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Role of Nutrient Supplements for Enhancing Milk Production

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Introduction

For dairy animals, increasing milk production is crucial, and supplementing with nutrients can help the impact of dietary supplements on milk production, including those containing lipids, carbohydrates, prolactin, oestrogen, amino acids, and peptides, as well as other substances. The functions of nutrients and associated pathways in enhancing the synthesis of milk protein and fat are outlined in this article which can aid in understanding how milk production and nutritional supplementation are related.

Keywords: Nutrients; Milk protein; Milk fat; Regulatory pathway

Introduction

One crucial aspect of dairy animals' economics is their ability to produce dairy products. Dairy products and milk are consumed worldwide. The world produced around 928 million tonnes of milk in 2021, but the need will only rise. Global milk output is expected to increase at a 1.7% yearly rate. By 2030, milk production is expected to surpass most other major agricultural products, with 1.020 billion tonnes produced. Providing high-quality feed and balanced nutrition is a promising and forthcoming technique for raising milk production and quality in poor nations (Tricarico *et al*., 2020). The strategy is supplementing the diet or cell culture medium with the right nutrients (lipids, peptides, and amino acids) to enhance milk output and quality.

The Enhancement of Milk Production by Amino Acids and Peptides

Amino acid: The mTOR pathway is the most basic mechanism via which amino acids can improve the production of milk. One important signaling component that is present in many mammalian cells is the mammalian target of rapamycin, or mTOR. It is necessary for the synthesis of proteins and cell development. The cytoplasm contains phosphatidylinositol-3 Kinase (PI3K),

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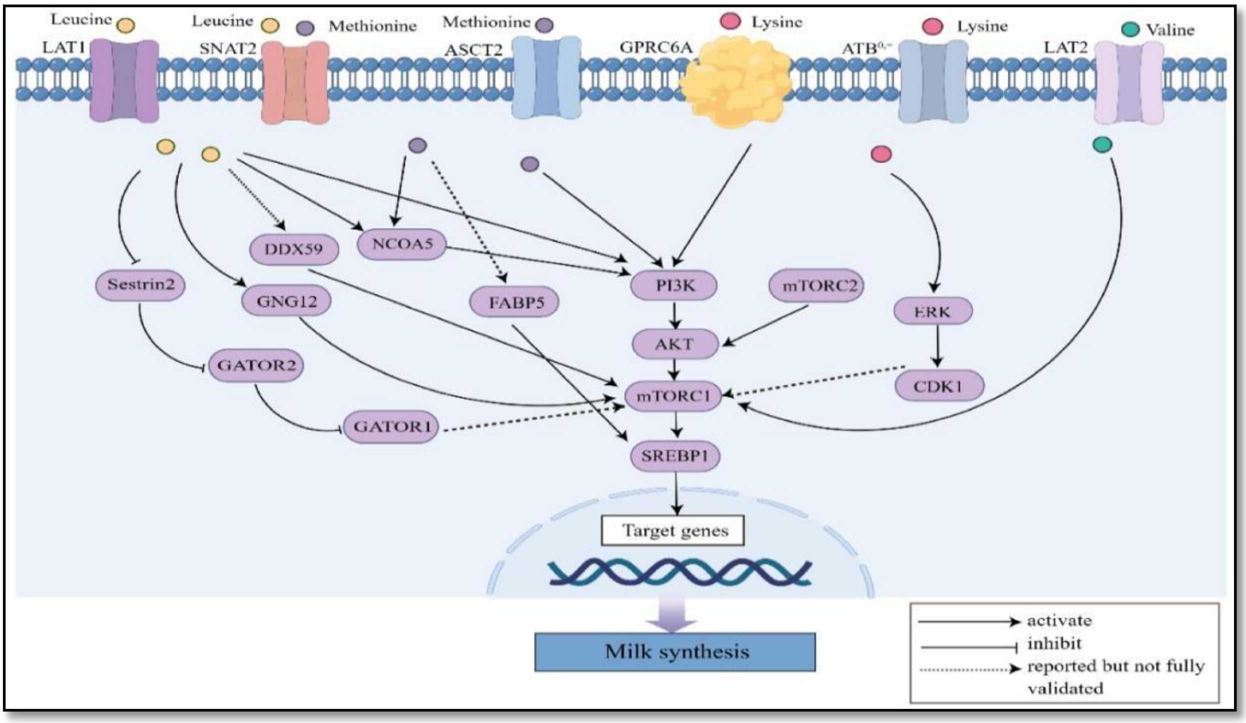
which is a dual-purpose protein kinase and phospholipid kinase. After activation, PI3K finally transforms into phosphatidylinositol 3,4,5-triphosphate (PIP3). According to reports, the addition of amino acids stimulates the mTORC1 pathway in dairy bovine mammary epithelial cells (BMECs) by means of the Septin6 factor, hence facilitating cell proliferation and the synthesis of milk proteins. Supplementing BMECs with amino acids can also activate mTOR signaling via Glycyl-tRNA synthetase (GlyRS) and Seryl-tRNA synthetase (SARS), which will benefit cell growth and casein synthesis. Furthermore, β-casein production can be stimulated by adding the right ratio of necessary amino acids to both BMECs and bovine mammary tissue explants (MTE). Methionine, leucine, valine, and lysine are among the amino acids on which researchers concentrate.



Peptides: When two or more amino acids dehydrate and condense, peptides are created. It has a major impact on biologically active processes and is implicated in hormones, neurons, cell growth, and reproduction. Peptides can influence a milk protein's possible signaling pathway and improve milk protein from mammals (goats, cows, etc.). Among these, mTOR continues to be significant. The promotion of mammalian milk fat synthesis has been shown to be greatly aided by ghrelin, kisspeptin-10, dipeptide (methionyl-methionine), and substrate (threonyl- phenylalanyl-phenylalanine). Peptides can influence a milk protein's possible signaling pathway and improve milk protein from mammals (goats, cows, etc.). Among these, mTOR continues to be significant. The promotion of mammalian milk fat synthesis has been shown to be greatly aided by ghrelin, kisspeptin-10, dipeptide (methionyl-methionine), and substrate (threonyl- phenylalanyl-phenylalanine). The peptide-promoted production of milk fat is also dependent on the JAK2-STAT5

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and mTOR signaling pathways. Related proteins like GPR54, ERK1/2, and AKT all influence the production of milk fat in these pathways. They will eventually achieve the impact

of boosting lactation by increasing the expression of PepT and β-casein in mammary epithelial cells via the route.

The enhancement of milk production by lipids

Triglycerides and lipoids (phospholipids, sterols) are examples of lipids. In addition to being a vital source of energy, fatty acids have an impact on tissue and cellular metabolism (Calder, 2019). Fatty acids stimulate the synthesis of milk fat, and this process is significantly aided by the mTOR pathway. Numerous fatty acid-related factors, including SREBP1, FABP3, PPARG (peroxisome proliferators-activated receptor gamma), and others, influence the production of milk fat. One important element controlling animal fat production is SREBPS. It controls fat production by regulating the gene transcription of lipogenesis-related enzymes, which in turn controls the activity of lipogenesis-related enzymes. FABP belongs to the class of intracellular lipid-binding proteins. It is important for intracellular absorption, transport, and metabolism of long-chain fatty acids. Additionally, a few C18 unsaturated fatty acids have been found, including oleic, linoleic, linolenic, palmitic, stearic, and palmitic. By altering the expression of FABP3, oleic acid, stearic acid, and palmitic acid can enhance the formation of lipid droplets in BMECs and upregulate SREBP1 and PPARG to stimulate milk fat production.

The enhancement of milk production by carbohydrates

Glucose is one of the most significant carbs, and energy metabolism is closely linked to carbohydrates. It is a necessary precursor for the lactating mammary gland to synthesize lactose, which powers the immune system and milk production in dairy cows. The production of lactose, nicotinamide adenine dinucleotide phosphate (NADPH), and milk fat are the three processes by which the mammary gland uses glucose. The uptake of glucose in the mammary gland of mammals is facilitated by two distinct transport mechanisms: sodium-dependent transport, which is mediated by the sodium+/glucose co-transporter, and facilitative transport, which is mediated by the glucose transporter family. The AMPK mTOR pathway is the most significant in milk protein synthesis that is stimulated by glucose. The AMPK and mTOR signaling pathways interact with one another. Closely linked to intracellular energy metabolism, adenosine monophosphate (AMP)-activated protein kinase (AMPK) is capable of preserving energy balance in the face of metabolic stress at the cellular and physiological levels. One of mTOR's upstream factors is AMPK. The mTOR signaling pathway is suppressed when AMPK is triggered by external stimuli, which lowers the number of related proteins synthesized.

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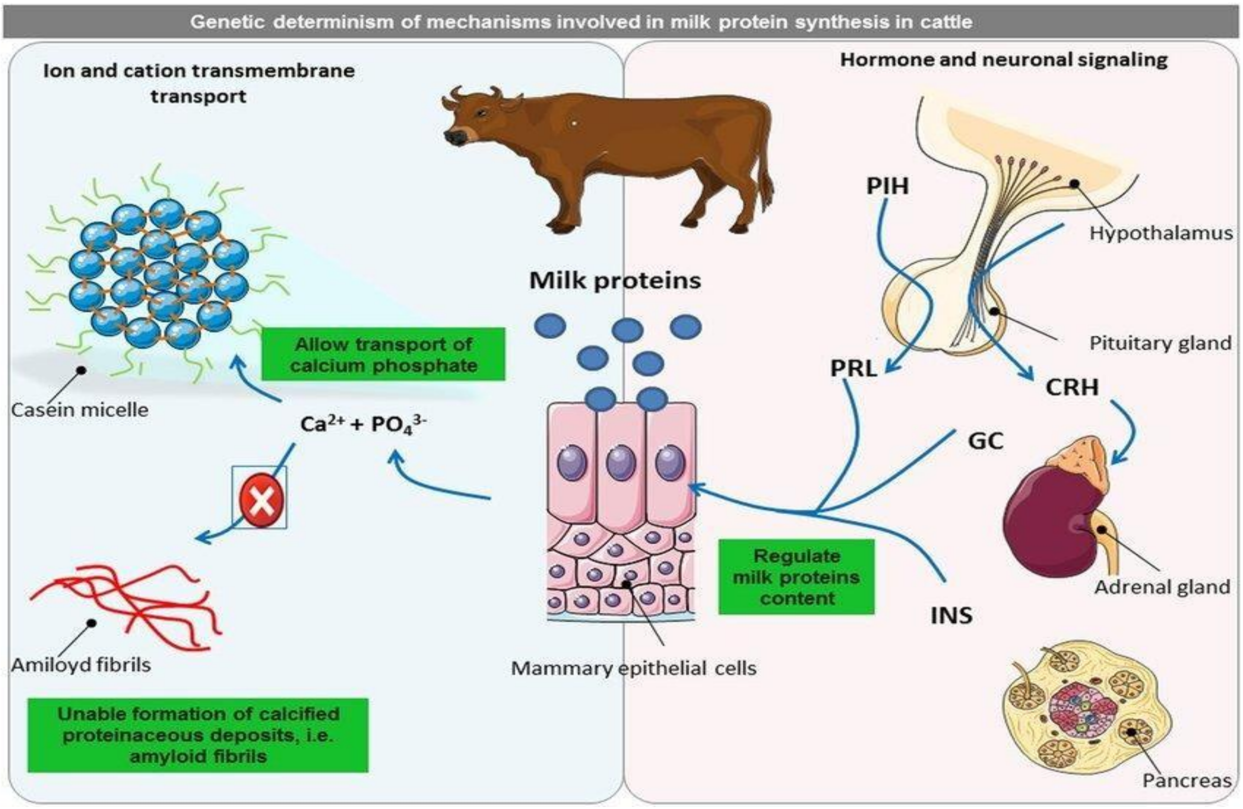

Conclusion

The improvement of milk production with vitamin supplements and associated processes are outlined in this article. Most research focuses on using lipids and amino acids to increase milk production. The mechanisms involved in protein synthesis, fat synthesis, and metabolism can all be impacted by nutrients. The transport systems that carry nutrients across membranes are also crucial for boosting the production of milk. Among all the pathways, JAK2-STAT5A, SREBP1, PPARG, and mTOR were the most often implicated. These pathways are crucial for encouraging the production of milk.

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