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MILK PRODUCTION ON PROTEIN-FREE FEED

ARTTURI L. VIRTANEN
Pontifical Academician

SVMMARIVM — Experimenta facta sunt ita mutando quarumdam vaccarum cibum, ut in eo nitrogenum non haberetur nisi ex urea et ammonii salibus. Perspectum est in lacte ab iis vaccis producto proteinas esse quantitate plerumque plures, sed eiusdem amino-acidae compositionis, cuius sunt in lacte earum vaccarum, quae consueto modo aluntur; item maiore quantitate inesse in illo lacte vitaminas B.

Experiments with cows (AYRSHIRE cows weighing about 450 kg) with the object of producing milk on a protein-free feed, with urea and ammonium salts as the sole sources of nitrogen, have been continued at the Biochemical Institute since 1962 (*). The adaptation of the first cow to this kind of feeding was started as early as in October 1961. During the transfer from normal feed to the test feed there are fundamental changes in the microbial flora of the rumen, and its capacity for the utilization of urea and ammonium nitrogen is developed. The following is a summary of what we know after the first

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(*) Laboratory of the Foundation for Chemical Research, Biochemical Research Institute - Helsinki, Finland.

four years of the experiments about the practicability of such a feeding.

The test feeding comprised starch (about 50%), surcrose (about 20%) and cellulose (about 30%). As fat small amounts of plant oil (36-130 g per day) were used. As the nitrogen nutrition urea (about 300-600 g per day) and small amounts of ammonium sulphate and phosphate have been given, and as the mineral supplement a salt mixture (400-800 g per day). Of the vitamins, only A and D preparations have been given during the main part of the test period, and in addition small amounts of vitamin E during a period of one year.

During the first years when the amount of urea used, to avoid any possibility of ammonia poisoning, was at the most 450 g per day, the yearly milk production of the four test cows was 2000-2600 kg (calculated as standard milk = 684 Kcal/kg milk). However, it was shown that there was no danger of ammonia poisoning, for the levels of ammonia in the rumen of the cows on the test feed were found to be very low, considerably lower than in the rumen of normally fed cows, when protein forms the main nitrogen nutrition. Neither have elevated ammonia levels been found in blood samples taken at different times from the test cows. Since 1965 the amount of urea fed daily was therefore increased to 600 g, with the result that the production of milk increased considerably. The best yield so far is 4217 kg (684 Kcal/kg milk) per year, but it is probable that the yield can be increased further, for the cow in question received still too little urea during the first four months lactation.

The amount of urea which can be fed depends naturally on the amount of carbohydrates used by the cow. During the first years we fed only 17-20 g of urea nitrogen per kg of organic material in the feed, but during the last year as much as 26-28 g. The digestibility coefficient of urea nitrogen then rose from 62 to 70. One fodder unit contained 1-1.1 kg organic material.

The milk produced using purified nutrients and urea nitrogen (including ammonium-N) is called, in short, o-milk (zero milk). Regarding the composition of the different components of this milk the following is known.

The amino acid composition of the proteins of o-milk is so similar to that of milk produced on normal feed that it can be concluded that there are no real differences. Various fractionating methods have been used to separate the different proteins of milk and no definite differences between the proteins of o-milk and normal milk have been found so far. The protein content of o-milk is generally higher than that of normal milk.

The vitamin content of the o-milk has been followed continuously by making determinations of the vitamin-B complex by microbiological methods. Judging by the high vitamin content of the o-milk, the synthesis of the vitamin-B complex brought about by the rumen microorganisms is vigorous. The contents of riboflavin, nicotinic acid and pantothenic acid in the o-milk are generally higher than in normal milk. The contents of thiamine, pyridoxine, folic acid, biotin, and B_{12} are on much the same level as in normal milk. The biosynthesis of the vitamins of the B group seems thus to be rapid enough to keep up a normal vitamin content of milk.

The flavour substances of the test milk are very similar to those of normal milk. This shows that the flavour substances of milk are formed mainly in the organism of cow and that the transfer of the flavour substances of the feed to milk is so slight that they hardly influence milk flavour. It is known that some plants with specific off-flavours (eg. chive, onion) may cause flavour defects in milk, but the protein-free test feed did not contain any flavour substances.

The composition of the milk fat depends decisively on the quantity and quality of the fat in the feed. When only small amounts of vegetable oil, 30-70 g per cow per day, were included in the feed, the fat content of the milk was high, but the amount of stearic and oleic acids was exceptionally low, and that of palmitic acid again very high. The results suggest that the fatty acids are then synthesized mainly in the mammary gland and that the synthesis of the C_{18} fatty acids is then very weak. When the amount of oil in the feed is increased, the amount of palmitic acid falls and that of oleic acid rises. The amount of linoleic and linolenic acids in the milk of the test cows is then at the same level as in the milk of normally-fed cows. The stearic and oleic acid content of the fat of the o-milk has, however, always been lower than that of the normal milk. The only milk constituent showing noticeable compositional differences between o-milk and normal milk is thus the fat.

New possibilities have thus been opened for the production of high-value protein with the help of the cow. Since it is known that proteins, hitherto regarded as essential in the feed of the cow, can be replaced by simple nitrogen compounds which industry can manufacture practically taken in unlimited amounts using the gaseous nitrogen of the atmosphere as ray material, the problem of how to get energy nutrition, above all carbohydrates, has become very important. Many different plans can be made in this field. In different countries various raw materials can be considered, above all wood and straw. The hemicellulose fraction of wood arouses special attention as a source of sugar. In tropical climatic zones the sugar cane is obviously in many places a very important raw material. Without starch a suitable feed mixture can hardly be achieved. How large the portion of starch shall be is still unknown. Much research and experimental work is needed before the results regarding the nitrogen nutrition of the cow obtained so far can be applied in practice.