

Analysis and substantiation of cooked sausage formulations for pregnant and nursing women nutrition

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Abstract -The aim of this research was to design and substantiate specialized cooked sausage formulations for pregnant and nursing women nutrition with the additives similar to phosphates and enriched with vitamins and long-chain polyunsaturated fatty acids (LCPUFA). Calcium salts, samples of sausage meat with added calcium salts, phosphates, vitamins and LCPUFAs, and corresponding finished products were used as the subjects of research. The total phosphorus and calcium content, the finished product yield and moisture binding capacity were measured by conventional methods; fatty acid composition, amino acid composition and vitamin content were analyzed by gas chromatography, ion exchange chromatography and liquid chromatography, respectively. Textural and rheological properties were determined using rotary viscosimeter "Rheotest" and universal testing machine Instron 1140. The addition of calcium salts into the model sausage meat samples allowed to obtain the ratio Ca:P 1:1.5 in the finished product. It is most advisable to use calcium lactate with the effective concentration range 0.7-1.7 g/100g of sausage meat. The addition of vitamins with consideration for losses during the technological process allowed to enrich the product in vitamins at the level regulated by scientifically based requirements. The w6/w3 fatty acids ratio 5:1 adequate to meet the nutritional needs of pregnant and nursing women was obtained.

Keywords – pregnant women, fatty acids, sausages

I. INTRODUCTION

Nutrition of a woman during pregnancy is an important factor determinative for her health and normal fetal growth and development. In this regard, meat products enriched with vitamins, minerals, long chain polyunsaturated fatty acids (LCPUFAs) and adequately selected food additives in the product composition that ensure its safety play a significant role. The aim of this research was to design specialized cooked sausage formulations for pregnant and nursing women nutrition enriched with calcium, vitamins and polyunsaturated fatty acids (PUFAs).

II. MATERIALS AND METHODS

Samples of sausage meat and corresponding finished products with added calcium salts, phosphates, vitamins and PUFAs were used as the subjects of research. The total phosphorus and calcium content, were measured by conventional methods; fatty acid composition and vitamin content were analysed using Gas Chromatograph HP6890 and Liquid Chromatograph ULTIMATE 3000, respectively. Moisture binding capacity (MBC) was measured by the filterpaper press method; shearing characteristics (effective viscosity, shear stress) were determined using rotary viscosimeter "Rheotest" and universal testing machine Instron 1140.

In the development of the specialized cooked sausages for pregnant women a lot of attention was paid to the selection of safe food additives that have the ability to eliminate the deficit of essential substances arising during pregnancy and breastfeeding of infants [1].

In the formulations of the traditional cooked sausages phosphate preparations that increase MBC and emulsifying capacity, stabilize pH, colour formation and oxidative processes in meat products are mainly used. However, their addition for our purposes is undesirable because of the negative effect on calcium digestibility in women's organism. In this connection, it is necessary to use additives similar to phosphates in terms of their functional effect on meat system, namely citrate and other calcium salts (lactate, chloride, carbonate) that increase MBC of sausage meat composition and consequently the yield of finished product [2]. In addition calcium salts allow to adjust imbalance of calcium and phosphorus in meat and bring it close to the physiological optimum, which is of particular importance to the adequate fetal development.

The substantiation of the possibility to use different calcium salts in the production of cooked sausages for pregnant women nutrition was done on the basis of the analysis of the changes in the functional technological

properties (FTP) of sausage meat and finished products depending on the type and concentration of salt, and used catalytic and tap water for brine preparation.

III. RESULTS AND DISCUSSION

The results of the analysis of FTP of sausage meat samples with different content of added soluble calcium salts dissolved in usual and catalytic water are presented in figures 1 and 2. The yield of finished products after the thermal treatment (t/t) is shown in figure 3. The catalytic water (EVR-K) was obtained on the apparatus 'Izumrud' [3].

The results demonstrated that the incorporation of calcium ions in the quantity of 2.2 to 5.5 mmol increases the MBC of the experimental samples of sausage meat up to 8%; the technological yield – from 8 to 15%. The effective concentrations of ionized calcium additives were 2.2 to 5.5 mmol per 100 g of sausage meat, which corresponds to 0.3-0.6 calcium chloride, 0.7-1.7 calcium lactate and 0.8-1.0 calcium citrate (g per 100 g of sausage meat).

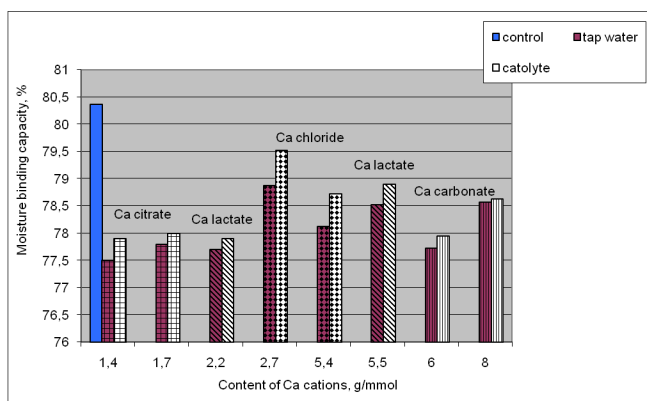


Fig. 1 Dependence of moisture binding capacity on the type of salt and Ca²⁺ content

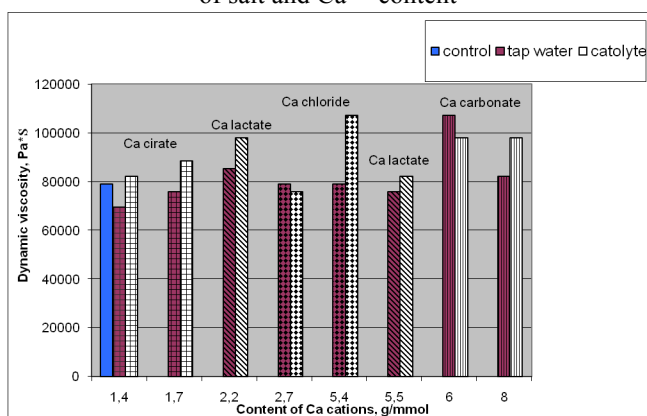


Fig. 2 Dependence of sausage meat viscosity on the type of salt and Ca²⁺ content

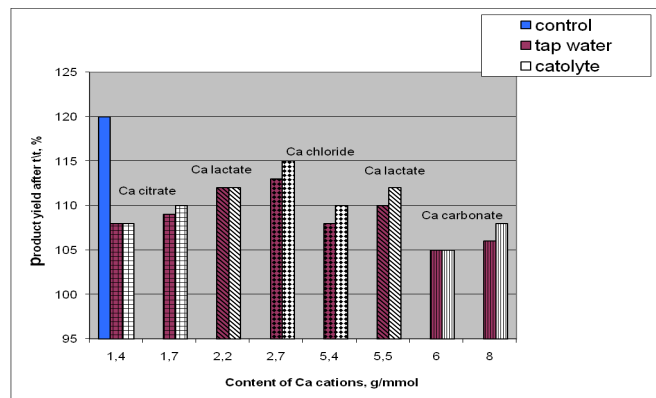


Fig. 3 Dependence of product yield on the type of salt and Ca²⁺ content

The value of MBC was also influenced by EVR-K, the usage of which increased pH and MBC in model samples. It can be explained by biological activity of applied EVR due to the increase in inner energy of curing ingredients; the process of redistribution into the muscle tissue accelerates, the effect of tissue enzymes on the muscle tissue structure increases, the functional technological properties of sausage meat changes. Therefore, the samples of the sausage meat with the use of the catalytic water were analyzed later on.

In order to establish the impact of calcium salts on the structural mechanical characteristics of finished products, shear stress in sausage samples was determined. The results of the structural mechanical examinations using the universal testing machine Instron showed that compared to the control sample with the pyrophosphate, the highest shear stress was in the sample containing calcium carbonate. The experimental sample was characterized by more resilient consistency due to the development of monolithic structural frame (table 1).

The effectiveness of the use of calcium salts has also been confirmed by the increase in mass fraction of calcium in samples that allowed to obtain the Ca:P ratio 1÷1.5, which corresponds to the medical recommendations with regard to the physiological requirements for calcium.

Besides calcium, vitamins are necessary for normal gestation course, embryonic growth, preparation for parturition, and the consequent development of a newborn infant.

The need for vitamins in women increases 1.5-2 times during pregnancy and lactation, which is conditioned by intensification of endocrine system function, metabolism and also by the transfer of a part

Salt type	Salt concentration in the sausage meat, %	Content in the finished product mg/100 g		Ratio Ca:P	Shear stress, N/m ²
		calcium	phosphorus		
Pyrophosphate	0.6	11.4	220.0	1:1.9	60.32±3.25
Ca citrate	0.8	83.3	168.4	1:2	65.43±3.25
Ca citrate	1.0	115.4	170.2	1:1.5	67.42±3.25
Ca lactate	0.8	81.4	166.8	1:2	54.91±2.34
Ca lactate	1.0	124.0	168.7	1:1.35	52.62±2.34

of them to the fetus, and losses of vitamins during parturition.

In order to compensate for the deficit of vitamins, we provided the enrichment of the specialized cooked sausage products with those vitamins, the deficit of which was the most prevalent. At the same time, we took into account that the excess of vitamins is harmful, and it is necessary to incorporate them into the enriched products in the amount corresponding to the degree of the deficit, i.e., 25-30% of the average daily requirement. With all this, we were guided by the consideration that the enrichment of cooked sausages with vitamins should not deteriorate consumer properties of sausages. The possibility of chemical interaction of enriching additives between each other and with the components of the enriched product was also considered. The amount of vitamins additionally incorporated into the enriched sausages was calculated with consideration for their natural content in sausage meat compositions used for the preparation of sausages and the losses during the manufacturing process. In general, the selected doses of the vitamins allowed to achieve enrichment with these vitamins at the level regulated by scientifically

woman as well as the requirements of a child. To this end, it is necessary to add products that are sources of these fatty acids into women's diets.

EPA and DHA are present in animal fats in very limited amount, and vegetable oils do not contain them. According to WHO (1994), the optimal ratio of omega-6 and omega-3 fatty acids for pregnant and nursing women is $\omega 6:\omega 3 = 5:1$.

Thereby, the study on the substantiation of the possibility to use the food additive 'Ropupha' as a source of $\omega 3$ PUFAs for the enrichment of cooked sausages was carried out. The additive 'Ropupha' is deodorized oil of pale green colour on the basis of fish fat. The level of the addition of the oil was calculated with consideration for fatty acid composition of oil and formulation in order to obtain the optimal w6:w3 fatty acid ratio in the finished product without deteriorating sensory characteristics. The selected dose of oil 0.78% was sufficient for ensuring the optimal fatty acid ratio in the product. On the basis of the conducted research, the technology of cooked sausages was developed, which can solve the problem of providing pregnant women with safe specialized meat products enriched in PUFAs and vitamins.

Table 2

Vitamins	Before enrichment		Losses,%	Stipulated requirements	Incorporation dose	After enrichment	
	Found in sausage meat	Found in sausage				Found in sausage meat	Found in sausage
A, $\mu\text{g RE}$	6.42±0.02	6.3±0.02	1.9	250-300	300	315.4±0.02	320.4±0.02
D ₃ , ME	2.73±0.02	2.6±0.02	4.7	100-150	100	104.3±0.02	110±0.02
B ₁ , mg	0.24±0.02	0.18±0.02	25.0	0.37-0.62	0.5	0.68±0.02	0.52±0.02
B ₂ , mg	0.2±0.02	0.13±0.02	35.0	0.4-0.52	0.5	0.75±0.02	0.53±0.02
B ₆ , mg	0.61±0.02	0.43±0.02	29.5	0.52-0.7	0.3	0.92±0.02	0.73±0.02
B ₉ , mg	0.006	0.006	30.0	0.12-0.15	0.1	0.09	0.11±0.02
B ₁₂ , μg	0.23±0.02	0.16±0.02	30.0	1.0	0.8	1.3±0.02	1.04±0.02
PP, mg	2.9±0.02	2.4±0.02	17.2	4.0-5.5	2.0	4.6±0.02	4.5±0.02
C, mg	1.8±0.02	0.5±0.02	70	25.0	70.0	60.0±0.02	24.5±0.02

based requirements. (table 2).

When considering a role of healthy nutrition of pregnant women in embryo and fetal development, it is necessary to point out the extremely topical problem of providing women with adequate amount of PUFAs because they play a significant part in the gestation course and formation of virtually all organs and systems of newborn infants.

A woman's organism gives 2.5 g of $\omega 3$ fatty acids daily for ensuring normal fetal development. In this connection, the diet of a pregnant woman should contain sufficient amounts of essential fatty acids and LCPUFAs in order to meet the requirements of a

The obtained results suggest that the incorporation of calcium salts into the model samples of sausage meat promoted the increase in calcium content in the finished product samples and the achievement of required Ca:P ratio 1÷1.5. The use of calcium lactate in cooked sausages with the effective concentration range 0.7-1.7 g/100 g of sausage meat is most advisable comparing to the other examined calcium salts.

The calculation of the dose of addition of vitamins with consideration for losses during the technological process allowed to obtain the enrichment with necessary vitamins at the level regulated by

scientifically based requirements. The selected dose of the oil containing the LCPUFAs provided the optimal w6:w3 fatty acid ratio in the finished product without deteriorating sensory characteristics.

IV. CONCLUSION

The product ensuring a good balance of protein and fat (1:1 -1.3), without phosphates, preserving agents and colour agents, with limited content of fat, salt, nitrites and species was developed. This sausage product is absolutely safe for pregnant women nutrition, provides an organism of a woman and a child with animal protein and a balanced set of necessary vitamins and minerals, and has an optimal ratio of omega-3, omega-6 LCPUFAs.

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