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Development of Technology of Substitute of Whole Milk On The Basis Of Processing By-Products.

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ABSTRACT

The technology production of the liquid substitute of whole milk (SWM) for calves on the basis of by-products of processing of the food industry is developed: dairy whey and a beer pellet, as a result the product on physical and chemical indicators most approached to structure of cow's milk is received. In the article the results of research of amino-acid score and fatly acid structure of SWM, also the determination of biological value of a product are presented.

Keywords: Amino-acid score, Beer pellet, Dairy whey, Fatly acid structure, Substitute of whole milk

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INTRODUCTION

Dairy industry is one of the key links in the food industry, which solves social problems of providing the population with milk and dairy products.

Currently, processing of secondary dairy raw materials remains to one of the main problems and tasks of the enterprises of this branch, for the solution of this problem wide opportunities open before use of all types of protein-carbohydrate raw materials, especially the dairy whey which is potential raw material for production of new types of dairy products and use as the main raw material for production of substitutes of whole milk.

In many countries the accurate tendencies of constant accumulation of rates of production of SWM with the use of secondary dairy raw materials, proteinaceous components of a phytogenesis, including by-products of processing of the brewing industry including in itself enough amount of protein are traced. Modern substitutes of milk are difficult, multi-component mixes which application allows to replace partially or completely whole milk at cultivation of calves.

One of the perspective components on production of SWM is dairy whey. The problem of using of whey at production of substitutes of milk gains particular activity in connection with wide resources in our country. Using of dairy whey allows to make the most efficient use of raw material resources of a dairy industry and to receive a product of a high biological and fodder values [1].

In this regard, it is obvious that work, concerning theoretical and experimental studies directed on joint use of high-proteinaceous vegetable components, dairy whey and an assessment of their application (at feeding of calves) is one of actual tasks which decision, allows annually to direct some million tons of milk for the food purposes.

Many works devoted for using of dairy whey on production of fodder products. The production technology of universal feed additive on the basis of dairy whey allowing to provide the maximum use of all its nutritious components and to expand food supply was developed by Alsultanov T.L. [2]. In the work of Burtsev D. G the resource-saving technology of a dry bifidogenic fodder concentrate on the basis of whey possessing treatment-and-prophylactic properties and the balanced fodder value for sagination of young growth of farm animals is developed [3].

The organization of industrial processing of whey allows to implement waste-free technology at the enterprises that conforms to modern requirements of the organization of production. In this regard production of SWM on the basis of dairy whey is economically profitable.

In development of healthy repair of young growth the key role is played by security of a diet with a protein and energy in an optimum ratio [4]. For creation of more nutritious composition of SWM is used high-proteinaceous vegetable raw materials, one of such are the secondary raw materials of the brewing industry a beer pellet. It is the main by-product of the brewing industry that makes about 85% of total of the formed by-product that is available in large numbers during the whole year and its main application isn't limited in a forage production.

The conducted research showed that a fresh and dry beer pellet without negative influence on dairy efficiency, can be used in a diet of highly productive cows, in exchange to amount of wheat bran equivalent on nutritiousness. Researches showed that inclusion in a diet of a beer pellet has no essential impact on technological properties of milk [5].

Despite high protein and celluloses content (about 20 and 70% of a dry basis), it can perfectly serve as substitute raw material in food of the person. The main characteristics and possibilities of application of a beer pellet with accent are looked through as raw materials in foodstuff, in energy production and in biotechnological processes [6].

The beer pellet is potentially valuable resource for the industry, in connection with its large volume of production, low cost and a various chemical structure [7]. Tendencies on use of a beer pellet in bread baking are traced. In works of Nádia C. Steinmacher is carried out bioconversion of a beer pellet on jet extrusion and used by production of dough for different types of bread [8]. Being also an important worldwide by-product of brewing process of production in large numbers, it is rich with carbohydrates, proteins, lipids and represents special interest in food and other industries [9].

The physical- chemical characteristics of beer pellet was studied and a variety of its chemical composition is in relative ranges of structure of wheat and barley that finds a great interest in a forage production [10]. In this regard the beer pellet can be considered as valuable fodder product with the high maintenance of a protein which can enrich substitutes of whole milk for calves both in stall and pasturable periods.

Substitutes of whole milk by all means have to contain fats as structural and reserve material. Properties of fats need to be considered at selection of fatty complex of SWM. Obviously, most fully meets requirements imposed to fatty phase of SWM, mixture of animal and vegetable fats.

Important factor in choosing the type of fat are the resources which are available in the country. According to chemical structure the beef and mutton fats are close to milk fat, by physical and chemical indicators most are suitable for fatty structure of SWM [11].

Nutritional value of fat in substitutes of whole milk in considerable degree depends on a way of its introduction and methods of preliminary processing. Usually fat is entered into SWM by its homogenization with the liquid or condensed dairy products to which any emulsifier is added. Emulsification of fat leads to considerable improvement of its comprehensibility.

The purpose of work is development of technology of substitute of whole milk for calves on the basis of by-products of processing of the food industry of the increased biological value.

MATERIALS AND METHODS

Objects of research were liquid substitute of whole milk on the basis of dairy whey (Dairy factory of Almaty), production of beer pellet "Carlsberg Kazakhstan Brewery LLP", fat of an animal of JSC "Meat-industrial complex Nuralem", sunflower oil production of LLP "May".

Experimental studies were conducted on the basis of research laboratory "Food Safety" of Almaty Technological University in Almaty, Kazakhstan and scientific laboratory of department "Technology of Milk and Dairy Products" at University of Food Technologies in Plovdiv, Bulgaria.

The physical-chemical structure is defined according to the established techniques: amount of dry substance determined by method of drying of samples at a temperature of 103-105 °C during 7 h (ISO 5534 | IDF 4:2004), the mass fraction of fat was carried out by a volume method with use of sulfuric acid by the Gerber method (ISO 488:2008 (IDF 105:2008), protein content determined by Kyeldal's method by a mineralization of a sample and the subsequent distillation (ISO 8968-1:2001), active acidity is determined by an electrometric method with the help of laboratory pH/mV - meter - InoLab pH 720, with a firm electrode of SenTix sp80, the content of ashes is determined by IDF standard 27:1964.

Researches on definition of fat and acid structure of ready products were conducted according to ISO 5508:2000, by the method of a gas chromatography on the equipment Shimadzu (Japan) a DB - wax, 30 m long, with an internal diameter of 0,25 mm. Lipids extracted according to the Rose method - Gothlib, the oily substance is received with the use of MeOH/BF3 (the methanol containing 14% of boron Bf3trifluoride). Fatty acids were analyzed in the following conditions of a chromatography: the program of temperature of 50 °C within 2 min., increasing the temperature to 200 °C at a speed of 10°C. min^{-1}, increasing to 218 °C, at a speed 2°C.min^{-1}, increasing to 250°C at a speed 10°C. min^{-1},delay on 250°C for 10min.

Researches on definition of amino-acid structure of raw materials and ready products are conducted.

The amino-acid structure was investigated on the amino-acid AAA-835 analyzer ("Hitachi", Japan) by the method of liquid chromatography on the column Biosil-400 after preliminary hydrolysis of samples 6N by

HCl during 24 h at a temperature of 105 ºC and evaporation on the rotor evaporator at a temperature of water bath no more than 60 ºC.

The amino-acid score (AAS) counted by the formula:

$$AAS = \frac{m1}{m2} \times 100\%$$

where m_1 – the content of irreplaceable amino acid in 1 g of protein of a sample, mg/g of protein; m_2 – the content of irreplaceable amino acid in 1 g of reference protein, mg/g of reference protein.

The indicator characterizing protein on extent of its assimilation, consumption with advantage is the utility coefficient considering balance of joint stock company of structure not only on limiting joint stock company, but also on their surplus (in relation to requirement).

We use the following formula for an assessment of coefficient of utilization of each joint stock company:

$$a = \frac{AAS\ min}{AAS\ i \times IAA}$$

where, a - coefficient of utilization, %

AAS min - the minimum chemical score of amino acids;
AAS i× IAA – amino-acid score of each IAA of protein of a sample.

The coefficient of utility of protein (Cu) counted by the formula:

$$Cu = \frac{\varepsilon(content\ iIAA \cdot AAS \cdot iIAA \cdot aiIAA)}{\varepsilon\ content\ IAA}$$

where, Cu – coefficient of utility of protein;

the contents iIAA– the content of each irreplaceable amino acid in the tested protein;

$AAS \cdot iIAA$ – the amino-acid score of each amino acid in the tested protein;

$aiIAA$ - coefficient of utilization of each amino acid of tested protein, %;

the content of IAA – the sum of irreplaceable amino acids, protein mg/g.

Statistical data processing carried out by definition of a standard deviation (± SD) in three frequency.

Production of liquid substitute of whole milk for calves was carried out according to the developed technological scheme (Fig. 1).

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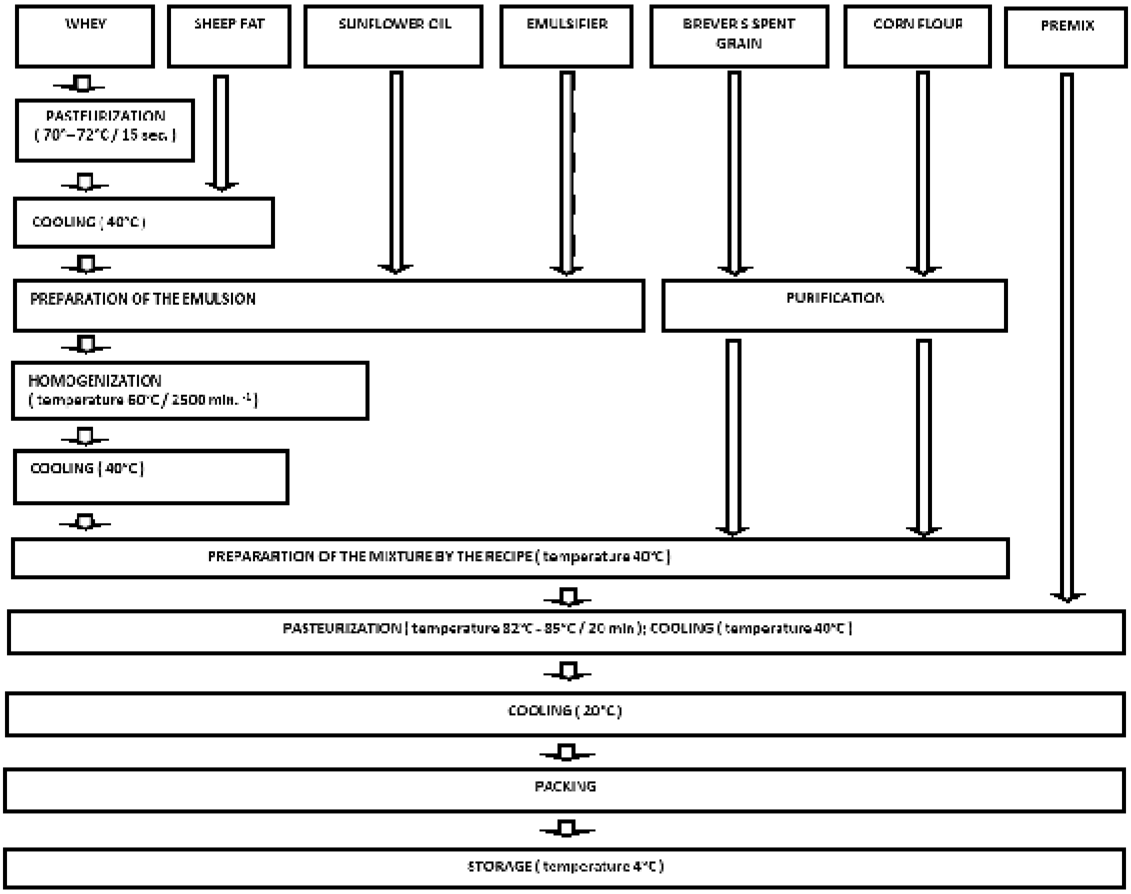

igure - 1 Technological scheme for the preparation of liquid milk replacer for calves

RESULTS AND DISCUSSION

Nowadays, the development of the new resource-saving technologies allowing to receive products with the necessary set properties is actual. Using of high-proteinaceous by-product of the brewing industry, a beer pellet in production of substitute of whole milk increases its biological value. At research of raw materials the special attention is paid to the analysis of protein content and its full value which is characterized by its amino-acid structure.

The amino-acid structure and amino-acid score of proteins of beer pellet is presented in the table 1.

Table 1: The amino-acid structure and amino-acid score of proteins of beer pellet.

Amino acid	Reference scale FAO/WHO		Beer pellet	
	A	C	A	C
Irreplaceable amino acid:				
Valine (Val)	5,0	100	5,20	104,0
Isoleucine (Ile)	4,0	100	3,80	95,0
Leucine (Leu)	7,0	100	7,41	105,8
Lysine (Lys)	5,5	100	2,60	47,3
Methionine (Met) + Cysteine (Cys)	3,5	100	3,54	101,1
Tryptophan (Trp)	1,0	100	+	+
Threonine (Thr)	4,0	100	3,58	89,5
Phenylalanine (Phe) + Tyrosine (Tyr)	6,0	100	8,11	135,2
The amount of essential amino acids	36,0	100	34,24	

Note. A - amino acid content (g / 100g protein); C – chemical score (according to FAO/WHO scale (1973).

The special attention in the analysis was paid to the content of the irreplaceable amino acids causing the biological value of proteins. As we see from the table-1, the greatest number among irreplaceable amino acids falls to the share of phenylalanine and a tyrosine (8,11g).

It should be noted that any of cereals can't provide good nutrition because of the low content of some amino acids and first of all, a lysine. According to FAO/WHO, optimum, i.e. corresponding to physiological requirements, the content of lysine in protein has to make 5,5 on 100 g of protein, in beer pellet contains 2,6 g on 100 g of protein that allows to speak about this amino acid as limiting. The second limiting amino acid is– threonine. Results of researches show that protein of a pellet contains all irreplaceable amino acids, including the limiting.

On the basis of the developed technology of production received the liquid substitute of whole milk on physical and chemical properties which was most approached to the structure of cow's milk (Table 2).

Table 2: Physicochemical composition of liquid milk replacer for calves.

№	Indicators	Content, g.100g^{-1}	
		Substitute of whole milk	Cow's milk
1	Dry matter	12.31 ± 0.60	12.13 ± 0.58
2	Proteins	3.00 ± 0.15	3.20 ± 0.18
3	Fat	3.20 ± 0.25	3.40 ± 0.30
4	Minerals	0.91 ± 0.08	0.82 ± 0.06
5	Carbohydrates	5.20 ± 0.20	4.61 ± 0.12
6	pH	6.60 ± 0.10	6.65 ± 0.05
7	Energy value, kcal.100g^{-1}	61.20 ± 0.82	61.84 ± 0.90

In comparison with a control sample it is established that concentration of carbohydrates in the developed SWM is 13% higher, an ash-content for 10%, the main indicators: the content of fat and protein are in similar limits. Close to the meaning and the power value of products from what follows that made on the developed SWM technology according to its physical and chemical properties it is not strongly differs from the structure of cow's milk and even exceeds its values.

The amino-acid structure of SWM is investigated and the amino-acid score is calculated (Table 3).

Table 3: Amino-acid score of SWM with respect to the "ideal" protein.

Amino acid	Reference scale FAO/WHO		Substitute of whole milk	
	A	C	A	C
Irreplaceable amino acid:				
Valine (Val)	5,0	100	6,0	120
Isoleucine (Ile)	4,0	100	6,25	156,3
Leucine (Leu)	7,0	100	6,25	89,29
Lysine (Lys)	5,5	100	6,25	113,6
Methionine (Met) + Cysteine (Cys)	3,5	100	3,1	88,57
Tryptophan (Trp)	1,0	100	+	+
Threonine (Thr)	4,0	100	6,25	156,3
Phenylalanine (Phe) + Tyrosine (Tyr)	6,0	100	6,25	104,2
The amount of essential amino acids	36,0	100	40,35	

Note. A - amino acid content (g / 100g protein); C – chemical score (according to FAO/WHO scale (1973).

As we see from the table-3 the developed substitute of whole milk incorporates all irreplaceable amino acids including limiting, methionine+cystine which contents made 88,57%, from their size on an adequacy scale in "ideal" protein. Total coefficient of utility for SWM proteins taking into account the limiting amino acid of methionine+cystine made 94,14% that means about high comprehensibility of protein of the developed product.

On the corrected amino-acid score the nutrition value of a protein of SWM taking into account the limiting amino acid and "visible" digestibility of protein made 84,1%.

The biological value of a product is characterized by qualitative content of fatty acids of great importance from which are poly-unsaturated fatty acids. The structure of fatty acids of lipids of SWM is presented in the (Table 4).

Table 4: Fatty acid composition of liquid milk replacer for calves.

Fatty acids	Content, $g.100g^{-1}$	
	Substitute of whole milk	Cow's milk
Saturated fatty acids		
Butyric acid (C4:0)	ND	2.18 ± 0.03
Caproic acid (C6:0)	ND	1.82 ± 0.12
Caprylic acid (C8:0)	ND	0.92 ± 0.10
Capric acid (C10:0)	0.04 ± 0.01	0.42 ± 0.02
Lauric acid (C12:0)	0.02 ± 0.00	0.01 ± 0.00
Myristic acid (C14:0)	2.99 ± 0.17	3.41 ± 0.28
Pentadecanoic acid (C15:0)	0.75 ± 0.12	0.55 ± 0.02
Palmitic acid (C16:0)	21.56 ± 1.22	29.42 ± 1.12
Margaric acid (C17:0)	1.42 ± 0.14	0.82 ± 0.04
Stearic acid (C18:0)	27.69 ± 1.67	30.21 ± 0.83
Arachidic acid (C20:0)	0.34 ± 0.08	0.52 ± 0.02
Monounsaturated fatty acids		
Myristoleic Acid (C14:1)	0.08 ± 0.01	0.38 ± 0.01
Palmitoleic acid (C16:1)	0.75 ± 0.01	2.83 ± 0.05
Oleic acid (C18:1)	28.67 ± 2.27	20.30 ± 1.20
Gadoleic acid (C20:1)	0.46 ± 0.01	0.64 ± 0.15
Docosenoic acid (C22:1)	0.27 ± 0.01	0.42 ± 0.12
Polyunsaturated fatty acids		
Linoleic acid (C18:2)	9.12 ± 0.72	2.56 ± 0.51
Linolenic acid (C18:3)	5.54 ± 0.41	2.38 ± 0.32
Docosadienoic acid (C22:2)	0.09 ± 0.01	0.04 ± 0.01
Ratio of saturated fatty acids : unsaturated fatty acids = 70:30		
* ND - Not Detected		

As a result of research of fatty acids structure (table 4) it is established that 19 fatty acids are a part of lipids, from which 11 is saturated, 5 is mono-unsaturated and 3 is poly-unsaturated.

In liquid substitute of milk aren't defined oleic acid (C4: 0); kapron acid (C6: 0), caprylic acids (C8: 0). The general level of concentration of low-molecular and high-molecular fatty acid in liquid substitute of milk 55,00 ± 0,80 $g.100g^{-1}$ on 70 $g.100g^{-1}$ of fatty acids in cow's milk. In SWM established, high concentration of mono-unsaturated and poly-unsaturated fatty acids in concentration 45,00 ± 0,60 $g.100g^{-1}$, in comparison with cow milk 30,00$g.100g^{-1}$. In liquid substitute of whole milk high concentration of oleic acid 28,67 ± 2,27 $g.100g^{-1}$, also linoleic 9.12 ± 0.7 $g.100g^{-1}$ and linolenic 5.54 ± 0.41$g.100g^{-1}$ acids is defined that determines the biological value of a product.

CONCLUSIONS

On the basis of the conducted experimental studies the technology of production of liquid substitute of whole milk for calves is developed and the compounding on amino-acid structure is optimized. The physical and chemical structure of SWM is investigated and is proved that this product on the quality indicators is most approached to structure of cow's milk. As a result of research of the saturated and non-saturated fatty acids of SWM and cow's milk their ratio makes 55:45 and 70:30.

Substitute of milk has high concentration of free amino acids - 14,65 ± 1,05 $mg.100g^{-1}$ in comparison with cow's milk - 6,44 ± 0,56 $mg.100g^{-1}$. It is experimentally proved that balance of SWM proteins has high result 84,1%, at coefficient of utility of 94,14%. Thus, use of by-products of processing of the dairy and brewing

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industry in production of SWM allows to receive a product of high biological value which can be used in feeding of calves both in pasturable and during the stall period.

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