

EFFECT OF AMBIENT TEMPERATURE ON DAILY MILK YIELD AND BLOOD FLOW TO THE MAMMARY GLAND IN LACTATING GOATS TREATED WITH GROWTH HORMONE.

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SUMMARY

The study was done with the objective of studying the effect of high temperature on the mammary gland production in terms of its blood supply and synthetic capacity. Growth hormone was injected to see whether high temperature has an interaction with the galactopoietic effects of the hormone in the mammary gland. Eight, one year old goats, in their 6th week of lactation (1st lactation) were put into two climatic chambers, four in a chamber at 12°C and four in a chamber at 30°C. After four weeks of exposure to their respective temperatures two goats in each chamber were injected with bovine somatotropin (BST) daily for fifteen days. Daily milk yield was recorded. Blood flow rate was calculated from velocities measured using the Doppler Ultrasound Technique. Milk yield in goats at 30°C was 78% of milk yield of goats at 12°C at all times. With BST treatment milk yield increased by 9% and 13% at 12°C and 30°C respectively. Blood flow rate (l/day) to the mammary gland was in accordance to the milk yield with a blood flow rate: milk yield (BF:MY) ratio of 572 ± 166: 1 and 760 ± 180 : 1 at 12°C and 30°C respectively. With BST treatment the BF:MY ratio was 1059 ± 263 : 1 and 89 ± 38: 1 at 12°C and 30°C respectively. It is herewith concluded that blood flow to the mammary gland is a factor contributing to increased milk yield as it supplies the necessary nutrients for milk synthesis in the udder. The depressive effects of high ambient temperature can be counteracted by BST treatment as this increases milk yield not only through increased blood flow but also increased efficient nutrient extraction and utilization by the mammary gland cells for milk synthesis.

INTRODUCTION:

Goats in Tanzania are kept mainly for meat production. Goats can be utilized as a cheap source for milk production for the peasants in the rural areas as well as urban people. Thus all information on goats as a dairy animal has to be studied.

An important question in relation to milk production in Tanzania, besides feeding, is, what influence does high temperature has on daily milk production, blood flow to the mammary gland and other factors within and exogenous which affect lactation.

The effect of an environmental change on the production process is a

consequence of the neuro-endocrine response to such changes. High or low temperature affects this neuro-endocrine response thereby affecting the production processes in the body.

It is a general experience that high ambient temperatures have a depressive effect on animal performance. Johnson (1965) introduced the concept of comfort zone for animal production and defined it as the range of temperatures in which maximum production is possible. The comfort zone for milk production in cows is 5 - 25°C (Johnson 1965) but there exists species difference in heat tolerance and production.

High ambient temperature depresses feed uptake thereby depressing production. Brown *et al* (1987) observed that high ambient temperature (34°C) depressed daily milk yield more so in temperate bred goats (Alpines) than sub-tropical species (Nubian).

Exogenous growth hormone (= Somatotropin) significantly increases milk yield in lactating animals. In dairy cows an increase of up to 30 - 40% in response to bovine somatotropin (BST) has been observed (Deboer and Kelly, 1989; Eppard *et al* 1985 and Fronk *et al*, 1983). Staples *et al* (1988) observed that under heat stress cows treated with BST increased milk yield only by 9.3% over the controls but with no change in feed intake.

This study was carried out with the objective of studying the effect of high ambient temperature on the mammary gland production in terms of its blood supply and synthetic capacity. Growth hormone was injected to see whether high temperature has an interaction with the galactopoietic effects of the hormone in the mammary gland.

MATERIALS AND METHOD.

Animals:

Eight, one year old, Norwegian Dairy goats, 1st lactation in their 6th week of lactation were used. They weighed 30.8 ± 4.1 and 31.2 ± 4.7 kg (mean \pm SE, n=4) for the goats in chamber A and chamber B respectively.

Treatments:

Goats were exposed to two different temperatures i.e. low (12°C) and high (30°C) and hormone treatment. Chamber A was maintained at 12°C chamber B was kept at 30°C. Both

chambers had a 70% relative humidity.

Management:

Goats were surgically prepared before being put into the climatic chambers. This included exteriorization of the left carotid artery for easier access during arterial blood sampling, which was used for analytical work. i.e. plasma metabolites concentrations (glucose, FFA, urea and α - amino nitrogen) and plasma hormones concentrations (growth hormone, insulin, glucagon and thyroxines) not reported in this paper. After recovery goats were placed in their respective chamber, in individual boxes, four goats in each chamber. The goats were fed *ad libitum* high quality hay and water and 1 kg/day/goat of dairy concentrate two times per day at milking times. Goats were hand-milked, each gland separately, total milk yield was recorded every day. After 27 days of being in their respective chambers, two goats in each chamber were injected with BST subcutaneously daily for 15 days at a dose of 100 μ g/kg body weight. The other two goats in each chamber were injected, subcutaneously a placebo (physiological buffered saline) for the same length of period.

Measurements.

- (i) Daily milk yield in g/day was recorded, during pretreatment, treatment, and post-treatment (27, 15 and 21 days respectively) periods. The last five days were used for taking the following measurements:
- (ii) Milk components i.e. milk fat, protein and lactose analysed by standard laboratory techniques, (Anonymous 1989).
- (iii) Blood flow in the mammary vein, done as briefly described below

Blood flow measurement:

In studying the effects on milk yield in lactating animals blood flow to the mammary gland has not received much attention until recently. That applies not least to goats. Blood flow to the mammary gland serves as a critical measure for milk yield increase. In this study blood flow measurement was done using the Doppler ultrasound technique as adapted by Christensen *et al.* (1989). The method measures blood velocity in the abdominal mammary veins, thus one has also to measure the diameter of the vein so as to get the cross sectional area of the vein. The blood flow is then calculated as a product of blood velocity times cross sectional area of the vein. The diameter was measured using an electronic mm device. The diameter included the double skin layer around the vein hence the actual vein diameter was total diameter (skin + vein) subtracting 2x the skin diameter alone which was measured by pulling the skin and measuring it as a fold without the vein. Blood velocity measurement was done four times per goat per day; viz two times after morning feeding/milking and 2x after the afternoon feeding/milking. During measurements the goats were trained to stand on their milking platform with minimal restraint on the whole body except the neck and head. In most cases goats stood quietly throughout the procedure which lasted 10 -15 minutes for each side (i.e. left and right abdominal mammary veins).

RESULTS:

Milk yields were corrected for fat (Fat corrected milk = FCM) at 4% for easy comparability. In chamber A milk yield followed the normal lactation curve for the placebo-treated goats while in the BST - treated goats,

there was an increased production at the time milk production was supposed to decline. Milk yield was 1871 ± 57 ; 1816 ± 35 and 1758 ± 49 g/day for the placebo treated goats and 1806 ± 87 ; 1966 ± 79 and 1823 ± 80 g/day for the BST treated goats (mean \pm SD) prior to treatment, during treatment and post-treatment periods respectively. In chamber B (30°) milk yield was about 30% lower than production of goats kept at 12° C. For the placebo-treated goats milk yield was 1525 ± 108 ; 1565 ± 125 and 1636 ± 102 g/d; while production for the BST - treated goats was 1347 ± 70 , 1530 ± 98 and 1506 ± 73 g/d (mean \pm SD) during pre-treatment, treatment and post treatment periods respectively.

Figure 1 shows daily milk yield for both chambers, shown as averages for two goats in each chamber for each period, Bar lines indicate the standard deviation. As seen in each period the milk yield for goats at 30° C was 78% of the yield of goats at 12° C. During the treatment period milk yield for the placebo treated goats remained the same both at 12° C and 30° C. Milk yield for the goats treated with BST increased 9% and 13% at 12° C and 30° C respectively.

From Table 1 it will be seen that milk components did not change significantly after the BST treatment while at high temperature there was less fat, less protein and less lactose i.e. total solids compared to the milk from goats kept at 12° C.

Figure 2 shows the total blood flow through the abdominal mammary veins; bars indicate standard deviations. Prior to treatment (clear rectangles) no significant difference was observed in blood flow rates at 12° C and 30° C for all goats. As seen in the figure there was an increased total blood flow rate in the BST - treated goats

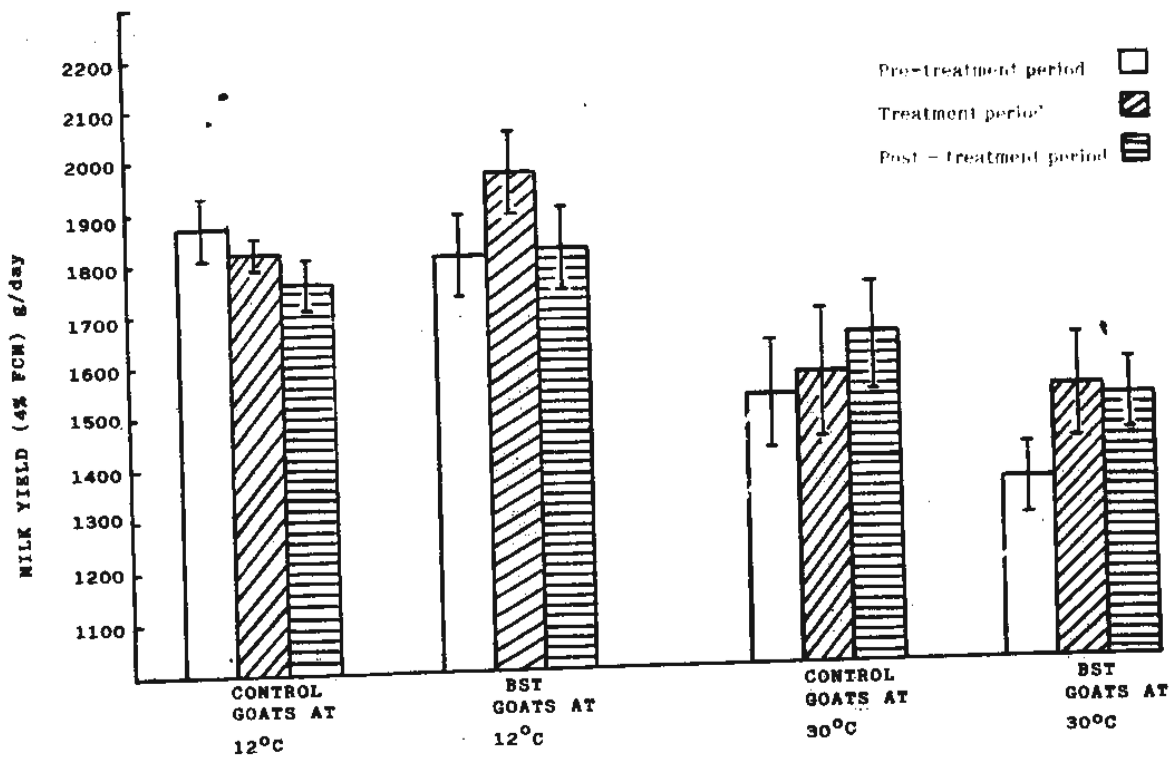


Figure 1: Milk yield (4% Fat corrected Milk = FCM) in goats treated with BST at 12°C and 30°C. Values represent mean ± standard deviation, n = 2. Pre-treatment period, Treatment period, and Post-treatment period.

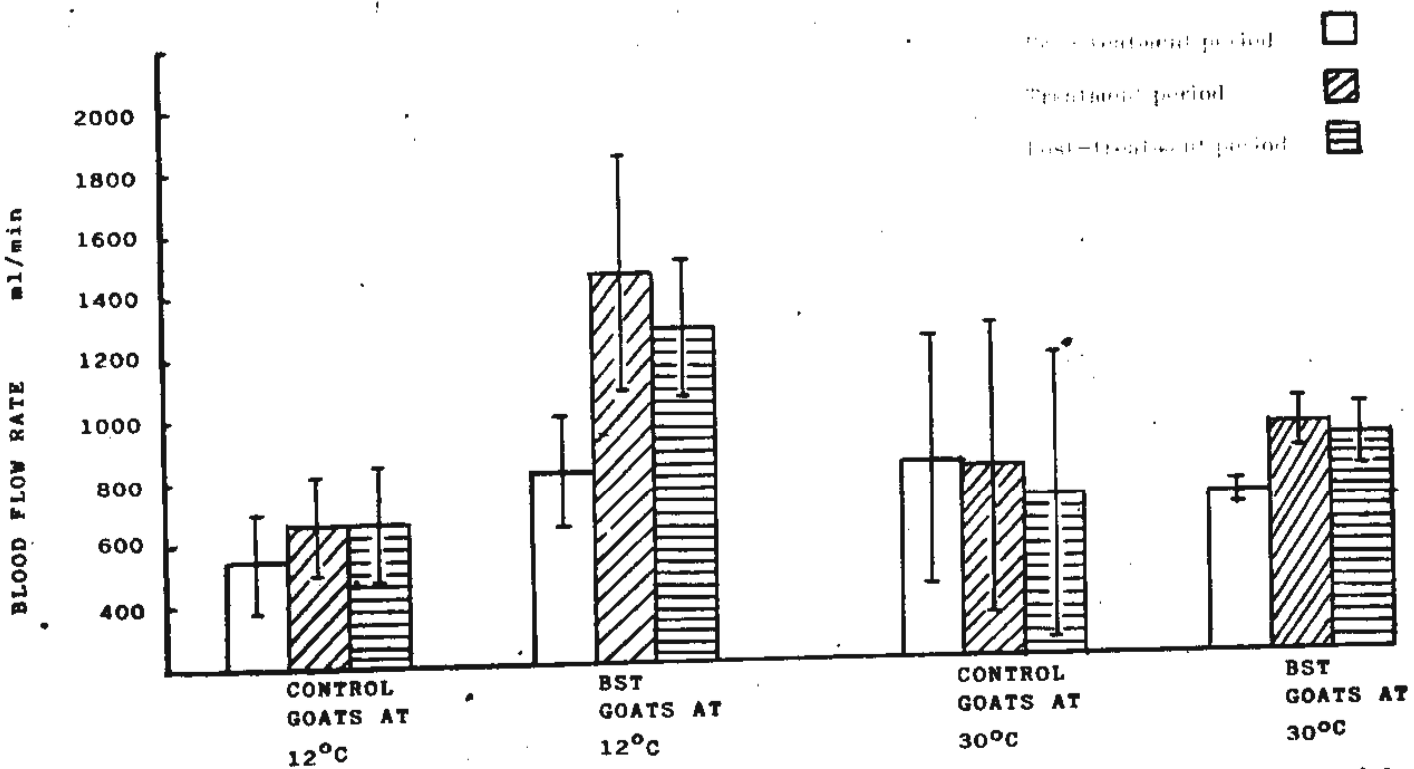


Figure 2: Blood flow rates to the mammary gland in lactating goats treated with BST at 12°C and 30°C. Values represent means ± standard deviation. Pre-treatment period, Treatment period and Post treatment period

Table 1. Milk yield and milk components at high (30°C) and low (12°C) ambient temperature in lactating goats, (Mean \pm SD; n=2)

Animals	Ambient Temp.	Milk yield kg/day	Fat g/100ml	Protein g/100 ml	Lactose g/100 ml
(a) Pretreatment period:					
Controls	12°C	1.6 \pm 0.2	49 \pm 4	32 \pm 2	52 \pm 1
For BST	12°C	1.9 \pm 0.1	39 \pm 1	31 \pm 2	50 \pm 0.5
Controls	30°C	1.7 \pm 0.4	32 \pm 3	27 \pm 2	47 \pm 2
For BST	30°C	1.7 \pm 0.2	29 \pm 0	47 \pm 0	47 \pm 0
(b) Treatment period					
Controls	12°C	1.6 \pm 0.2	48 \pm 4	50 \pm 2	50 \pm 2
BST	12°C	2.0 \pm 0.1	38 \pm 2	29 \pm 0.5	49 \pm 0.5
Controls	30°C	1.7 \pm 0.5	32 \pm 1	27 \pm 1	46 \pm 3
BST	30°C	1.9 \pm 0.3	31 \pm 0	25 \pm 1	46 \pm 0.5

at 12°C; an increase from 820 \pm 189 to 1453 \pm 390 ml/min (mean \pm SD) which is an increase of up to 77% over the pre-treatment values. At 30°C the BST - treated goats increased the total blood flow rates from 723 \pm 22 to 941 \pm 73 ml/min (mean \pm SD) over the pre-treated values, an increase of up to 30%. The placebo-treated goats total blood flow rates increased from 551 \pm 143 and 829 \pm 414 ml/min to 657 \pm 170 and 818 \pm 463 ml/min (mean \pm SD), an increase of 19% and a decrease of 1% at 12°C and 30°C respectively

DISCUSSION

The comfort zone for milk production is 5 - 25°C and animals become acclimatized to the environmental temperature after an exposure of two weeks (in cows 1.5 - 2 weeks, Johnson, 1965). In this study the goats had long enough period of exposure and feed was not a limiting factor. Within 2 weeks, production had resumed to normal at 12°C but not at 30°C. High ambient temperature has

a depressing effect on feed uptake hence production remained low. This was clearly observed as production for goats at 30°C was 78% of the yield at 12°C. At the high temperature, though not measured in absolute terms, it was observed that goats ate less but drank more water than at 12°C. It was noted that the daily concentrate ration of 1.0 kg/goat/day (500g per milking time) was not always finished and hay was always there while water had to be replenished 3 to 4 times a day. At low temperature (12°C) goats drank less, water was thrown out every cleaning time (twice a day). In this chamber (12°C) concentrates was eaten and finished within the milking period; hay had to be added 2x a day. As all the feedstuff and water were from the same source the explanation to the goats feeding behaviour observed above could probably be due to the high temperature. That is, the goats in the high ambient temperature reduced their solids intake probably to reduce the heat stress by reduction in body heat production. Also the excess water intake would probably help the animal to reduce heat stress. In so

doing the gastro-intestinal volume probably was filled up with more water than feedstuff. The little feed available to the animal was used for maintenance leaving less for production. This depressive effect of high ambient temperature could be the reason for the less milk yield for the goats at 30°C which was 78% of the yield of the goats kept at 12°C. This observation concurs with that of Johnson (1965) who observed decreased feed uptake together with decreased milk production in cows. With BST treatment, feed intake could have been increased both at 12°C and 30°C as observed in ewes by Sandles *et al* (1988) and McDowell *et al* (1988) thereby increasing the milk yield as observed. The response to BST was higher in goats at 30°C suggesting that either high ambient temperature enhances the galactopoietic effects of BST *per se* or indirectly through increased peripheral blood circulation thereby increasing nutrient supply for milk yield.

In this study the BST response, 9% and 13% at 12°C and 30°C respectively, was low compared to studies in cows where response was up to 30-40% (Deboer and Kennelly, 1989; Eppard *et al* 1985 and Fronk *et al*, 1983). But it concurs with the low response observed in heifers in their first lactation treated with BST (Deboer and Kennelly, 1989). This could be due to the fact that the presently investigated goats (1 year old) were still growing. Injection of BST to these goats caused an increased stimulation of growth processes such that metabolic turnover of body nutrient was directed more to body weight rather than to the mammary gland for milk synthesis processes.

Blood flow through the abdominal mammary veins was in accordance to the milk yield with a blood flow rate:

milk yield ratio (BF:MY) of 572 ± 166 ; and 760 ± 180 ; at 12°C and 30°C respectively. This is within the range as observed by Christensen *et al* (1989) in lactating goats. With BST treatment blood flow increased significantly for goats at 12°C, 77% above the pretreatment value. This observation concurs with Sandles *et al* (1988) and McDowell *et al* (1988) who observed increased milk yield, increased mammary blood flow and increased blood flow: milk yield ratios in lactating ewes treated with BST. This clearly indicates the importance of blood flow to the mammary gland for the increased milk yield. The increased blood flow would mean increased nutrient supply to the gland there-by increasing its output in terms of milk.

At 30°C blood flow rate in the abdominal mammary veins was not in accordance with the milk yield increase for the BST treatment as was the case with goats at 12°C. The increased milk yield could have been caused by other effects on the synthetic mechanisms rather than blood flow *per se*. Such effect could have been increased efficient utilization of nutrients for milk synthesis by the udder. Long term effects of exogenous BST in lactating ewes was reflected by increased feed uptake and efficiency utilization of nutrients for milk production thereby increasing milk yield as observed by McDowell *et al* (1988). In the present study it can be stated that the depressive effects of high ambient temperature can be counteracted by BST treatment. Exogenous BST treatment increased milk yield most probably through increased blood flow rates to the mammary gland; but also it could have been through increased feed uptake, nutrient extraction rate and efficiency in nutrient utilization in the mammary tissue for milk production.

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