7.42±0.36	6.14±0.31	5.89±0.35
	Min.	6.10	5.25	5.12
Potassium Carbonate	Max.	7.60	7.40	6.90
	Mean	6.74±0.18	6.03±0.25	5.83±0.19
	Min.	2.80	3.80	4.18
Magnesium Oxide	Max.	7.40	8.20	8.28
	Mean	5.29±0.45	6.02±0.49	5.97±0.53

* Mean of 18 observations (6 animals x 3 samples)

Table 5(b). Results of t-test

Treatments	Pre-treatment x Experimental	Pre-treatment x post-feeding	Experimental x post-feeding
Acetic Acid	-0.43	-0.00	0.41
Sodium bicarbonate	2.72*	3.08*	0.54
Potassium Carbonate	2.24*	3.27*	0.59
Magnesium Oxide	-1.10	-0.98	0.08

* t-values significant at five percent level.

and 6.03±0.46 during pre-treatment, experimental and post-feeding periods respectively. The differences between these means were not significant.

On feeding sodium bicarbonate mean yields of milk were 7.42±0.36 and 6.14±0.31 during pre-treatment period and experimental period. These values differed significantly ($P<0.05$). The mean milk yield during post-feeding period was 5.89±0.35. On statistical analysis this value differed significantly from pre-treatment period mean ($P<0.05$). There was no significant difference between average milk yields during experimental and post-feeding periods.

Potassium carbonate supplementation lead to average yields of milk, 6.74±0.18, 6.03±0.25 during pre-treatment and experimental period. These yields differed significantly ($P<0.05$). The average milk yield was 5.83±0.19 during post-feeding period which was significantly different from average yield during pre-treatment period. There was no significant difference between post-feeding period mean and experimental period mean of milk yield.

In response to feeding magnesium oxide the average milk yield were 5.29±0.45, 6.02±0.49 and 5.97±0.53 during pre-treatment, experimental and post-feeding periods, respectively. These values did not differ significantly among themselves.

6. Fat yield

The minimum and maximum fat yields (kg/d) during pre-treatment, experimental and post-feeding periods on feeding different additives along with the mean fat yields are presented in Table 6(a). The results of comparison between these means using t-test are given in Table 6(b).

The average yields of fat on feeding acetic acid were 0.22 ± 0.02, 0.26 ± 0.03 and 0.25 ± 0.02 during pre-treatment, experimental and post-feeding periods rerspectively. On statistical analysis the differences among these averages were not significant.

On feeding sodium bicarbonate the pre-treatment, experimental and post-feeding periods gave the average fat yields of 0.26 ± 0.01, 0.24 ± 0.01 and 0.22 ± 0.01 respectively. There were no significant differences among these values on pairwise comparison.

Table 6(a). Range and mean* values of MILK FAT YIELD (kg/d)

Treatments		Pre-treatment period	Experimental period	Post-feeding period
	Min.	0.12	0.12	0.14
Acetic Acid	Max.	0.28	0.37	0.31
	Mean	0.22±0.02	0.26±0.03	0.25±0.02
	Min.	0.17	0.17	0.15
Sodium bicarbonate	Max.	0.32	0.28	0.26
	Mean	0.26±0.01	0.24±0.01	0.22±0.01
	Min.	0.20	0.21	0.17
Potassium Carbonate	Max.	0.32	0.31	0.27
	Mean	0.24±0.01	0.24±0.01	0.22±0.01
	Min.	0.10	0.14	0.12
Magnesium Oxide	Max.	0.25	0.29	0.29
	Mean	0.19±0.02	0.22±0.02	0.22±0.02

* Mean of 18 observations (6 animals x 3 samples)

Table 6(b). Results of t-test

Treatments	Pre-treatment x Experimental	Pre-treatment x post-feeding	Experimental x post-feeding
Acetic Acid	-1.11	-0.89	0.37
Sodium bicarbonate	1.14	1.83	0.79
Potassium Carbonate	0.33	1.34	0.98
Magnesium Oxide	-1.23	-0.91	0.27

The mean fat yields were 0.24±0.01, 0.24±0.01 and 0.22±0.01 during pre-treatment, experimental and post-feeding periods respectively with feeding potassium carbonate. The differences between these means were not statistically significant.

In response to feeding magnesium oxide the pre-treatment, experimental and post-feeding period means were 0.19±0.02, 0.22±0.02 and 0.22±0.02 respectively. There was no significant difference among these average values during three periods.

7. Protein yield

The minimum and maximum yields of protein (kg/d) recorded during the three periods under each additive along with mean values are presented in Table 7(a). The results of pairwise comparison among the means are given in Table 7(b).

The feeding of acetic acid gave rise to average yields of protein 0.17±0.01, 0.19±0.02 and 0.18±0.02 during pre-

Table 7(a).Range and mean* values of MILK PROTEIN YIELD(kg/d)

Treatments		Pre-treatment period	Experimental period	Post-feeding period
	Min.	0.12	0.09	0.09
Acetic Acid	Max.	0.23	0.26	0.22
	Mean	0.17±0.01	0.19±0.02	0.18±0.02
	Min.	0.16	0.14	0.12
Sodium bicarbonate	Max.	0.25	0.22	0.20
	Mean	0.22±0.01	0.18±0.01	0.16±0.01
	Min.	0.15	0.15	0.14
Potassium Carbonate	Max.	0.22	0.25	0.22
	Mean	0.18±0.01	0.18±0.01	0.18±0.01
	Min.	0.10	0.13	0.11
Magnesium Oxide	Max.	0.23	0.24	0.24
	Mean	0.16±0.01	0.18±0.01	0.18±0.01

* Mean of 18 observations (6 animals x 3 samples)

Table 7(b). Results of t-test

Treatments	Pre-treatment x Experimental	Pre-treatment x post-feeding	Experimental x post-feeding
Acetic Acid	-0.65	-0.35	0.32
Sodium bicarbonate	2.95*	4.09*	1.31
Potassium Carbonate	-0.50	0.03	0.54
Magnesium Oxide	-1.11	-0.92	0.12

* t-values significant at five percent level.

treatment, experimental and post-feeding periods respectively. On statistical analysis no significant difference was observed between these mean values.

Sodium bicarbonate on feeding to experimental cows gave rise to protein yields of 0.22 ± 0.01, 0.18 ± 0.01 and 0.16 ± 0.01 kg/d of protein during pre-treatment, experimental and post-feeding periods respectively. The mean protein yield during pre-treatment period differed significantly from average protein yields during experimental and post- feeding periods ($P < 0.05$). There was no significant difference between mean protein yields during experimental and post-feeding periods on feeding sodium bicarbonate.

In response to feeding potassium carbonate the average protein yields were 0.18 ± 0.01, 0.18 ± 0.01 and 0.18 ± 0.01 during pre-treatment, experimental and post-feeding periods respectively. On statistical analysis the differences between mean values were not significant.

The feeding of magnesium oxide gave rise to average protein yields of 0.16 ± 0.01, 0.18 ± 0.01 and 0.18 ± 0.01 during pre-treatment, experimental and post-feeding periods respectively. The differences between these values were statistically not significant.

Comparative study between different additives

1. Milk fat per cent

The mean treatment effects and carry over effects on fat percentage resulting from feeding different additives are presented in Table 8(a). The results of pairwise comparison between additives with respect to these effects are presented in Table 8(b).

The mean values for treatment effects were 0.33 ± 0.14 for acetic acid, 0.39 ± 0.15 for sodium bicarbonate, 0.34 ± 0.11 for potassium carbonate and 0.04 ± 0.07 for magnesium oxide. Carry-over effects had mean values of 0.06 ± 0.11, -0.10 ± 0.09, 0.15 ± 0.07 and -0.08 ± 0.05 for feeding acetic acid, sodium bicarbonate, potassium carbonate and magnesium oxide respectively.

When comparison was made between acetic acid and sodium bicarbonate there was no significant difference between treatment effects or carry over effects [Table 8(b)].

Table 8(a). Mean values* of treatment effect and carry-over effect on MILK FAT PERCENTAGE

Treatment	Treatment effect (Experimental - Pre-treatment)	Carry-over effect (Post-feeding - Experimental)
Acetic Acid	0.33±0.14	0.06±0.11
Sodium bicarbonate	0.39±0.15	-0.10±0.09
Potassium Carbonate	0.34±0.11	0.15±0.07
Magnesium Oxide	0.04±0.07	-0.08±0.05

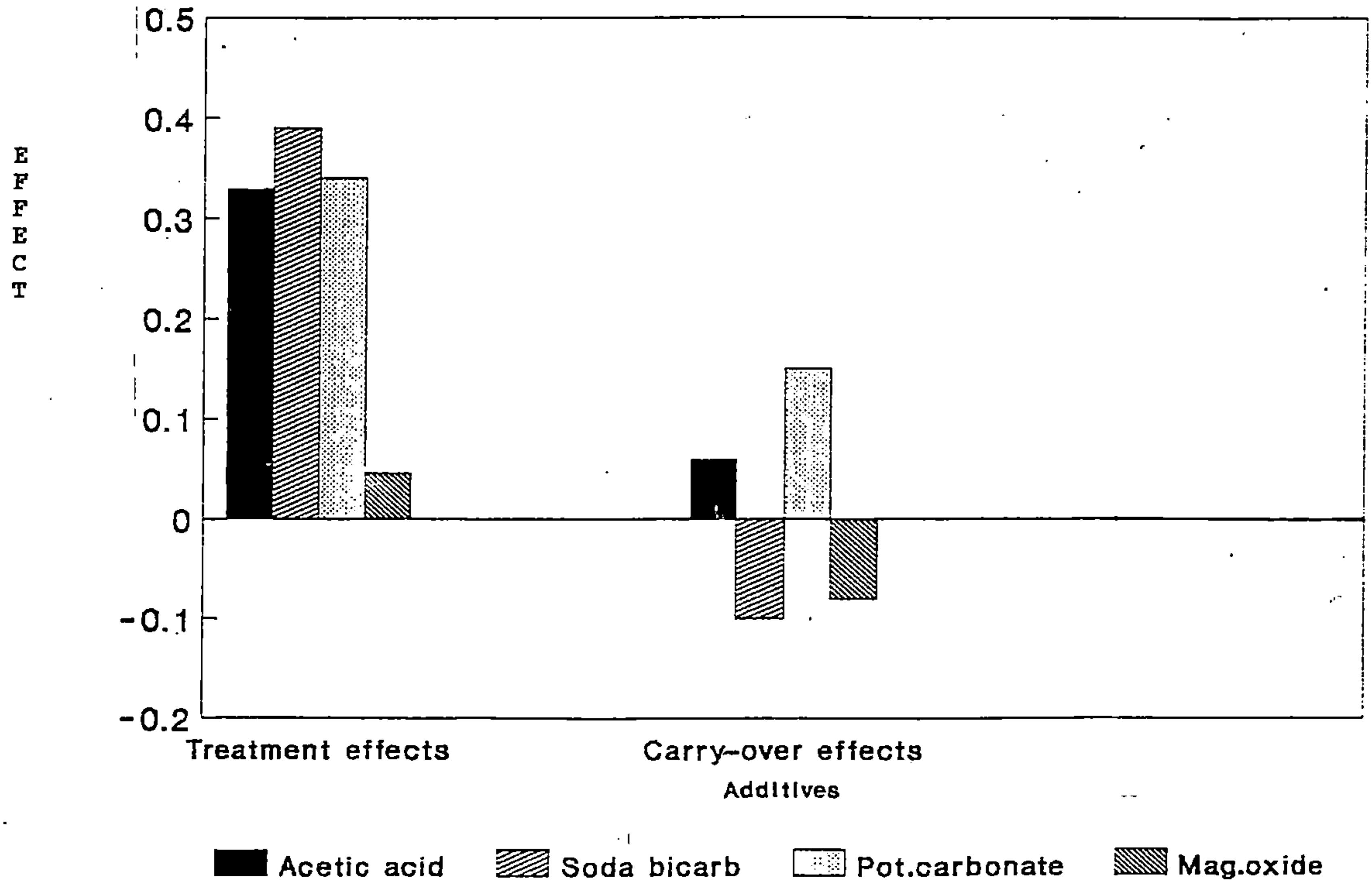
* Each value represents mean of six differences (effects)

Table 8(b). Results of t-test

Treatments under comparison	Treatment effect	Carry-over effect
Acetic acid x Sodium bicarbonate	-0.31	1.12
Acetic acid x potassium carbonate	-0.06	-0.65
Acetic acid x magnesium oxide	1.79	1.09
Sodium bicarbonate x potassium carbonate	0.27	-2.09
Sodium bicarbonate x magnesium oxide	2.08	-0.25
Potassium carbonate x magnesium oxide	2.27*	2.55*

* t-values significant at five per cent level.

Fig. 6 COMPARISON BETWEEN ADDITIVES FOR DIFFERENT EFFECTS ON MILK FAT PERCENTAGE



The treatment and carry-over effects of potassium carbonate on fat percentage when compared with effects of acetic acid, they were not significantly different between these additives.

The treatment effects and carry-over effects of acetic acid and magnesium oxide on fat per cent when compared did not differ significantly.

The results of comparison between sodium bicarbonate and potassium carbonate for their effects on fat per cent showed that none of these effects differed significantly between these additives.

The treatment effect and carry over effect of sodium bicarbonate when compared with those produced by magnesium oxide there was no significant difference between these effects produced by the two additives.

The statistical comparison between treatment effects and carry-over effects produced by potassium carbonate and magnesium oxide showed the two effects differed significantly between these additives ($P<0.05$).

The two effects produced by each additive on fat percentage in comparison to other additives are presented in Fig.6.

2. Milk protein percentage

The mean effects produced by different additives on protein percentage of milk are presented in Table 9(a). The results of comparison between additives for mean values of treatment effect and carry-over effect are given in Table 9(b).

The mean values for treatment effect on protein percentage were 0.07±0.08 for acetic acid, -0.02±0.08 for sodium bicarbonate, 0.43±0.04 for potassium carbonate and -0.06±0.07 for magnesium oxide.

When averages were found for carry-over effect produced by each additive, the figures were -0.03±0.05, -0.15±0.05, -0.02±0.05 and -0.15±0.04 for acetic acid, sodium bicarbonate, potassium carbonate and magnesium oxide respectively.

When average values obtained for different effects were compared between acetic acid and sodium bicarbonate the difference between treatment effects was not significant. There was significant difference between carry-over effects of these two additives ($P<0.05$) on milk protein percentage.

Table 9(a). Mean values* of treatment effect and carry-over effect on MILK PROTEIN PERCENTAGE

Treatment	Treatment effect (Experimental - Pre-treatment)	Carry-over effect (Post-feeding - Experimental)
Acetic Acid	0.07±0.08	0.03±0.05
Sodium bicarbonate	-0.02±0.08	-0.15±0.05
Potassium Carbonate	0.43±0.04	-0.02±0.05
Magnesium Oxide	-0.06±0.07	-0.15±0.04

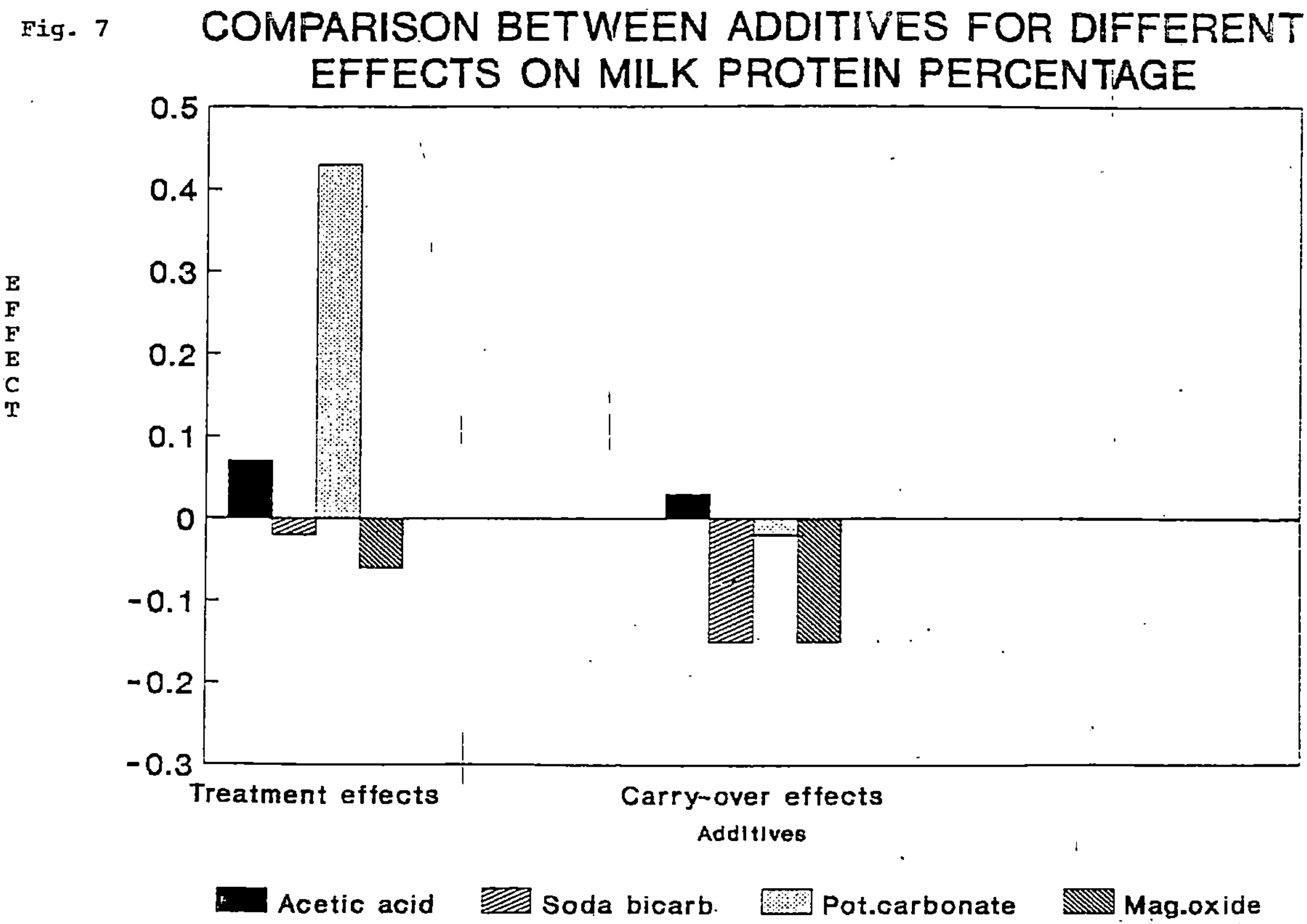
* Each value represents mean of six differences (effects)

Table 9(b). Results of t-test

Treatments under comparison	Treatment effect	Carry-over effect
Acetic acid x Sodium bicarbonate	0.73	2.48*
Acetic acid x potassium carbonate	-3.97*	0.74
Acetic acid x magnesium oxide	1.17	2.74*
Sodium bicarbonate x potassium carbonate	-4.76*	-1.75
Sodium bicarbonate x magnesium oxide	0.40	0.06
Potassium carbonate x magnesium oxide	5.84*	1.99

* t-values significant at five per cent level.

Fig. 7


COMPARISON BETWEEN ADDITIVES FOR DIFFERENT EFFECTS ON MILK PROTEIN PERCENTAGE
EFFECT
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
Treatment effects
Carry-over effects
Additives
Acetic acid
Soda bicarb.
Pot.carbonate
Mag.oxide

The average values of treatment effect when compared between acetic acid and potassium carbonate the values differed significantly ($P<0.05$). There was no significant difference between carry-over effects produced by these additives on milk protein percentage.

The t-test for comparing mean effects produced by acetic acid and magnesium oxide showed significant difference between carry-over effects produced by acetic acid and magnesium oxide ($P < 0.05$). Treatment effects produced by these two additives did not differ significantly.

Results of comparison between sodium bicarbonate and potassium carbonate showed significant difference between mean treatment effects ($P < 0.05$). There was no significant difference between carry-over effects produced by these two additives on milk protein percentage. The mean effects produced by sodium bicarbonate on protein per cent when compared statistically with mean effects produced by magnesium oxide differences between the effects were not significant.

When average value obtained for treatment effect for potassium carbonate when compared with corresponding value obtained for magnesium oxide there was significant differences between them ($P < 0.05$). The difference between carry-over effects produced by these two additives was not significant.

Graphical representation of the different effects on protein per cent by different additives in a comparative manner is given in Fig. 7.

3. Total solids percentage

The percentage values of treatment effects and carry-over effects on feeding different additives on total solids per cent of milk are presented in Table 10(a). The results of pairwise comparison between the additives in relation to each effect are given in Table 10(b).

The mean values noted for treatment effect on total solids content were 0.23±0.19 for acetic acid, 0.22±0.09 for sodium bicarbonate, 0.42±0.16 for potassium carbonate and 0.19±0.08 for magnesium oxide.

Acetic acid produced a mean carry-over effect of 0.19±0.12 on total solids percentage while the values for sodium bicarbonate, potassium carbonate and magnesium oxide were 0.09±0.05, -0.22±0.12 and 0.04±0.07 respectively.

Table 10(a). Mean values* of treatment effect and carry-over effect on TOTAL SOLIDS PERCENTAGE OF MILK

Treatment	Treatment effect (Experimental - Pre-treatment)	Carry-over effect (Post-feeding - Experimental)
Acetic Acid	0.23±0.19	0.19±0.12
Sodium bicarbonate	0.22±0.09	0.09±0.05
Potassium Carbonate	0.42±0.16	-0.22±0.12
Magnesium Oxide	0.19±0.08	0.04±0.07

* Each value represents mean of six differences (effects)

Table 10(b). Results of t-test

Treatments under comparison	Treatment effect	Carry-over effect
Acetic acid x Sodium bicarbonate	0.04	0.84
Acetic acid x potassium carbonate	-0.78	2.47*
Acetic acid x magnesium oxide	0.18	1.09
Sodium bicarbonate x potassium carbonate	-1.13	2.44*
Sodium bicarbonate x magnesium oxide	0.23	0.57
Potassium carbonate x magnesium oxide	1.29	-1.97

* t-values significant at five per cent level.

Comparison between acetic acid and sodium bicarbonate regarding the two effects on total solids content of milk revealed no significant difference between these additives.

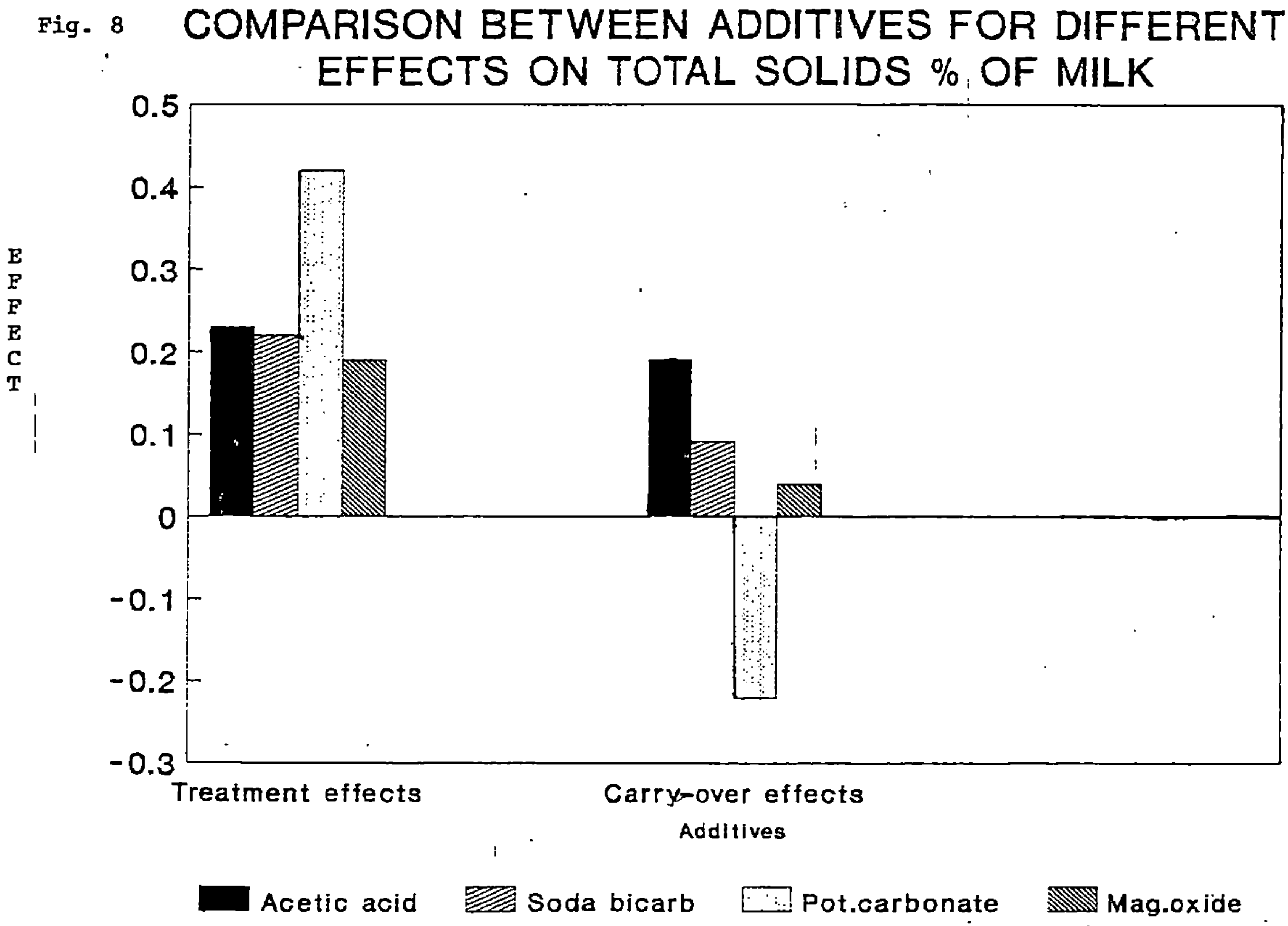
A significant difference was observed between carry-over effects of acetic acid and potassium carbonate ($P<0.05$). The differences betweem treatment effects produced by these additives were not significant.

When comparison was made between acetic acid and magnesium oxide all the two effects were not significantly different between these two additives.

A significant difference was there between carry-over effects produced by sodium bicarbonate and potassium carbonate ($P<0.05$). Treatment effects on total solids percentage produced by these two additives were not significantly different.

A comparison between sodium bicarbonate and magnesium oxide showed that differences between these additives with respect to treatment effects and carry-over effects were not significant.

Fig. 8


COMPARISON BETWEEN ADDITIVES FOR DIFFERENT EFFECTS ON TOTAL SOLIDS % OF MILK
EFFECT
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
Treatment effects
Carry-over effects
Additives
Acetic acid
Soda bicarb
Pot.carbonate
Mag.oxide

Treatment effect and carry-over effect produced by feeding potassium carbonate on total solids per cent were not significantly different from similar effects produced by feeding magnesium oxide.

The comparative representation of treatment and carry-over effects produced by different additives on total solids content of milk is given in Fig. 8.

4. <u>Solids-not-fat percentage</u>

The averages of treatment effects and carry-over effects produced by different feed additives are presented in Table 11(a). The results of pairwise comparison between additives in relation to each effect using t-test are given in Table 11(b).

The mean values of treatment effects on SNF per cent produced by acetic acid, sodium bicarbonate, potassium carbonate and magnesium oxide were -0.22 ± 0.08, -0.14 ± 0.11, 0.14 ± 0.15 and 0.05 ± 0.07 respectively.

Feeding of acetic acid produced an average carry-over effect of 0.20 ± 0.08 while the values for feeding of sodium

Table 11(a). Mean values* of treatment effect and carry-over effect on SOLIDS-NOT-FAT PERCENTAGE OF MILK

Treatment	Treatment effect (Experimental - Pre-treatment)	Carry-over effect (Post-feeding - Experimental)
Acetic Acid	-0.22±0.08	0.20±0.08
Sodium bicarbonate	-0.14±0.11	0.31±0.09
Potassium Carbonate	0.14±0.15	-0.31±0.12
Magnesium Oxide	0.05±0.07	0.13±0.04

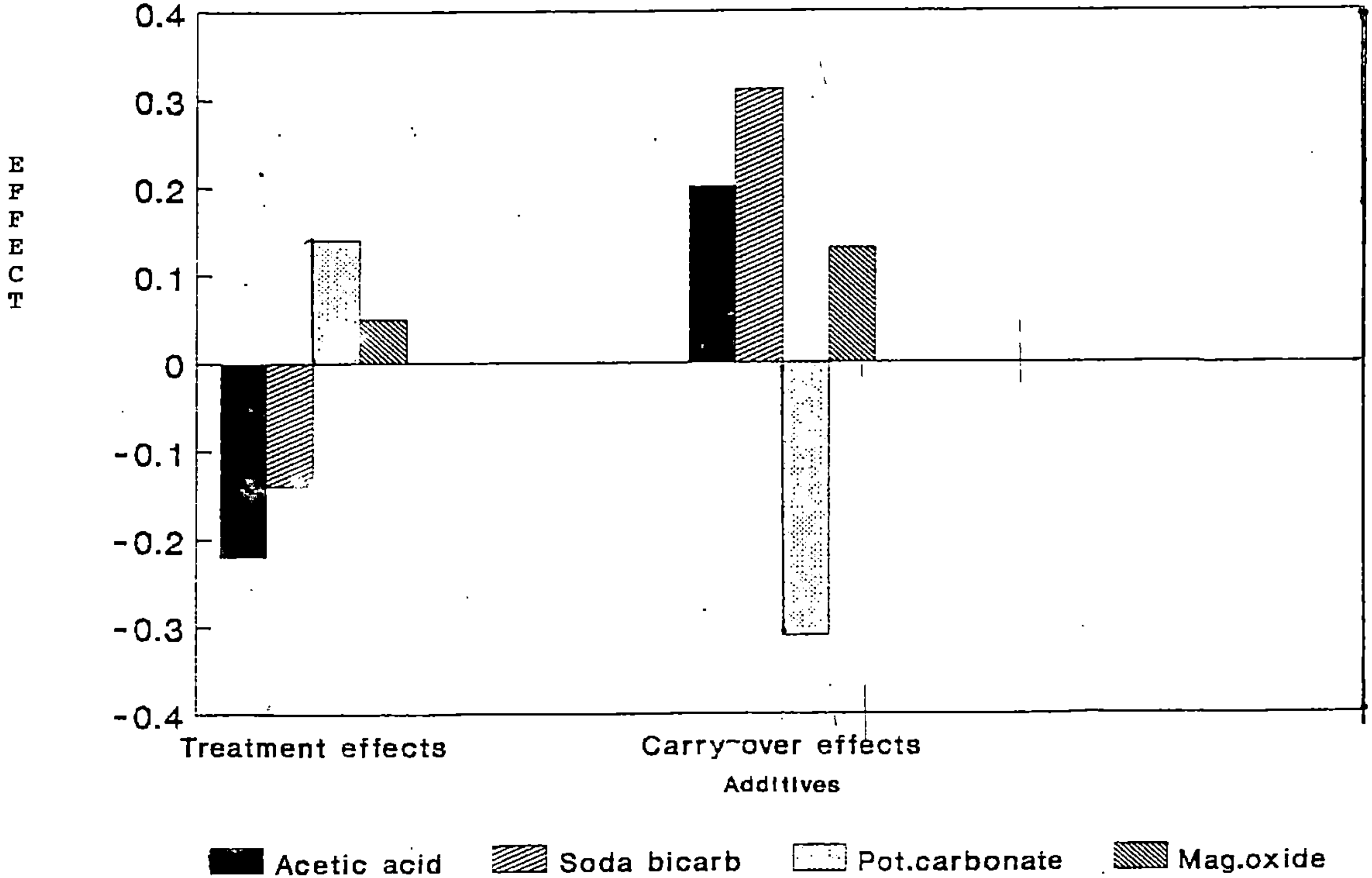
* Each value represents mean of six differences (effects)

Table 11(b). Results of t-test

Treatments under comparison	Treatment effect	Carry-over effect
Acetic acid x Sodium bicarbonate	-0.51	-0.89
Acetic acid x potassium carbonate	-2.15*	3.51*
Acetic acid x magnesium oxide	-2.41*	0.76
Sodium bicarbonate x potassium carbonate	-1.53	4.11*
Sodium bicarbonate x magnesium oxide	-1.41	1.81
Potassium carbonate x magnesium oxide	0.52	-3.40*

* t-values significant at five per cent level.

Fig. 9 COMPARISON BETWEEN ADDITIVES FOR DIFFERENT EFFECTS ON SNF % OF MILK



bicarbonate and potassium carbonate were 0.31±0.09 and -0.31±0.12 respectively. The average carry-over effect produced by magnesium oxide on SNF per cent was 0.13±0.04.

When the effects produced by acetic acid on SNF per cent were compared with those produced by sodium bicarbonate, both the effects did not differ significantly between acetic acid and sodium bicarbonate.

The treatment effect and carry over effect produced by feeding acetic acid on SNF per cent differed significantly from similar effects produced by potassium carbonate on SNF per cent ($P<0.05$).

Treatment effect of acetic acid on SNF per cent was significantly different from that of magnesium oxide on SNF per cent ($P < 0.05$). There was no significant difference between these additives when comparison was done based on carry over effects on SNF per cent.

The comparison between sodium bicarbonate and potassium carbonate showed that there was no significant difference between treatment effects produced by these additives. The carry over effect produced by sodium bicarbonate on SNF per cent differed significantly from similar effect produced by potassium carbonate ($P<0.05$).

The treatment effect and carry-over effect produced by sodium bicarbonate on SNF per cent when compared with similar effects produced by magnesium oxide all the effects were not significantly different between these additives.

The difference between treatment effects produced by potassium carbonate and magnesium oxide on SNF per cent was not significant. Statistical analysis showed a significant difference between potassium carbonate and magnesium oxide in case of carry over effect on SNF per cent ($P<0.05$).

The Fig. 9 is a graphical representation of treatment effects and carry-over effects produced by each additive on SNF per cent in comparison to another.

5. Milk yield

Table 12(a) shows the mean values of treatment effect and carry-over effect produced by different additives on milk yield from experimental cows. The results of pairwise comparison between these mean values of effects are given in Table 12(b).

The average treatment effects on milk yield by acetic acid, sodium bicarbonate, potassium carbonate and magnesium oxide were 0.29 ± 0.25, -1.16 ± 0.17, -0.72 ± 0.19 and 0.73 ± 0.12 respectively.

Table 12(a). Mean values* of treatment effect and carry-over effect on MILK YIELD

Treatment	Treatment effect (Experimental - Pre-treatment)	Carry-over effect (Post-feeding - Experimental)
Acetic Acid	0.29±0.25	-0.29±0.16
Sodium bicarbonate	-1.16±0.17	-0.23±0.23
Potassium Carbonate	-0.72±0.19	-0.19±0.13
Magnesium Oxide	0.73±0.12	-0.06±0.14

* Each value represents mean of six differences (effects)

Table 12(b). Results of t-test

Treatments under comparison	Treatment effect	Carry-over effect
Acetic acid x Sodium bicarbonate	4.88*	-0.23
Acetic acid x potassium carbonate	3.17*	-0.47
Acetic acid x magnesium oxide	-1.59	-1.11
Sodium bicarbonate x potassium carbonate	-1.75	-0.12
Sodium bicarbonate x magnesium oxide	-9.01*	-0.63
Potassium carbonate x magnesium oxide	-6.38*	-0.73

* t-values significant at five per cent level.

The acetic acid produced a mean carry-over effect of -0.29 ± 0.16 on milk yield. The mean values of carry-over effect for sodium bicarbonate, potassium carbonate and magnesium oxide were -0.23 ± 0.23, -0.19 ± 0.13 and -0.06 ± 0.14 respectively.

When a comparison was made between acetic acid and sodium bicarbonate with respect to different effects there was a significant difference between them when treatment effects were compared ($P < 0.05$). Carry-over effects on milk yield did not show any significant difference between them.

The treatment effect produced by acetic acid on milk yield showed a significant difference from similar effect by potassium carbonate. They differed significantly between these additives ($P < 0.05$). The carry-over effects produced by acetic acid and potassium carbonate did not differ significantly.

The effects produced by acetic acid on milk yield did not show any significant difference from similar effects produced by magnesium oxide.

The t-test for comparison between treatment effects as well as carry over effects produced by sodium bicarbonate and potassium carbonate on milk yield showed that the difference between these effects were not significantly different.

The differences between treatment effects produced by sodium bicarbonate and magnesium oxide on milk yield were significant on statistical analysis ($P<0.05$). The difference between carry-over effects produced by sodium bicarbonate and magnesium oxide on milk yield was not significant.

There was significant difference between the treatment effect produced by potassium carbonate and that of magnesium oxide ($P < 0.05$). The difference between carry-over effects produced by potassium carbonate and magnesium oxide was not significant.

6. Milk fat yield

The averages of treatment effects and carry-over effects of different additives on yield of fat are presented in Table 13(a). The results of pairwise comparison between the additives regarding the two effects are given in Table 13(b).

The mean treatment effects were 0.03±0.01 for acetic acid, -0.02±0.01 for sodium bicarbonate, -0.01±0.01 for potassium carbonate and 0.03±0.03 for magnesium oxide.

Acetic acid produced an average carry-over effect of -0.01±0.01 on fat yield. Sodium bicarbonate, potassium carbonate and magnesium oxide produced mean carry-over effects of -0.01±0.01, -0.01±0.01 and -0.01±0.01 respectively.

The comparison between acetic acid and sodium bicarbonate showed that treatment effects produced by these additives differed significantly ($P < 0.05$). There was no significant difference between carry-over effects produced by these additives on fat yield.

Table 13(a). Mean values* of treatment effect and carry-over effect on MILK FAT YIELD

Treatment	Treatment effect (Experimental - Pre-treatment)	Carry-over effect (Post-feeding - Experimental)
Acetic Acid	0.03±0.01	-0.01±0.01
Sodium bicarbonate	-0.02±0.01	-0.01±0.01
Potassium Carbonate	-0.01±0.01	-0.01±0.01
Magnesium Oxide	0.03±0.03	-0.01±0.01

* Each value represents mean of six differences (effects)

Table 13(b). Results of t-test

Treatments under comparison	Treatment effect	Carry-over effect
Acetic acid x Sodium bicarbonate	2.83*	0.15
Acetic acid x potassium carbonate	1.94	0.09
Acetic acid x magnesium oxide	-0.26	-0.39
Sodium bicarbonate x potassium carbonate	1.51	-0.04
Sodium bicarbonate x magnesium oxide	-5.47*	-0.70
Potassium carbonate x magnesium oxide	-4.54*	-0.50

* t-values significant at five per cent level.

The t-test results showed that treatment effect and carry-over effect produced by acetic acid on milk fat yield did not differ significantly from similar effects produced by Potassium carbonate.

The treatment effect and carry-over effect produced by acetic acid on fat yield when compared with effects produced by magnesium oxide, showed no significant difference between them.

Sodium bicarbonate feeding gave rise to the two effects which did not differ significantly from corresponding effects produced by potassium carbonate.

There were significant differences between sodium bicarbonate and magnesium oxide when comparison was done for treatment effects ($P<0.05$). The difference between carry-over effects of these two additives was not significant.

Treatment effect produced by potassium carbonate on fat yield differed significantly from corresponding effect produced by magnesium oxide ($P<0.05$). There was no significant difference between carry-over effects of these two additives on fat yield.

7. Milk protein yield

The average effects on yield of protein on feeding different additives are presented in Table 14(a). These averages were compared between each additive and results of this pairwise comparison are given in Table 14(b).

The acetic acid feeding produced an average treatment effect of 0.02 ± 0.01. The average treatment effects by sodium bicarbonate, potassium carbonate and magnesium oxide on protein yield were -0.04 ± 0.01, 0.01 ± 0.01 and 0.02 ± 0.01 respectively.

The mean carry over effects were -0.01 ± 0.01, -0.02 ± 0.01, -0.01 ± 0.01 and -0.002 ± 0.01 for feeding acetic acid, sodium bicarbonate, potassium carbonate and magnesium oxide respectively.

The mean treatment effect produced by acetic acid on protein yield differed significantly from corresponding effects produced by Sodium bicarbonate ($P<0.05$). There was no significant difference between carry-over effect, produced by these two additives.

Table 14(a). Mean values* of treatment effect and carry-over effect on MILK PROTEIN YIELD

Treatment	Treatment effect (Experimental - Pre-treatment)	Carry-over effect (Post-feeding - Experimental)
Acetic Acid	0.02±0.01	-0.01±0.01
Sodium bicarbonate	-0.04±0.01	-0.02±0.01
Potassium Carbonate	0.01±0.01	-0.01±0.01
Magnesium Oxide	0.02±0.01	-0.002±0.01

* Each value represents mean of six differences (effects)

Table 14(b). Results of t-test

Treatments under comparison	Treatment effect	Carry-over effect
Acetic acid x Sodium bicarbonate	4.36*	1.13
Acetic acid x potassium carbonate	0.72	-0.45
Acetic acid x magnesium oxide	-0.19	0.45
Sodium bicarbonate x potassium carbonate	-4.48*	-1.27
Sodium bicarbonate x magnesium oxide	-7.19*	-1.45
Potassium carbonate x magnesium oxide	-1.44	-0.48

* t-values significant at five per cent level.

The effects produced by acetic acid on protein yield were not significantly different from corresponding effects produced by potassium carbonate. The treatment effect and carry-over effect produced by acetic acid did not differ significantly from those effects produced by magnesium oxide on yield of protein.

When comparison was made between effects produced by sodium bicarbonate and potassium carbonate significant differences were noticed between treatment effects produced by these two additives ($P<0.05$). Carry-over effects on protein yield did not differ significantly between these additives.

There were significant differences between treatment effects produced by sodium bicarbonate and those produced by magnesium oxide ($P<0.05$). The carry-over effects did not differ significantly between these additives.

The treatment effect and carry-over effect produced by potassium carbonate on yield of protein when compared with effects produced by magnesium oxide, both effects were not significantly different between these additives.

8. Feed consumption

The concentrate allowance was given based on the milk yield of animals. *Ad libitum* green grass was fed to each animal. Tables 15 to 18 represent the average quantity of concentrate and grass consumed by each animal during the three periods of experiment. None of the treatments had any influence on feed consumption.

Table 15. Average Feed Consumption by Cows fed with ACETIC ACID

Animal No.	Pre-treatment period		Experimental period		Post-feeding period	
	Concen-trate	Fodder	Concen-trate	Fodder	Concen-trate	Fodder
T 157	4.00	35	4.00	34	4.00	36
205	4.00	33	4.00	35	4.00	35
214	3.50	34	3.50	35	3.50	33
278	4.00	33	4.00	33	4.00	31
338	2.50	34	2.50	35	2.50	36
379	4.00	32	4.00	33	4.00	32

Table 16. Average Feed Consumption by Cows fed with SODIUM BICARBONATE

Animal No.	Pre-treatment period		Experimental period		Post-feeding period	
	Concen-trate	Fodder	Concen-trate	Fodder	Concen-trate	Fodder
078	3.50	34	3.25	33	3.00	31
191	3.00	35	3.00	35	3.00	35
368	4.00	36	3.75	37	3.75	35
408	4.00	35	4.00	33	3.50	35
T 414	4.00	32	3.50	31	3.50	33
T 182	3.75	34	3.50	34	3.25	33

Table 17. Average Feed Consumption by Cows fed with POTASSIUM CARBONATE

Animal No.	Pre-treatment period		Experimental period		Post-feeding period	
	Concentrate	Fodder	Concentrate	Fodder	Concentrate	Fodder
189	3.50	35	3.50	35	3.25	35
246	4.00	33	4.00	34	4.00	35
268	3.50	31	3.25	32	3.00	30
321	2.75	33	2.75	34	2.75	34
345	3.00	32	3.25	32	3.25	31
443	3.50	31	3.50	33	3.50	33

Table 18. Average Feed Consumption by Cows fed with MAGNESIUM OXIDE

Animal No.	Pre-treatment period		Experimental period		Post-feeding period	
	Concentrate	Fodder	Concentrate	Fodder	Concentrate	Fodder
T 235	3.50	30	3.50	34	3.75	33
377	3.25	31	3.50	32	3.50	32
474	3.00	33	3.50	34	3.50	34
669	3.50	35	3.25	34	3.25	35
704	3.00	32	3.25	33	3.50	32
T 751	4.00	31	4.00	33	4.00	32

Discussion

5. DISCUSSION

1. Fat Percentage

It can be seen from Table 1(a) and 1(b) that acetic acid feeding produced a non-significant increase of 0.33 units in fat per cent during experimental period. After withdrawal of additive from feed this increase became 0.35 units which was significant ($P < 0.05$). This indicated that effect of acetic acid on milk fat per cent can be of practical value.

These findings are in accordance with the report of Omel Yanenko and Shliko (1982). Intra ruminal infusion of acetic acid produced an increase of 0.62 per cent (Orskov *et al*., 1969), 0.4 per cent (Rook and Balch, 1961) and 0.28 per cent (Rook *et al*., 1965) on fat content of milk.

Rook and Balch (1961) infused 900 ml acetic acid/day into the rumen of cows fed with normal ration, while in this study rate of supplementation was 200 ml/d. When the quantity of acetic acid was increased from 900 ml/d to 1500 ml/d the fat per cent of milk elevated from 0.28 to 0.56 units (Rook *et al*., 1965). These results suggest that by enhancing level of supplementation the level of fat per cent in milk can be improved. Rook *et al*. (1965) noticed a reduction in feed intake only at a level of infusion of 1800 ml acetic acid/day. But the feasibility of feeding cows with larger quantities of acetic acid should be considered because the said authors practiced intra-ruminal infusion of this supplement. The direct correlation between rumen acetic acid and milk fat per cent was stated by Vansoest and Allen (1959) and McCullough (1966). Rook and Balch (1961) described acetic acid as the only VFA directly utilised by mammary tissue in the synthesis of milk fat.

Feeding of sodium bicarbonate at a level of 1.5 per cent of the concentrate feed increased milk fat content by 0.4 per cent (Table 1(a) &1(b)) which was significant ($P<0.05$). On withdrawal of the additive fat per cent showed a decreasing trend but maintained a significant difference from pre-treatment value. This result is in agreement with that of Erdman et al. (1982 a) who reported 0.5 per cent increase in fat content at same level of supplementation in a normal ration. Emery et al. (1965 a) also got similar increase of 0.44 per cent in fat content with use of this additive in high-grain ration. After analysing data from a number of experiments Erdman (1988) suggested an average increase of 0.1 per cent in fat content of milk by supplementing rations containing >30% forage with sodium bicarbonate. Emery and Brown (1961); Schultz et al. (1965)

and Dutton (1981) noticed greater rise in fat per cent by using sodium bicarbonate with high concentrate-low roughage rations. Results of this study is disagreeing with the reports of Donker and Marx (1985); Rogers et al. (1985); ST. Laurent and Block (1989); Erdman and Sharma (1989) and McKinnon et al. (1990) who indicated no effect on fat per cent by feeding Sodium bicarbonate.

Many reports indicated the capability of sodium bicarbonate in buffering acidity produced by feeding high grain rations. But in this study ration fed was not acid producing and need for buffering was limited. The advantage of using sodium bicarbonate in hot weather was highlighted by Coppock et al. (1981). Garg and Nangia (1991) noticed that supplementation of this additive increased voluntary water consumption, rumen volume; rumen dilution rate and total rate of outflow from rumen in buffaloes fed with normal ration. Similar observations were made by Rogers et al. (1979). Rogers and Davis (1982) and Rogers et al. (1982) These changes in rumen lead to increased proportion of acetate and decreased proportion of propionate in rumen resulting in increased fat content of milk (Harrison et al., 1975; Thomson et al., 1978; Rogers et al., 1979 and Rogers et al., 1982).

Noble (1990) concluded that supplementing 0.85 per cent sodium bicarbonate in the ration of cross-bred cows helped in alleviating heat stress thereby improving milk fat per cent. Swenson (1977) noticed that during heat stress metabolic changes in the system reduces availability of sodium bicarbonate in saliva disturbing ruminal ecosystem. Sodium bicarbonate, being the predominant salt in saliva helped in the normal functioning of rumen (Hadjipanayiotou, et al., 1992).

Thomson et al. (1978) reported that salivary salts including sodium bicarbonate, increased number of chain forming cocci and some group of protozoa which altered fermentation pattern in rumen to produce more acetate. From all these reports we can assume that the increase in fat per cent observed in this study was due to advantages of sodium bicarbonate during heat stress and for its ability to increase osmotic pressure inside rumen causing higher rumen dilution rate and outflow rate.

From Table 1(a) and 1(b) it can be seen that feeding potassium carbonate increased fat per cent of milk significantly by 0.35 units ($P < 0.05$). This increase continued even after withdrawal of additive from feed because average increase in milk fat content during post-feeding period was 0.49 per cent. But the mean fat percentage during experimental and post-feeding periods did not differ significantly. These results were in full accordance with report by Mckinnon et al.(1990) who observed increase of 0.22 per cent and 0.41 per cent in fat content of milk for cows and heifers respectively when 0.75 per cent potassium carbonate was added to a ration containing 50 per cent silage and 50 per cent concentrate. Erdman (1988) calculated that an average increase of 0.4 per cent was possible on supplementing this additive in rations containing ≥30 per cent forage using data from previous experiments. Similar results were reported by West et al. (1986 a) and West et al. (1987) who noticed 0.5 per cent and 0.2 per cent increase respectively in fat content of milk when level of supplementation was 1.2 per cent of the concentrate ration. Results of this study are at variance with the observation by Dennis et al. (1976); Mallonee et al. (1985) and Schneider et al.(1984) who observed no change in fat per cent by feeding potassium carbonate.

Buffering capacity of potassium carbonate is of limited value in rations used for this study. Potassium carbonate is also an osmotically active salt which can increase rumen dilution rate and ruminal outflow (Thomson et al., 1978). These changes lead to higher proportion of acetate in rumen and increased milk fat content. The dietary supplementation of potassium salts are beneficial during heat stress because under hot climate loss of potassium from the skin is elevated (Mallonee et al., 1985). The increase in fat per cent produced by potassium carbonate was more persistent than increase produced by sodium biarbonate in this study. This may be explained by the fact that potassium ions are more slowly absorbed from the rumen, and retain moisture content of rumen for longer period (Ward, 1966).

The effect of magnesium oxide on fat content of milk was negligible and non-significant [Table 1(a) & 1(b)]. This result was in line with the findings of Teh et al. (1985) who got only 0.1 per cent increase in fat content when 0.8 per cent magnesium oxide was added to a ration containing 50:50 corn silage and concentrate on DM basis. Erdman (1988) arrived at a conclusion after reviewing previous literature that an average increase of 0.16 per cent is possible in fat content of milk when magnesium oxide was added to a ration containing >30 per cent forage. O'Connor et al. (1988) and Lough et al. (1990) reported similar results. Findings of this study are disagreeing with reports of Thomas and Emery (1969); Erdman (1980); Erdman et al. (1982 b) and Thomas et al. (1984) where a significant increase in fat per cent was reported when magnesium oxide was added to high concentrate rations. Magnesium oxide is reported to be having maximum capacity for neutralising acid in the rumen among additives (Erdman, 1988). Since acidity was not a probable reason for depression in fat per cent in this study, this capacity was of limited benefit. Moreover magnesium oxide being insoluble in water cannot influence osmotic pressure or dilution rate inside rumen. So those factors responsible for increasing fat per cent with the use of sodium bicarbonate and potassium carbonate do not hold true in this case. Combined use of magnesium oxide and potassium carbonate may prove beneficial because magnesium oxide can improve mammary uptake of acetate as reported by Emery et al. (1965 b).

Table 8(a) and 8(b) show the comparison between different additives for their effect on milk fat per cent. The effects produced by acetic acid did not differ signifiantly from those produced by sodium bicarbonate or potassium carbonate. This indicated that the changes brought about by acetic acid on fat per cent, though not significant statistically are comparable with these additives. Sodium bicarbonate and potassium carbonate were similar in their effect on fat per cent. Both effects differed significantly between magnesium oxide and potassium carbonate because the changes brought about by magnesium oxide in fat content of milk were negligible when compared to changes brought about by potassium carbonate.

2. Protein percentage

It can be seen from Table 2(a) and 2(b) that feeding acetic acid had only negligible effect on milk protein content. The differences among values obtained during three periods were not significant.

These results were in line with the findings of Rook and Balch (1961) who got inconsistent and small changes in protein per cent when acetic acid was infused into rumen at a rate of 900 ml/d. Similar non-significant changes were reported by Rook et al. (1965) on infusing 1500 ml acetic acid daily. But the report of Rook and Balch (1961) indicating significant decrease in protein per cent on infusing 1500 ml acetic acid into the rumen was contradictory to results of this study.

The percentages of protein during three periods of feeding sodium bicarbonate did not differ significantly between them (Table 2(a) & 2(b)). This result was in conformation with the reports of Donker and Marx (1985);

Emery et al. (1965 a); Jalora and Yadava (1979); Thomas and Emery (1969) and West et al. (1987). Erdman (1988) reported a negligible average decrease of 0.04 per cent based on data from a group of experiments on feeding sodium bicarbonate. The report of West et al. (1986 a) indicating an increase of 0.22 per cent in protein content disagreed with results of this study.

From Table 2(a) & 2(b) it can be seen that protein content increased by 0.42 per cent on feeding potassium carbonate which was significant ($P < 0.05$). On withdrawal of additive from feed the protein per cent showed a decreasing trend. This finding did not agree with the results reported by West et al. (1986 a); West et al. (1987) and Erdman (1988) who could not observe any significant effect by potassium carbonate. With available literature, reason for the significant increase in protein per cent observed in this study cannot be explained further.

Magnesium oxide produced only non-significant effects on protein per cent of milk (Table 2(a) & 2(b)). But there was a trend for decrease in protein per cent. This finding was in full accordance with the reports of Emery et al. (1965a); Lough et al. (1990) and Thomas and Emery (1969). Average decrease in protein per cent from results of a group of experiments was 0.02 per cent (Erdman, 1988). The reports of O'Connor et al. (1988) indicating a significant decrease in protein per cent on feeding magnesium oxide did not agree with findings of this study.

Tables 9(a) and 9(b) show the comparison between different additives for their effects on milk protein percentage. Since potassium carbonate alone produced a significant change in protein per cent, the three other additives differed from it in treatment effect. Magnesium oxide and sodium bicarbonate by showing a decreasing trend on protein per cent differed from acetic acid in carry-over effect. There was no significant difference between sodium bicarbonate and magnesium oxide in their effects.

3. Total solids percentage

Feeding acetic acid did not produce any significant change in Total solids per cent (Table 3(a) & 3(b)). There was a trend for increase in total solids per cent and this increase was continued even after withdrawal of the additive from the ration. Most the of reports on feeding/infusing acetic acid did not describe any changes in total solids per cent. In this study the change in total solids per cent actually reflected changes in fat per cent and solids-not-fat per cent.

The increase in fat per cent and negligible decrease in solids-not-fat per cent cancelled each other producing this result.

Feeding sodium bicarbonate produced only non-significant changes on total solids per cent (Table 3(a) &3(b)). The increase during experimental period was 0.22 per cent which was in accordance with results of West et al. (1987). The report by West et al. (1986 a) indicating a decrease in total solids per cent do not agree with findings of this study. Significant increase in fat per cent associated with a non-significant decrease in solids-not-fat per cent produced this increasing trend in total solids per cent.

Tables 3a and b show that feeding potassium carbonate produced significant increase of 0.42 per cent in total solids content ($P < 0.05$). On withdrawal of additive total solids per cent showed a decreasing trend. This result is in line with the finding of West et al. (1986 a) and West et al. (1987). Significant increase in total solids per cent observed in this study was produced by significant increase in fat per cent and non-significant increase in solids-not-fat per cent.

Feeding magnesium oxide could not produce any significant change in total solids per cent in any of the periods (Table 3(a) & 3(b)). But there was an increasing trend in total solids per cent during experimental period and this trend remained during post-feeding period. The available literature did not indicate any effect on total solids per cent probably due to the negligible changes produced by it. Table 10(a) and 10(b) show comparison between additives for their effect on total solids per cent. Out of four additives there was significant difference between potassium carbonate and acetic acid or Potassium carbonate and sodium bicarbonate in relation to carry-over effects. This difference was produced by the significant increase in total solids per cent on feeding potassium carbonate. All other comparisons showed no significant difference.

4. Solids-not-fat percentage

It can be seen from Table 4(a) and 4(b) that solids-not-fat content of milk was not significantly affected by feeding acetic acid. But there was a decreasing trend on solids-not-fat per cent during experimental period showing a decrease of 0.2 per cent. This results are in line with findings of Rook et al. (1965) who observed a non-significant decrease of 0.01 per cent and 0.04 per cent in solids-not-fat per cent on infusing 900 ml and 1500 ml acetic acid respectively. Similar inconsistent changes in solids-not-fat per cent were also reported by Rook and Balch (1961). Acetic acid, being a lipogenic fatty acid a decrease in solids-not-fat per cent is expected along with rise in fat per cent (Van Soest,1963). Moreover infusion of glycogenic propionic acid produced the opposite effects (Rook and Balch, 1961). It is further proved that reason for effect of acetic acid on fat per cent and solids-not-fat per cent observed in this study was mainly due to changes in acetate:propionate ratio in rumen.

Sodium bicarbonate feeding did not produce significant differences between solids-not-fat per cent observed during the three periods (Table 4(a) &4(b)). There was a 0.14 per cent decrease during experimental period and again increased by 0.31 per cent during post-feeding period. The average value noticed during post-feeding period was 0.17 per cent higher than mean solids-not-fat per cent noted during pre-treatment period eventhough this difference was not significant. This increase after withdrawal of the additive cannot be considered as one produced by Sodium bicarbonate. Results of this study was in accordance with reports of Emery et al. (1965 a) and Rogers et al. (1982) who reported no change in solids-not-fat per cent on feeding Sodium bicarbonate.

Report of Thomas and Emery (1969) indicating 0.07 per cent increase was contradictory to the findings of this study. The changes in solids-not-fat per cent were justified by the changes observed in total solids per cent and fat per cent observed in this study. Significant increase in fat per cent was not able to produce similar changes in total solids per cent because of decreasing trend on solids-not-fat per cent.

Table 4(a) and 4(b) showed that feeding potassium carbonate produced a non-significant increase of 0.13 per cent in solids-not-fat content during experimental period. On withdrawal of additive from the ration there was a significant decrease of 0.31 per cent in solids-not-fat per cent ($P < 0.05$). The increase in solids-not-fat content during experimental period agrees with findings of Dennis et al. (1976). This increase was justified by the significant increase in both total solids per cent and fat per cent during experimental periods. The marked decrese in solids-not-fat per cent during post-feeding period was a reflection of non-significant decrease both in total solids per cent and fat per cent during post-feeding period.

Magnesium oxide produced a non-significant increase of 0.06 per cent during experimental period and on withdrawal of additive an increase of 0.12 per cent was recorded in solids-not-fat per cent (Table 4(a) &4(b)).

This result is in agreement with findings of Emery et al (1965a) and Lough et al. (1990). Report by Thomas and Emery (1969) indicating 0.42 per cent increase in solids-not-fat was contradictory to the result of this study. The negligible increase in solids-not-fat per cent during experimental period was justified by non-significant increase in fat per cent and total solids per cent. During post-feeding period decrease in fat per cent along with increase in total solids per cent contributed to further increase in solids-not-fat per cent.

Comparison between the additives for their effects on solids-not-fat per cent is presented in Table 11(a) and 11(b). Since none of the additives could produce noteworthy changes in solids-not-fat per cent, results of comparison is not of much relevance. Treatment effect produced by acetic acid differed significantly from that produced by potassium carbonate and magnesium oxide ($P < 0.05$) because these additives produced opposite changes in solids-not-fat per cent to the changes by acetic acid. Carry-over effect produced by potassium carbonate differed significantly from similar effect produced by other three additives ($P < 0.05$).

5. Milk yield

It can be seen from Table 5 (a) and 5(b) that acetic acid produced non-significant increase of 0.29 kg/d in milk yield and on withdrawal of additive milk yield reduced by 0.29 kg/d. These changes, equal in magnitude indicated the probable effect of acetic acid on milk yield. This result is in accordance with reports of Rook and Balch (1961) and Rook et al. (1965) indicating increase of 1.7 kg/d and 1.2 kg/d respectively on infusing 900 ml of acetic acid. Rook et al. (1965) further noted an increase of 1.4 kg/d on infusing 1500 ml of acetic acid. This report suggested possible enhancement of milk yield, noted in this study by increasing level of supplementation.

Sodium bicarbonate reduced milk yield significantly by 1.28 kg/d ($P < 0.05$). During post-feeding period a further decrease of 0.25 kg/d was noticed which was not significant (Table 5 a & b). This result is in line with the findings of Thomas and Emery (1969); Emery et al. (1965 a) and Erdman et al. (1982 b) who reported decreases of 0.9 kg/d, 2 kg/d and 3 kg/d respectively in milk yield. Pronounced effect in these works might have resulted from higher level of supplementation in a high concentrate-low roughage diet. The report of Noble (1990) using cross-bred cows consuming a ration similar to that used in this work was in full accordance with results of this study. Supplementation of 0.85 per cent sodium bicarbonate reduced milk yield from 5.8 kg to 5.5 kg in that report (Noble, 1990).

Tables 5 (a) and 5(b) show that the effect of potassium carbonate on milk yield was similar to that of sodium bicarbonate. A significant decrease of 0.71 kg/d was noted during experimental period ($P < 0.05$). This change continued during post-feeding period with a decrease of 0.2 kg/d. Findings of this study are in agreement with reports of West et al. (1986 b) and West et al. (1987). McKinnon et al. (1990) reported a 0.3 kg/d decrease in milk yield with normal ration while West et al (1987) observed a decrease of 1.8 kg/d when level of supplementation of potassium carbonate was 1.25 per cent of the concentrate. Results of this study do not agree with the suggestion of Erdman (1988) who noted a 0.3 kg/d increase in milk yield from data of a group of experiments.

The changes brought about by sodium bicarbonate and potassium carbonate were similar. Both these additives significantly increased milk fat per cent but reduced milk yield significantly. Mechanism of action may be similar for these additives. The intensity of changes were less for potassium carbonate probably because of its slow absorption from rumen (Ward, 1966).

Magnesium oxide increased milk yield by 0.73 kg/d during experimental period and on withdrawal of additive from the ration milk yield showed a decreasing trend. Both these changes were not significant (Table 5a & b). This result was in full accordance with the findings of Erdman et al. (1982 b), Teh et al. (1985) and Lough et al. (1990) who reported increases in milk yield of 0.6 kg/d, 3 kg/d and 1.2 kg/d respectively on feeding magnesium oxide. After analysing data from a group of experiments using rations containing $\geq$ 30 per cent forage Erdman (1988) suggested a possible increase of 0.1 kg/d in milk yield. Results of this study are at variance with findings of Emery et al. (1965a) and Thomas and Emery (1969) who reported a significant increase in milk yield.

The fact that mechanism of action of magnesium oxide in altering milk composition is different from that of sodium bicarbonate and potassium carbonate was established by Emery et al. (1965 b); Emery and Thomas (1967). Results of this study agree with the above reports.

Results of comparison between different additives for effect on milk yield can be understood from Table 12a and b. Out of the four additives acetic acid and magnesium oxide increased milk yield while sodium bicarbonate and potassium carbonate reduced milk yield. Treatment effects differed significantly between these two groups of additives ($P < 0.05$).

6. Milk fat yield

The feeding of acetic acid produced a non-significant increase of 0.04 kg/d in fat yield. During post-feeding period there was a decreasing trend on fat yield. This result was in accordance with reports of Rook and Balch (1961) and Rook *et al*. (1965). The increase in fat yield was a result of non-significant increase in fat per cent as well as in milk yield produced by acetic acid.

It can be seen from Table 6(a) and 6(b) that sodium bicarbonate caused a non-significant decrease in fat yield which continued during post-feeding period. This result agreed with the findings of Thomas and Emery (1969) who reported a decrease of 0.01 kg/d and the report of West *et al*. (1987). Contradictory results indicating increase in fat yield was reported by Erdman *et al*. (1982 b); Synder *et al*. (1983) and Schricker (1989). Sodium bicarbonate reduced fat yield in spite of significant increase in fat per cent because of severe depression in milk yield caused by sodium bicarbonate.

Potassium carbonate did not produce any change in fat yield and negligible decrease noticed during post-feeding period was not accountable. Results agreed with findings of West *et al*. (1987). Results of this study show that benefits derived from significant increase noticed in fat per cent was nullified by the significant decrease in milk yield.

Table 6(a) and 6(b) showed a negligible increase in fat yield from feeding magnesium oxide. This result agreed with findings of Lough *et al*. (1990) who observed 0.06 kg/d increase in fat yield. The reports of Erdman (1980); Erdman *et al*. (1982 b) and Thomas *et al*. (1984) indicating significant increase in fat yield are at variance with results of this study. Table 13(a) and 13(b) showed results of comparison between different additives for their effect on fat yield. Since none of the additives produced a significant change in fat yield these results are not indicative of any inference.

7. Protein yield

Acetic acid produced only negligible increase in protein yield (Table 7(a) & 7(b)). This insignificant change resulted from changes in protein per cent and milk yield produced by acetic acid which were not significant.

Sodium bicarbonate produced a significant decrease of 0.04 kg/d in protein yield ($P < 0.05$) during experimental period. This trend continued during post-feeding period (Table 7(a) & 7(b)). This result was in line with the report of West *et al*. (1987).

Potassium carbonate did not produce any change in protein yield (Table 7(a) & 7(b)). This result agreed with the report of West *et al*. (1987). The benefits derived from significant increase produced by potassium carbonate in milk protein per cent was nullified by significant reduction in milk yield.

It can be seen from Table 7 (a) and 7 (b) that magnesium oxide produced only a negligible increase in protein yield during experimental period. Lough *et al*. (1990) reported a similar increase of 0.05 kg/d. Increase in protein yield was contributed by rise in milk yield even though protein per cent was lowered on feeding magnesium oxide.

Table 14 (a) and 14(b) revealed the results of comparison between different additives for their effects on protein yield. Treatment effect produced by sodium bicarbonate was significantly different from similar effects produced by other three additives ($P < 0.05$). There was no significant difference between effects produced by magnesium oxide and acetic acid or magnesium oxide and potassium carbonate. Effects produced by acetic acid did not differ significantly from similar effects by potassium carbonate.

From the foregoing discussions, it is clear that acetic acid increased fat per cent, protein per cent, total solids per cent of milk and yields of fat and protein. Even though these increases were not significant reports suggest a more marked effect on increasing level of supplementation. So acetic acid can be recommended under field conditions. Sodium bicarbonate and potassium carbonate increased milk fat per cent significantly, but they produced a significant reduction in milk yield. So their use cannot be recommended.

Potassium carbonate significantly increased fat per cent, protein per cent and total solids per cent of milk. Its use did not affect fat yield and protein yield. So a combination of potassium carbonate and magnesium oxide may improve yield and composition of milk. Synergestic effects of this combination demands further investigation.

Summary

6. SUMMARY

An experiment was conducted to study the effects of acetic acid (200 ml/d), Sodium bicarbonate (1.5% of the concentrate feed), Potassium carbonate (1.2% of the concentrate feed) and Magnesium oxide (0.8% of the concentrate feed) on solids content of cow's milk.

Cross-bred cows within 60-160 days of lactation showing a milk fat content of three to four per cent were selected for the study. Effect of each additive was studied in six cows. Milk samples were collected before feeding additive (pre-treatment period), during adaptation period of 20 days, 21st to 25th day of feeding additive (experimental period) and after removal of additive from feed (post-feeding period).

On feeding acetic acid, milk fat content, milk protein content and total solids content showed non-significant increase. On withdrawal of acetic acid from feed, milk fat per cent further increased to 4.08 which was significantly different from fat per cent noticed during pre-treatment period (3.73). During post-feeding period the protein content and total solids contents increased further which was not significant.

Milk yield, milk fat yield and milk protein yield increased non-significantly on feeding acetic acid. During post-feeding period, milk yield as well as yields of fat and protein lowered non-significantly.

Sodium bicarbonate increased milk fat per cent significantly from 3.51 to 3.91. A non-significant decrease in protein content and a non-significant increase in total solids content were produced on feeding sodium bicarbonate. On withdrawal of sodium bicarbonate from feed, milk fat per cent and milk protein per cent lowered while total solids content increased. All these changes were not statistically significant.

Milk yield lowered significantly from 7.42 kg/d to 6.14 kg/d on feeding sodium bicarbonate. Milk protein yield reduced significantly from 0.22 kg/d to 0.18 kg/d. Milk fat yield lowered non-significantly. When sodium bicarbonate was removed from feed, milk yield, milk fat yield and milk protein yield lowered non-significantly.

On feeding potassium carbonate milk fat per cent increased significantly from 3.57 to 3.92. Milk protein per cent increased significantly from 2.64 to 3.06 and total solids content increased significantly from 12.26 to 12.68.

Potassium carbonate feeding produced an increasing trend in solids-not-fat per cent. On withdrawal of potassium carbonate from feed, milk fat per cent showed a further increase while milk protein per cent and total solids per cent lowered non-significantly. Solids-not-fat per cent showed a significant decrease from 8.78 to 8.47 during post-feeding period.

Potassium carbonate feeding lowered milk yield significantly from 6.74 kg/d to 6.03 kg/d. When the additive was withdrawn from the feed, milk yield showed a further non-significant decrease. Feeding of potassium carbonate did not change milk fat yield and milk protein yield.

On feeding magnesium oxide, milk fat per cent and total solids per cent increased while milk protein per cent decreased. All these changes were not statistically significant. When the additve was removed from the feed non-significant decrease was produced in fat content and protein content.

Feeding magnesium oxide increased milk yield, milk fat yield and milk protein yield. All these changes were non-significant. During post-feeding period, milk yield showed a non-significant decrease while there was no change in fat yield and protein yield.

Feed consumption by experimental animals was not affected by feeding the four different additives.

The results of this study revealed that acetic acid feeding produced an increasing trend in milk yield, fat, protein and total solids content of milk. Sodium bicarbonate and potassium carbonate significantly increased milk fat per cent. But their use in the ration is not recommended due to significant reduction in milk yield.

References

7. REFERENCES

Abidur Reza (1988). Replacement of conventional forage by water hyacinth in the ration of milch cow. Nutr. Abstr. Rev., 60(7): 3762.

Anon., (1989). Experimental system for increasing milk-protein. Nutr. Rev. Abstr., 60(8): 4347.

A O A C (1980). Official Methods of Analysis. Association of official analytical chemists, Washington, 13th Ed. pp. 243.

Atwal, A.S. and Erfle, J.D. (1990). Day-to-day Variations in fat percent of cow's milk. Can.J. Anim. Sci., 70(2): 731-734.

Bailey, C.B. and Balch, C.C. (1961). Saliva secretion and its relation to feeding in cattle. Br. J. Nutr., 15(3): 371-402.

Balch, C.C. and Rowland, S.J. (1959). Studies of the secretion of milk of low fat content by cows on diets low in hay and high in concentrates. J. Dairy Res., 26(2): 162-172.

Banks, W., Clapperton, J.W., Girdler, A.K. and Steele, W. (1984). Effect of inclusion of different forms of dietary fatty acid on the yield and composition of cow milk. J. Dairy Res., 51(3): 387-395.

Barbuat, G.DE. (1989). Vitamins: essential additives. Nutr. Abstr. Rev., 60(3): 1436.

Bartocci, S., Terzano, G.M. Omero, A. and Borghese, A. (1988). Whole cottonseed in dairy goat feeds. Nutr. Abstr. Rev., **60**(7): 3799.

Beauchemin, K.A. and Buchanan-Smith, J.G. (1989). Effects of dietary neutral detergent fibre concentration and supplementary long hay on chewing activities and milk production of dairy cows. J. Dairy Sci., **72**(9): 2288-2300.

Bernard, J.K., Mc Neil, W.R., Milleri, J.K. and Montgomery, M.J. (1989). Response of Lactating dairy cows to diets containing high energy-high fibre byproducts. J. Dairy Sci., **72** Suppl(1): 1183.

Bringe, A.N. and Schultz, L.H. (1969). Effect of roughage type or added bentonite in maintaining fat test. J. Dairy Sci., **52**(4): 465-471.

Chase, L.E. (1989). Cocoa shell meal as an ingredient in dairy cattle rations. J. Dairy Sci., **72** Suppl(1): 1191 (Abstr.).

Coppock, C.E., Grant, P.A., Portzer, S.J., Charles, D.A. and Escobosa, A.(1981). Lactating dairy cow responses to dietary sodium chloride and bicarbonate during hot weather. J. Dairy Sci., **65**(4): 566-576.

Coppock, C.E. (1988). Nutritive value of cottonseed products for lactating dairy cows. Dairy Sci. Abstr., **52**(2): 718.

Dennis, R.J., Hemken, R.W. and Jacobson, D.R. (1976). Effect of dietary potassium per cent for lactating dairy cows. J. Dairy Sci., **59**(2): 324-328.

Depeters, E.J., Taylor, S.J., Franke, A.A. and Aguirre, A. (1985). Effects of feeding whole cottonseed on composition of milk. J. Dairy Sci., **68**(4): 897-902.

Dolby, R.M. (1961). Dye binding methods for estimation of protein in milk. J. Dairy Res., **28**(1): 43.

Donker, J.D. and Marx, G.D. (1985). Dietary sodium bicarbonate for high producing Holstein cows over complete lactation. J. Dairy Sci., **68**(1): 140-146.

Dutton, J. (1981). Bicarb boosts butter fat level. Dairy Sci.Abstr., **43**(6): 3225.

Emery, R.S. and Brown, L.D. (1961). The effect of feeding sodium and potassium bicarbonates on milk fat, rumen pH and organic acid production. J. Dairy Sci., **44**: 1179 (Abstr.).

Emery, R.S.,Brown, L.D. and Bell, J.W.(1965a). Supplementing restricted roughage rations with magnesium oxide or sodium bicarbonate prevents milk fat depression. J. Dairy Sci., **48**: 809.

Emery, R.S., Borwn, L.D. and Bell, J.W.(1965b). Correlation of milk fat with dietary and metabolic factors in cows fed restricted roughage rations supplemented with magnesium oxide or sodium bicarbonate. J. Dairy Sci., **48**(12): 1647-1651.

Emery, R.S. and Thomas, J.W. (1967). Increased fat production due to parenteral administration of magnesium salts. J. Dairy Sci., **50**(6): 1003 (Abstr.).

Erasmus, L.J. and Prinsloo, J. (1989). The potential of a phyllosilicate (Palabora vermiculite) as buffer in dairy cattle diets. J. Dairy Sci., 72(4): 964-971.

Erdman, R.A. (1980). The effects of dietary sodium bicarbonate and magnesium oxide on acid-base metabolism and performance of lactating dairy cows. Dairy Sci.Abstr., **44**: 4927.

Erdman, R.A., Douglass, L.W., Hemken, R.W., Teh, J.H. and Mann, L.M. (1982 a). Effects of sodium bicarbonate on palatability and voluntary intake of concentrates fed lactating diary cows. J. Dairy Sci., **65**(8): 1647-51.

Erdman, R.A, Hemken, R.W. and Bull, L.S. (1982 b). Dietary sodium bicarbonate and magnesium oxide for early post-partum lactating dairy cows: Effects on production, Acid-base metabolism and digestion. J. Dairy Sci., **65**(5): 712.

Erdman, R.A. (1988). Dietary buffering requirements of the lactating dairy cow - A review. J. Dairy Sci., **71**(12): 3246-3266.

Erdman, R.A. and Sharma, B.K. (1989). Effect of yeast culture and sodium bicarbonate on milk yield and composition in dairy cows. J. Dairy Sci., **72**(7): 1929-1932.

Ferris, T.A. and Vasavada, P.C. (1989). Altering milk composition - An introduction. J. Dairy Sci., **72**(10): 2788-2789.

Garg, S.L. and Nangia, O.P. (1991). Studies on dilution rate and pattern of rumen fermentation by inclusion of sodium bicarbonate in the diet of Buffaloes. Int. J. Anim. Sci., 6(2): 111-121.

Ghorbani, G.R., Jacobson, J.A. and Hemken, R.W. (1989). Effects of sodium bicarbonate and sodium sesqui carbonate on animal performance, ruminal metabolism and systemic acid-base status. J. Dairy Sci., 72(8): 2039-2045.

Gordon, F.J. (1989). A further study on the evaluation through lactating cattle of a bacterial inoculant as an additive for grass silage. Nutr. Abstr. Rev., 60(1):388.

Gunther, K.D. (1990). Yeast culture, yea-sacc^{1026}. success under German dairy conditions. Nutr. Abstr. Rev., 60(5): 2550.

Hadjipanayiotou, M.(1988). Effect of sodium bicarbonate on milk yield and milk composition of goats and on rumen fermentation of kids. Dairy Sci. Abstr., 52(1): 109.

Hadjipanayiotou, M., Rowlinson, P., Harrison, D.G. and Armstrong, D.G. (1992). Effect of inclusion of saliva salts in the diet on milk yield and composition in dairy cows. J. Dairy Res., 59(1):1-9.

Harrison, D.G., Beever, D.E., Thomsun, D.J. and Osbourn, D.F. (1975). Manipulation of rumen fermentation in sheep by increasing the rate of flow of water from the rumen. J. Agric. Sci. Camb., 85: 93-101.

Hermansen, J.E. (1990). Food intake, milk yield and live-weight gain of dairy cows given increased amounts of calcium saponified fatty acids of palm acid oil. Nutr. Abstr. Rev., 60(3): 1431.

Higginbotham, G.E., Torabi, M. and Huber, J.T. (1989). Influence of dietary protein concentration and degradability on performance of lactating cows during hot environmental temperatures. J. Dairy Sci., 72(10): 2554-2564.

Huber, J.T. and Boman, R.L. (1965). Nutritional factors affecting the solids-not-fat content of milk. J. Dairy Sci., 48: 808 (Abstr.).

I.S:1479

Indian Standards: 1479 (1961). Determination of Total solids (Gravimetric method). Methods of test for Dairy Industry: Part II - Chemical Analysis of Milk. Indian Standards Institution, New Delhi, pp. 6.

I.S:1224

Indian Standards: 1224 (1977). Determination of fat by the Gerber method: Part I - Milk (first revision). Indian Standards Institution, New Delhi, pp. 4-8.

Jalora, M.L. and Yadava, R.K. (1979). Effect of added sodium bicarbonate in maintaining fat test in Buffalo milk. Indian Vet. J., 56(5): 443-444.

Jambor, V., Rittich, B. and Krasa, A. (1988). The effect of fodder sugar beet on ruminal fermentation and milk composition. Dairy Sci.Abstr., 52(2): 727.

Kankare, V., Antila, V., Vaatainen, H., Miettinen, H. and Setala, J. (1989). The effect of calcium salts of fatty acids added to the feed of dairy cows on fatty acid composition of milk fat. Nutr. Abstr. Rev., 60(6): 3117.

Klein, F., Giesecke, D., Propstmeier, G. and Burgstaller, G. (1989). Crystalline fat in rations for high yielding dairy cows in early lactation. Dairy Sci.Abstr., **52**(3): 1373.

Klusmeyer, T.H., Cameron, M.R., McCoy, G.C. and Clark, J.H. (1990). Effect of feed processing and frequency of feeding on ruminal fermentation, milk production and milk composition. J.Dairy Sci., **73**(12): 3538-3543.

Knezo, J. and Hlinka, D. (1988). Fibre in ruminant feeding:- Effect on health and production. Nutr. Abstr. Rev., **60**(4): 1982.

Kvitko, A.Z. and Li, A.CH. (1985). A source for increasing the milk fat yield of cows. Dairy Sci.Abstr., **48**(3): 1243.

Lough, D.S., Beede, D.K. and Wilcox, C.J. (1990). Lactational responses to and in vitro ruminal solubility of magnesium oxide or magnesium chelate. J. Dairy Sci., 73(2): 413-424.

Lyons, T.P. (1989). Yeast culture. The logical supplement to complete a balanced dairy nutrition programme. Indian Dairym., **41**(5): 255-258.

Mallonee, P.G., Beede, D.K., Collier, R.J. and Wilcox, C.J. (1985). Production and physiological responses of dairy cows to varying dietary potassium during heat stress. J. Dairy Sci., **68**(6): 1479-1487.

McCullough, M.E. (1966). Relationships between rumen fluid VFA and milk fat percentage and feed intake. J. Dairy Sci., **49**: 896-898.

McKinnon, J.J., Christensen, D.A. and Laarveld, B. (1990). The influence of bicarbonate buffers on milk production and acid base balance in lactating dairy cows. Can. J. Anim. Sci., **70**(3): 875-886.

Noble, D. (1990). Productive performance of cross-bred cows in hot, humid environment. Ph.D. thesis, Kerala Agricultural University, Mannuthy.

O'Connor, A.M., Beede, D.K. and Wilcox, C.J. (1988). Lactational responses to dietary magnesium, potassium and sodium during winter in Florida. J. Dairy Sci., **71**(4): 971-981.

Omel'Yanenko, I. and Shliko, A. (1982). Acetic acid in cow rations - A means of increasing fat content of milk. Dairy Sci.Abstr.,**45**: 1381.

Órskov, E.R., Flatt, W.P., Moe, P.W., Munson, A.W., Hemken, R.W. and Katz, I.(1969). The influence of ruminal infusion of VFA's on milk yield and composition and on energy utilisation by lactating cows. Br. J. Nutr., 23(3): 443-453.

Pushkaran, P.S. (Ed) (1987). Package of Practices: Recommendations for Livestock, Poultry, Elephant, Rabbit and Dog. Kerala Agricultural University, Mannuthy, pp. 15-21.

Peirce-Sandner, S.B., Papas, A.M., Rogers, J.A., Sweenly, J.F., Cummins, K.A., Conrad, H.R. and Muller, L.D. (1985). Supplementation of Dairy cow diets with Ammonium Salts of volatile fatty acids. J. Dairy Sci., **68**(11): 2895-2907.

Pruthi, T.D., Khatri, T.R. and Singh, H.K. (1987). Effect of cross-breeding of cows on the composition of milk. Indian Dairym., 39(5): 225-229.

Rindsig, R.B., Schultz, L.H. and Shook, G.E. (1969). Effect of addition of Bentonite to high grain dairy rations which depress milk fat per cent. J. Dairy Sci., 52(11): 1770-1775.

Rogers, J.A. and Davis, C.L. (1982). Effects of intraruminal infusions of mineral salts on volatile fatty acid production in steers fed high grain and high roughage diets. J. Dairy Sci., 65(6): 953-962.

Rogers, J.A., Davis, C.L. and Clark, J.H. (1982). Alteration of rumen fermentation, milk fat synthesis and nutrient utilization with mineral salts in dairy cow. J. Dairy Sci., 65(4): 577-586.

Rogers, J.A., Marks, B.C., Davis, C.L. and Clark, J.H. (1979). Alteration of rumen fermentation in steers by increasing rumen fluid dilution rate with mineral salts. J. Dairy Sci., 62(10): 1599-1605.

Rogers, J.A., Muller, L.D., Synder, T.J. and Maddox, T.L. (1985). Milk production, nutrient digestion and rate of digesta passage in dairy cows fed long or chopped alfalfa hay supplemented with sodium bicarbonate. J. Dairy Sci., 68(4): 868-880.

Rook, J.A.F. and Balch, C.C. (1961). The effects of intraruminal infusions of acetic, proipionic and butyric acids on the yield and composition of milk of the cow. Br. J. Nutr., 15(3): 361.

Rook, J.A.F., Balch, C.C. and Johnson, V.W. (1965). Further observations on the effects of intra ruminal infusions of volatile fatty acids and of lactic acid on the yield and composition of the milk of the cow. Br. J. Nutr., **19**: 93.

Schingoethe, D.J. and Casper, D.P. (1989). Total lactational response to added dietary fat during early lactation. J. Dairy Sci., **72** Suppl(1): 1172 (Abstr.).

Schmidt, G.H., Vanvleck, L.D. and Hutigens, M.F. (1988). "Factors affecting yield and composition of milk" in Principles of Dairy Science, Pentice Hall, New Jersey. 2nd ed., pp. 63-73.

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. J. Dairy Sci., **67**(11): 2546-2553.

Schricker, B.R. (1989). Composition and method for increasing milk fat production in ruminants. Dairy Sci. Abstr., **52**(2): 728.

Schultz, L.H., Jorgensen, N.A. and Pendleton, R.A. (1965). Effect of addition of sodium bicarbonate to pelleted rations which depress milk fat percentage. J. Dairy Sci., **48**:808-809.

Simkins, K.L.Jr. and Rock, D.W. (1989). Improvement in milk production from lactating ruminants while increasing milk fat and lactose content in milk produced. Dairy Sci. Abstr., **52**(2): 955.

Snedecor, G.W. and Cochran, W.G. (1967). Statistical Methods. 6th ed. pp. 100-106. Oxford and IBH Publishing Company, New Delhi.

Sporndly, E. (1989). Effects of diet on milk composition and yield of dairy cows with special emphasis on milk protein content. Nutr. Abstr. Rev., **60**(1): 380.

Stanley, R.W., Morita, K. and Ueyma, E. (1964). Effect of feeding different roughage levels and sodium acetate in high grain rations on milk production. J. Dairy Sci., **47**: 258-262.

Staples, C.R. and Lough, D.S. (1989). Efficacy of supplementing dietary neutralizing agents for lactating dairy cows - A review. Nutr. Abstr. Rev., **60**(1): 389.

ST. Laurent, A.M. and Block,E. (1989). Effects of feeding sodium bicarbonate to prepartum dairy cows on their performance in early lactation. Can. J. Anim. Sci., **69**(3): 683-689.

Storry, J.E. and Rook, J.A.F. (1966). The relationship in the cow between milk fat secretion and ruminal volatile fatty acids. Br. J. Nutr., **20**: 217.

Stott, G.H. (1960). Tolerance of dairy cows to high climatic temperatures on low roughage ration. J. Dairy Sci., **43**: 871-872 (Abstr.).

Sutton, J.D., Hart, I.C., Morant, S.V., Schuller, E. and Simmonds, A.D. (1988). Feeding frequency for lactating cows. Diurnal patterns of hormones and metabolites in peripheral blood. Br. J. Nutr., **60**(2): 265-274.

Sutton, J.D. (1989). Altering milk composition by feeding. J. Dairy Sci., **72**(10): 2801-2814.

Sutton, J.D. and Morant, S.V. (1989). A review of the potential of nutrition to modify milk fat and protein. Liv. Prod. Sci., **23**(3-4): 219-237.

Swenson, M.J. (Ed). (1977). Duke's Physiology of Domestic Animals. Comstock Publ. Assoc., New York. 9th ed., pp. 256.

Synder, T.J., Rogers, J.A. and Muller, L.D. (1983). Effects of 1.2 per cent sodium bicarbonate with two ratios of corn silage:grain on milk production, rumen fermentation and nutrient digestion by lactating dairy cows. J. Dairy Sci., **66**(6): 1290-1297.

Teh, T.H., Hemken, R.W. and Harman, R.J. (1985). Dietary magnesium oxide interactions with sodium bicarbonate on cows in early lactation. J. Dairy Sci., **68**(4): 881-890.

Teter, B.B., Gaynor, P.J., Sampugna, J., Keeney, M., Erdman, R.A. and Waldo, D.R. (1989). Diet induced bovine milk fat depression is associated with increased trans-fatty acid level in milk. J. Dairy Sci., 72 Suppl(1): 1327.

Thomas, J.W. and Emery, R.S.(1967). Influence of sodium bicarbonate plus magnesium oxide on milk fat production and grain intake. J. Dairy Sci., **50**(6): 1003 (Abstr.).

Thomas, J.W. and Emery, R.S. (1969). Additive nature of sodium bicarbonate and magnesium oxide on milk fat concentrations of milking cows fed restricted roughage rations. J. Dairy Sci., 52(11): 1762-1769.

Thomas, J.W., Emery, R.S., Breaux, J.K. and Liesman, J.S. (1984). Response of milking cows fed a high concentrate, low roughage diet plus sodium bicarbonate, magnesium oxide or magnesium hydroxide. J. Dairy Sci., 67(11): 2532-2545.

Thomson, D.J., Beever, D.E., Latham, M.J., Sharpe, M.E. and Terry, R.A. (1978). The effect of inclusion of mineral salts in the diet on dilution rate, the pattern of rumen fermentation and the composition of the rumen microflora. J. Agric. Sci. Camb., 91: 1-7.

Vandersall, J.H., Douglass, L.W. and Aschenbrenjer, R.A. (1989). The effect of buffers on the fat content of milk produced by cows fed a high concentrate fish meal diet. J. Dairy Sci., 72 Suppl (1): 479.

Vansoest, P.J. and Allen, N.N. (1959). Studies on the relationships between rumen acids and fat metabolism of ruminants fed on restricted roughage diets. J. Dairy Sci., 42: 1977-1985.

Vansoest, P.J. (1963). Ruminant fat metabolism with particular reference to factors affecting low milk fat and feed efficiency - A review. J. Dairy Sci., 46: 204.

Ward, G.M. (1966). Potassium metabolism of domestic ruminants - A review. J. Dairy Sci., 49: 268-276.

West, J.W., Coppock, C.E., Nave, D.H. and Schelling, G.T. (1986 a). Effects of potassium buffers on feed intake in lactating dairy cows and on rumen fermentation. J. Dairy Sci., 69(1): 124-134.

West, J.W., Coppock, C.E., Nave, D.H. and Labore, J.M. (1986 b). Effects of potassium carbonate and sodium bicarbonate in lactating Holstein cow diets. J. Dairy Sci., 69 Suppl (1): 113.

West, J.W., Coppock, C.E., Nave, D.H., Labore, J.M., Greene, L.W. and Odom, T.W. (1987) Effect of potassium carbonate and sodium bicarbonate on rumen function in lactating Holstein cows. J. Dairy Sci., 70(1): 81-90.

Williams, P.E.V. (1989). Understanding the biochemical mode of action of yeast culture, Yea-saac. Indian Dairym., 41(7): 353-366.

Woodford, J.A., Jorgensen, N.A. and Barrington, G.P. (1986). Impact of dietary fibre and physical form on performance of lactating dairy cows. J. Dairy Sci., 69(4): 1035-1047.

Woodford, S.T. and Murphy, M.R. (1988). Effect of forage physical form on chewing activity, Dry matter intake and rumen function of dairy cows in early lactation. J. Dairy Sci., 71(3): 674-686.

Zalewska, E., Krasucki, J. and Cakala, S. (1985). The trace elements and milk production in cows given feed supplemented with Bentonite. Dairy Sci. Abstr., 48: 126.

EFFECT OF FEEDING ADDITIVES ON TOTAL SOLIDS OF COWS' MILK

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ABSTRACT OF A THESIS

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ABSTRACT

A study was undertaken to evaluate effect of feeding acetic acid (200 ml/day), sodium bicarbonate (1.5% of the concentrate), potassium carbonate (1.2% of the concentrate) and magnesium oxide (0.8% of the concentrate) on solids content of cow's milk.

An exhaustive review of literature has been presented about the use of these additives in cow ration for modifying milk composition.

Six cross-bred cows within the stage of 60 to 160 days of lactation with milk fat content of three to four per cent were alloted for feeding each additive.

The feeding was done for 25 days of which first 20 days served as adaptation period. Milk samples were collected during pre-treatment period, adaptation period, treatment (experimental) period and post-feeding period. Pre-treatment period samples served as the control. Milk samples were analysed for fat per cent, protein per cent and total solids per cent. The methods of analysis have been detailed. Solids-not-fat per cent was found out by difference. Daily milk yield (kg/d) of each cow was noted. Fat yield (kg/d) and protein yield (kg/d) were calculated.

The feed consumption by animals was recorded. The effect of additives were compared.

Sodium bicarbonate and potassium carbonate significantly increased fat per cent of milk by 0.4 and 0.35 from pre-treatment values respectively. Acetic acid and magnesium oxide produced only non-significant increases in fat per cent which continued during post-feeding period also.

Potassium carbonate feeding increased milk protein per cent significantly by 0.42 from pre-treatment value. Comparison between additives showed that effects produced by potassium carbonate on protein per cent significantly differed from effects produced by acetic acid.

Total solids content was significantly increased by 0.42 per cent on feeding potassium carbonate from pre-treatment value. None of the additives produced significant changes in solids-not-fat percentage.

Sodium bicarbonate and potassium carbonate significantly reduced milk yiled by 1.28 kg/d and 0.71 kg/d from the pre-treatment values respectively. This reduction continued during post-feeding period. Non-significant changes in fat yield and protein yield were produced by all the additives except potassium carbonate.

Feed consumption by the animals was not affected by feeding any of the additives.

Sodium bicarbonate and potassium carbonate significantly increased milk fat per cent. But their use in the ration is not recommended due to significant reduction in milk yield.