MAMMARY DEVELOPMENT IN HEIFERS

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TAKE HOME MESSAGES

- There are five stages of mammary development: fetal, prepubertal, postpubertal, pregnancy, and lactation.

- Hormones and nutrition play critical roles in the development of the mammary gland.

- Feeding regimens with varying nutrient levels during critical phases of mammary gland development in heifers can optimize lactational performances by taking advantage of normal patterns of mammary growth.

MAMMARY DEVELOPMENT

A primary goal of the dairy industry is to produce healthy heifers with mammary glands capable of synthesizing and secreting significant quantities of high quality milk. Structural development of the mammary gland is critical to achieving that goal. Mammary growth can be separated into five phases: 1) fetal, 2) prepubertal, 3) postpubertal, 4) pregnancy, and 5) lactation. During some of these growth stages, the mammary tissue is undergoing allometric growth (growing at rates two to four times faster than the rest of the body). Growth at rates similar to the rest of the body is called isometric growth. Most body growth occurs relatively early in life, while the mammary gland expresses its maximal growth potential during pregnancy and early lactation. Hormonal changes and nutrition levels are two of the factors which influence mammary development. Most research in this area has focused on the importance of growth in prepubertal, postpubertal, and pregnant heifers.

PREPUBERTAL MAMMARY GROWTH

A large portion of mammary growth before puberty is seen as an increase in connective tissue, ductal growth, and growth of the fat pad. Prepubertal mammary growth begins as isometric growth, and before puberty mammary gland growth becomes allometric.

Prepubertal nutrition can have a significant effect on future milk yield. Raising heifers on high planes of nutrition during prebubertal mammary growth has been shown to have a negative effect on milk yield. Feed restricted heifers can have up to 30 percent larger mammary glands at puberty. Furthermore, mammary tissue on heifers fed ad libitum was over 80 percent fat, while heifers fed a restricted diet have around 65 percent fat, and 13 percent more parenchymal tissue (tissue that will eventually become milk producing tissue) compared with heifers fed ad libitum. It should be noted that mammary parenchymal tissue grows into a layer of fat referred to as the fat pad.

Studies have also shown that feeding high energy diets during the prepubertal period suppresses serum bovine somatotropin (bST) levels, and that serum levels of bST have a positive correlation with prepubertal mammary growth. Injections of bST during the prepubertal period can increase prepubertal mammary development compared to non-bST injected control heifers. However, by the time the heifers begin lactating there is no difference in milk yield.

POSTPUBERTAL MAMMARY GROWTH

Rapid mammary growth continues through the first several estrous cycles after puberty has been reached. After this early postpubertal mammary development, the estrogens present during subsequent estrous cycles continues to stimulate mammary growth, although most of the growth is lost through regression during the luteal phase of each estrous cycle. Consequently, the number of estrous cycles after puberty and before pregnancy can influence total mammary growth. Nutrition plays an important, though controversial, role in postpubertal mammary development, with energy intake being particularly critical. Some studies have found that ad libitum feeding has no effect on mammary development after puberty had been reached, while others have found that feeding after puberty affects mammary development.

MAMMARY GROWTH DURING PREGANCY

The majority of mammary growth occurs during pregnancy. Mammary growth is a continuous, exponential process from conception to parturition, with the greatest increase in mass of parenchymal tissue occurring in late pregnancy. The udder increases markedly in size during the fifth and sixth months of pregnancy. This increase in udder size is due to the elongation of mammary ducts, the formation of alveoli, and the reduction of identifiable fat cells in the fat pad. Mammary epithelial cells complete differentiation during pregnancy and milk component synthesis begins. In the last month of pregnancy, the alveoli show secretory activities, and the udder begins increasing in size due to the accumulation of the secretory material. The primary cause of mammary growth during pregnancy is the simultaneously elevated blood concentrations of estrogen and progesterone, though nutrition has been shown to have a role. High levels of nutrition have been shown to be beneficial in increasing future lactation potential and in improving mammary development. A study found that with each pound increase in body weight at first calving, there is an increase in milk yield during the first lactation. In addition, studies in Japan have shown that feeding high levels of energy during pregnancy results in substantial improvements in subsequent milk yields.

MAMMARY GROWTH DURING LACTATION

Mammary growth continues in early lactation, but this growth may account for less than 10 percent of total mammary development in ruminants. After peak lactation (45-60 days after calving), there is a gradual decline in milk yield. Peak milk yield is dependent on the number of milk secreting cells. Persistency of lactation (maintaining peak milk yield) depends on the continual survival of those milk-secreting cells. There has been relatively little intensive research on mammary growth during lactation in dairy cattle, though there are several studies looking at this growth in rats and swine. In rats, increases in total mammary DNA was seen from parturition until weaning. The increase in DNA represents an increase in cell number and this growth is important in determining milk production. Similar results have been found in pigs where total mammary DNA increased through at least three weeks of lactation. The growth and development of the mammary gland during lactation is an area that needs further study.

STAIR-STEP COMPENSATORY NUTRITION

The negative effect of high levels of feeding on mammary development appears to be related to a critical period of mammary development. This critical period of mammary growth appears to be related to the allometric growth that the mammary gland undergoes in the months prior to puberty.

In the past ten years, several studies (from North Dakota State University, Israel, and Korea) have focused on the role of induced compensatory growth in heifer development. This stair-step compensatory nutrition (SSCN) regimen is a unique blend of energy restriction and re-alimentation (re-feeding at higher energy levels to induce compensatory growth) phases. The restriction and re-alimentation phases coincide with periods of allometric mammary gland growth during prepuberty, puberty, and gestation. For example heifers are fed a restricted diet just prior to puberty, and then during the first few months after puberty they are feed a re-alimentation diet. The process is then repeated twice with the high energy or re-alimentation diet being feed at breeding and late gestation. During the re-alimentation phase of the SSCN regimen the animal grows faster than during the restriction phase.

The result of this induced compensatory growth allows for maximal mammary gland growth. During the compensatory growth period, the animals reach a catch-up point, where body weight is the same as non-restricted animal. Heifers grown on the SSCN regimen gain more while consuming less feed, resulting in improved body growth efficiencies when compared with conventionally raised heifers. The SSCN regimen can also improve total mammary DNA, which shows an increase in milk secreting cells, and thereby increases milk yield over that of conventionally raised control heifers. The SSCN regimen takes advantage of the natural allometric growth phases as well as optimizing body growth.