BST and antibiotics in milk production

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Introduction

The vast majority of milk and milk products produced in and available for sale in RSA are produced from cows' milk so my discussion will be confined to "our" (RSA) cow's milk. The time limit does not allow detailed examination of the topic so I will try to convey the science in succinct laymen's terms answering 5 main questions:

1. What is the product?
2. Why use it?
3. How does it work?
4. How safe is the cow?
5. How safe is the consumer of milk products?

Antibiotics

In common with all domesticated animal species dairy cattle receive antibiotics in the treatment of infection (Gk *anti* = against, *bios* = life). Antibiotics are chemicals produced naturally by bacteria and fungi, usually, to kill/retard the growth or proliferation of other competing microbes. These bugs have been doing this for millions of years to ensure their place in the sun, or out of it, in most cases, because they are sensitive to UV light. Man identified the pathogenic microbes and then looked for microbes that produced antibiotics to these and now we can synthesise these substances in the laboratory.

Treatment of infection

Antibiotics are regarded as essential treatment for most infections and there are strict protocols controlling their use. The most significant of these is a withdrawal period to allow for the clearance of any antibiotic residue from saleable milk. Reputable milk buyers test every load of milk collected for substances that inhibit bacterial growth. This is in their own interests otherwise their yoghurts, cheeses and other cultured products are at risk, representing a direct loss to them. The likelihood of any milk contaminated by treatment antibiotics entering the human food chain is therefore extremely small and I will not dwell further on this unlikely source of human food contamination.

Performance enhancement

The more emotive issue is contained in those antibiotics that are included in the feed of cows as performance enhancers. Fortunately cows are ruminants, which means that an essential part of their digestive system is the rumen, a large fermentation vat containing millions of microbes that are themselves sensitive to antibiotics. Kill the microbes indiscriminately and this fermentation would be impaired, thus impairing the digestion of the animal's food (feed) and its productive efficiency, leading to eventual demise of that milk producing enterprise.

These antibiotics, amongst other performance enhancing effects, selectively kill certain gram-positive bacteria in the rumen. The bacteria they kill have been shown to be primarily responsible for the production of lactic acid in the rumen and with their numbers reduced the utilisation of dietary energy is more efficient. The accumulation of lactic acid in the rumen can lead to lactic acidosis, a condition in which the contents of the rumen, whose pH is normally around 6,2, become very acid (sometimes below pH 5), which can cause cessation of normal fermentation, and gut motility and can result in the death of the cow. By suppressing the production of lactic acid we can keep the digestive process optimal while feeding larger proportions of feedstuffs whose fermentation carries the risk of acidosis. These feedstuffs usually contribute energy and, generally, if we can feed more energy to the cow she will respond by producing more milk. For the cow and the farmer a win/win situation, the cow is more comfortable and the farmer sells more milk.

The antibiotic feed additives currently registered for use in RSA for this purpose in lactating cows are products whose active components are flavophospholipol, virginiamycin and the ionophores, monensin and lasalocid. No build-up of resistance or cross-resistance has been observed for flavophospholipol nor was

any active ingredient detected in milk (Flavomycin, product profile). Virginiamycin was banned for use in animal feed by the EU on the "precautionary principle" (McDermott, 2000) although "no extractable or biologically active residues could be detected in any experiment" in the muscle, liver, kidney, fat or milk where this antibiotic was fed to cattle (Stafac 500, technical information). The registered ionophores do not have relatives among the disease-treating antibiotics (McDermott, 2000), therefore there is no likelihood of resistance or cross-resistance to these. Only about 10% of the recommended dose of ionophores is transported across the gut wall and this is immediately metabolised by the liver (Hesse, 2002), hence they cannot contaminate the milk if fed at recommended dosage.

Tissue and milk residue studies are usually conducted at higher doses than recommended but overdosing of ionophores may cause the liver's capacity to be exceeded and then residues may find their way into milk. The likelihood of this however, is extremely small as there is no production advantage to excess dosing and it usually results in sick or dead animals.

BST

The significant and desirable economic consequence of injecting BST into lactating cows is that they produce more milk (about 4 to 5 kg per day extra, on average). This means that the same number of cows can produce more milk and they do so more efficiently. Since milk sales income commonly constitutes over 95% of dairy farming income this is good news for the farmer.

BST is an abbreviation for Bovine Somatotrophin. The name is derived from the Greek *somatikos*, which means "of the body" and *trophikos* means "nourishment or nourish". Body nourishing substance/hormone aptly describes its action as it enhances the activity of several other hormones, including some male and female reproductive hormones, as well as having growth-promoting effects on growing bone. Somatotrophin (ST) is naturally produced in animals throughout their lives. Just as there is bovine ST so there is also porcine ST, ovine and human ST and it seems that these mammal species are specific for their own particular ST (Turner & Bagnara, 1971). ST is produced by the pituitary gland and since the early 1900's scientists noted a positive response in milk production in animals injected with crude pituitary extracts. In the 1940's it was firmly established that ST was responsible for the increased milk production effects they had observed (Breier *et al*., 1991).

When we talk about BST these days we are actually referring to the "artificially" produced product whose full correct name is **recombinant bovine somatotrophin (rbST)**. This substance is produced by implanting suitable bovine DNA into bacteria cells (*E. coli*). These bacteria are then grown and multiplied in large fermentation vats during which process they produce various products, among them BST, in large quantities. The BST is collected, purified and manufactured into the commercial product. So, animals no longer have to be slaughtered to collect pituitaries from which to extract minute amounts, bacteria are harnessed to do the work. As such, BST is one of the first products of biotechnology applicable to animal agriculture (Breier *et al*., 1991).

Growth stimulation

Are we producing monster cows due to the growth-promoting effects of BST? **No!** The direct "growth" effects of ST are in stimulating the growth of growing cartilage and bone. Once the bone has ceased to grow ST cannot stimulate additional bone growth. BST is administered to mature and virtually fully-grown cattle. The growth enhancing effect in growing first lactation cows is less than about 3% above controls (Hesse, 2002) and no additional growth effects have been reported in mature cows that received BST over several lactations (Bauman, 2002). Cows, like other mammals, continue to produce ST, naturally, all their lives.

Milk production

"Exogenous ST improves lactation performance by altering the partitioning of absorbed nutrients:

- lipid accretion is reduced,
- lipid mobilisation is increased,
- glucose uptake by peripheral tissues and whole body oxidation of glucose and amino acids are reduced,
- cardiac output and mammary blood flow are increased.

The net effect of these changes is that the limited supply of glucose and amino acids is spared for synthesis of milk components, and lipid reserves are preferentially used as an energy source. The increases

in cardiac output and mammary blood flow are prominent physiological responses to BST by the dairy cow. These responses permit a greater share of nutrient input to the mammary gland." (Breier *et al*., 1991)

Detrimental to the cow?

BST exerts its effect on milk yield by changing the partitioning, of especially energy reserves, and feed energy from building body condition (fattening) to producing milk. Thus, by increasing the level of circulating ST the cow's physiology continues to favour milk production rather than building body reserves.

God created perfect cows, and you just have to work with these amazing animals to begin to appreciate just how wonderful a creation they are, but He also created man and gave him dominion over them (Genesis 1:24-26). So man bred cows to produce much more milk than their calves would need and he discovered the effectiveness of BST to further enhance milk yield. The cow uses energy reserves to produce milk so it follows that it then has less to commit to improving body condition. Well, in God's plan you get nothing for nothing so the scientists soon discovered that Daisy's feed intake increased soon after the first injection of BST, to compensate for the added energy demand for both milk and body-building. In practice problems arose when farmers saw BST as a means to an end and failed to follow accurately the guidelines for its use, namely:

- cows should be in good body condition (not thin),
- beyond the point of "negative energy balance" usually encountered within the first 40 to 50 days of lactation anyway (even without BST),
- they should be adequately supplied with plentiful nutritious feed.

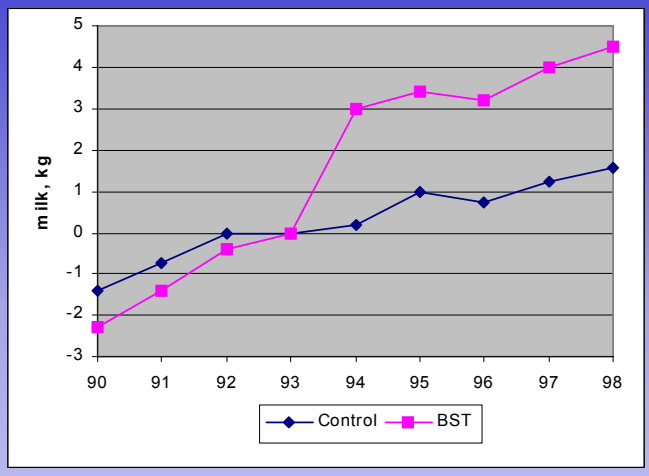
Our own field observations of South African dairy herds and anecdotal evidence we have collected over the past nine years has revealed some instances of thin cows and BST gained a bad name, for the wrong reasons as, in each case investigated, one or more of the basic guidelines had been ignored. In herds where the product was used correctly there was substantial benefit of improved milk yield and cow condition and fertility did not appear to suffer adversely.

Some early studies with experimental preparations of rbST had shown increased mastitis incidence in BST-treated cows but these data included those from trials where daily injection was required to maintain higher doses than currently in commercial use (Hesse, 2002). Analysis of more recent commercial experience in Northeastern USA suggests this to be no greater than might be expected in higher-yielding cows (Bauman *et al*., 1999).

Using the Test Day Model Bauman *et al.* (1999) analysed the DHI records of 340 commercial dairy herds in Northeastern USA for four years prior to the approval of BST for commercial use in USA to four years after approval. In 176 of these herds BST had never been used whereas the other 164 herds consistently purchased sufficient BST to treat at least 50% of their cows. In the process the records of over 80 000 cows were analysed and some of their results are represented in Figures 1, 2 and 3 and Table 1. They found that:

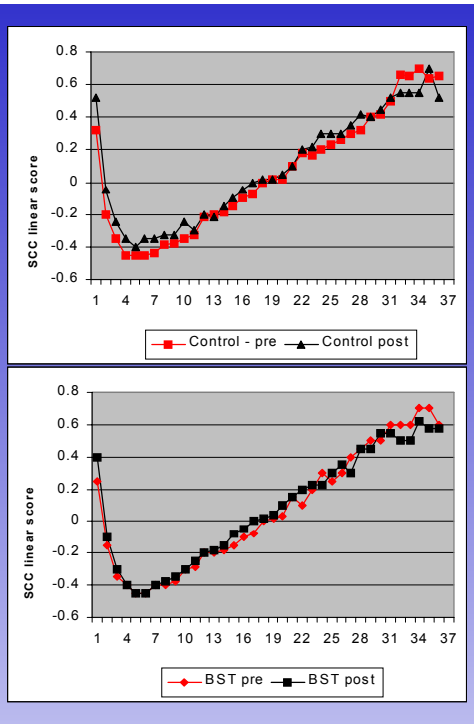
1. BST improved lactation yield (Fig 1.) and persistency consistently over the four-year post-approval period, estimated to be approximately 5kg per cow daily for those cows that received BST;

Fig 1. Daily milk yield averages



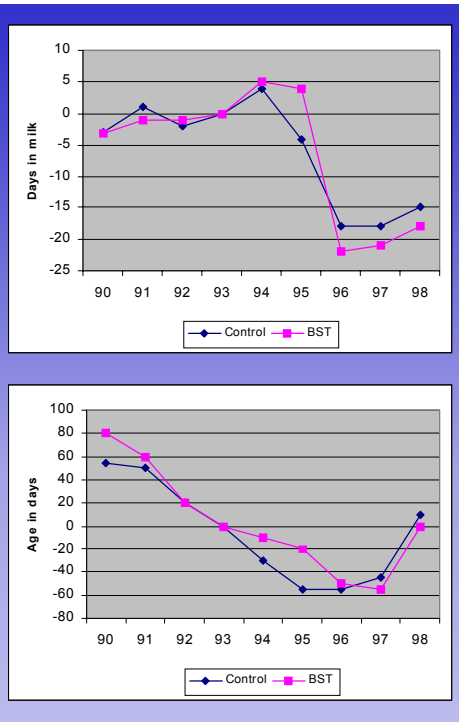
2. There was no difference between the average ages of cows in BST-treated and non-treated herds nor in their respective lactation stages (days in milk) (Fig 2.) indicating, together with the consistent significant improvement in milk yield, that animal well-being was not disadvantaged by BST treatment;

Fig 2. Trends in SCC linear score for multiparous cows



3. Although statistically significant the increase in SCC linear scores (an indication of mammary infection) was minimal in herds utilising BST and that the pattern of SCC over the lactation cycle was unaffected in both first lactation and mature cows (Fig. 3). This difference was consistent with that observed with similar milk yield increases.]

Fig 3. Trends in average days in milk and age in days



The results of this study confirmed those of several others cited. Injection of BST elicits additional milk yield without detrimentally affecting the cow.

Consumer concerns

Under normal (non-BST) conditions, as a cow's milk yield increases the milk becomes more watery. This was observed with BST but the milk was no more or less watery than similar "natural" increases in yield might be expected to cause (Table 1; Bauman *et al*., 1999).

Table 1. Average herd parameters pre- and post-approval periods

Variable	Control herds (176)		BST herds (164)	
	Pre	Post	Pre	Post
Milk, kg/d	27.2	28.8	28.7	33
Fat, g/d	998	1048	1043	1179
Fat, %	3.67	3.64	3.63	3.57
Protein, g/d	871	907	916	1048
Protein, %	3.21	3.15	3.19	3.17

There is no way in which the milk from BST-treated cows can be distinguished from that produced by cows that have not received exogenous BST. The cow's body does not distinguish between the injected and its endogenous production so it follows that it is unlikely it will respond any differently. No differences could be found in products made from the milk of BST-treated cows when compared with those made from the milk of untreated cows (Breier *et al*., 1991).

Part of the registration protocol for the FDA required extensive testing of milk from BST-treated cows for possible harmful effects on its consumers. Since BST is a protein molecule it is logical to accept that when taken by mouth it would be treated like any other dietary protein and be broken down into its constituent amino acids and peptides that no longer bear any resemblance to the original food or hormone protein and therefore lack its effect. Even if, by some freak event, BST was absorbed as such by a human it has been demonstrated that humans do not respond to ST from other species (Turner & Bagnara, 1971). Extensive testing in neonatal laboratory mammals (not yet fully developed digestive systems) revealed no different reactions to milk from BST-treated cows when compared with those fed milk from untreated cows (Bauman, 2002).

Fears have been expressed that elevated levels of IGF-1 in the milk of BST-treated cows could be detrimental to consumers. Coan (2001) cited a 1999 report from the E U Scientific Committee on Veterinary Measures in which it was stated, "Risk characterisation has pointed to an association between circulating IGF-1 levels and an increased relative risk of breast and prostate cancer." Although researchers like Brier *et al*. (1991) found a statistically increased level of IGF-1 in the milk of BST-treated cows compared with controls (no BST) they concluded that these levels were similar to the levels of IGF-1 normally found in human breast milk and that the small increase they observed was "not of biological significance to the consumer". According to Bauman (2002) IGF-1 does not cause cancer but is an essential protein regulator

involved in repair and maintenance; its levels in the milk of BST-treated cows do not differ [substantially enough] from untreated cows and levels of IGF-1 in milk result in an intake of IGF-1 that is less than 0,1% of the levels our bodies produce every day and 100-fold less than we swallow from that produced in our saliva each day. IGF-1 levels in the milk of BST-treated cows therefore does not appear to pose any threat.

Now what possible ill-effects can consumption of milk produced by cows treated with rbST have on humans? Will little boys develop boobs or girls grow abnormally tall or will there be an explosion of acromegalics? Maybe from the combined effects of global warming and increased exposure to toxic fumes and strange radiations, but not from the consumption of milk produced by BST-treated cows.

It seems generally accepted that the decisions by the EU and Canada to ban the use of BST in their countries was motivated by socio-political and socio-economic considerations. In the EU there is pressure on governments to keep small farmers on the land and the perception amongst a highly educated electorate that "hormones are bad". In Canada possibly similar considerations apply together with her competitiveness with USA. In both cases the scientific reports of their respective agencies declared BST safe.

The FDA insists on exhaustive testing to ensure human safety and would not have allowed registration in USA had there been any hint of risk. Exhaustive tests have been carried out on laboratory mammals and the world's public have been consuming "treated cows'" milk since about 1994. Surely, if there was any immediately significant ill effect it would have manifested by now but, as scientists, we must keep an open mind.

Conclusion

Provided the antibiotics registered for use as performance enhancers in dairy cows in RSA are responsibly used by observing the correct dosages they pose no risk to consumers of milk or meat from dairy cattle. Fortunately any temptation to over dosage is severely curbed by its substantial economic and, in some cases, animal health detriment. High cost considerations should similarly limit any tendency to over-use of treatment antibiotics and irresponsible non-observance of withdrawal periods is likely to result in severe economic consequences to the perpetrator as well as consumer protection, due to regular testing of farm milk collections for inhibitory substances.

BST is a relatively new technology but has been in commercial use on dairy farms in many countries for about eight years now. No detrimental effects to consumers of milk from BST-treated cows have been demonstrated. Even if this milk contained some harmful substance it is likely this would be greatly diluted by the time it reached the average consumer's table as not all cows in a herd routinely warrant BST treatment and not all herds use BST. Its banning in certain countries, notably the EU and Canada is based on overtly socio-political concerns rather than scientifically proven fact.

It is good that there are individuals and consumer watchdog organisations that are concerned for consumer safety and leave no stone unturned to question the validity, usefulness and safety of new technologies but PLEASE let's look at the facts and not allow ourselves, as consumers, to be "carried away" by poorly-informed emotionalism.

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