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Original article

Improving the organoleptic and structural-chemical properties of semi-smoked sausages

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ABSTRACT

The decline of meat resources and the rapid growth of the world's population creates a need for resource management. The purpose of the study was to test the original technology of the semi-smoked sausages production adding goji berries at different concentrations, and to assess the technological risks in the production of sausages. 400 pieces of semi-finished sausages were divided into 4 groups, 100 pieces each. The sausages for the first control group were made according to the "Krakowska" recipe. The remaining three groups were experimental, with the addition of goji berry at different concentrations (30, 50 and 70 g per 100 kg of meat). The prepared samples were analysed for the content of particulate matter and water using hydrological methods. All experimental samples were recorded with a decrease in water activity by 1.2 times compared with the control ($p \leq 0.05$ between the 1st and 4th groups). A new technology for the production of semi-smoked sausage adding goji berries powder at a concentration of 0.3, 0.5, and 0.7% to meat is proposed and tested. The addition of goji berries provides solidity to the sausage samples, as well as better organoleptic and structural-chemical properties compared to the control.

1. Introduction

There have been two multidirectional trends in the world over the past few decades. Firstly, there is a constant increase in the world's population (up to 7.8 billion, according to 2020, 89% of which are potential consumers of meat) (Gu et al., 2021, Kemper, 2020). Secondly, the resource of meat raw materials is reduced (Kirkin et al., 2019). Meanwhile, meat products are one of the most popular in the diet of modern people, due to essential amino acids (Silva et al., 2019). Therefore, the issue of minimal and rational use of raw meat materials in products is becoming increasingly relevant (Raheem, 2016). Modern meat production is characterized by the introduction of protein-containing vegetable fillers (Al-Adawi et al., 2016) that improve the quality and taste of products (Phan et al., 2017). Particularly, such additives are used in the production of sausage meat and meat compositions (Lisitsyn et al., 2018). Plant fillers contain various proteins, carbohydrates, a complex of mineral compounds, and fibres. The technology of using plant fillers integrated into sausage production increases the quality of products.

Soy and its derivatives are one of the main additional components in the production of sausages, in particular, protein soy products, as well as soy flour (Kozyrev et al., 2018). At the same time, the issue of the appropriateness of using soybean varieties related to genetically modified organisms (GMOs) in meat products of various manufacturers is becoming increasingly debatable. According to some studies, the consumption of GMO products leads degenerative and irreversible changes in the organs of people, as well as a decrease in reproductive function (Lisitsyn et al., 2017). The search for new plant fillers for meat products with high nutritional and technological indicators is becoming increasingly relevant (BusinesStat, 2020).

The modern meat industry uses orange fibres as plant fillers (product name "CitriFi", manufacturer "Fiberstar Incorporated", USA), in two types – hydrated raw materials and dry mass. The use of this plant filler helped to increase the mass of end product and its

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nutritional value as the fibre contained in it (Khan et al., 2015). Likewise, significantly improves the mechanical and structural parameters of the product adding of up to 2 % of the mass of wheat fibres derivatives (de Almeida et al., 2015). The addition of amaranth seeds in meat products is gaining also popularity. Thus, the products are enriched with proteins and microelements such as iron and selenium. The selenium gives the product not only nutritional, but also medicinal value, and reduces cost (Hautrive et al., 2019).

If sausages have a low fat content, the addition of starch, peas fibre and wheat flour may be effective (Alejandre et al., 2016). The products from leguminous plants known to be rich in minerals (Lee et al., 2015). Legumes flour does not contain GMO, and is not allergenic unlike other plants. The products of the German corporation GeorgBreurer GmbH Food Ingradients have proved to be effective, as they use bean and pea flour having the properties of water and fat binding. Suitable varieties for sausages production are Fabatex 33 and Sativa 32/100 (Baek et al., 2016). The effective use of sprouted lentils in the production of minced beef has been studied and proved in detail (Yum et al., 2018). The lentil seedlings significantly improved the structural parameters of meat systems. Additionally, additives from thyme (as spices) and juniper fruits have proven themselves well. It was found that these additives improved the organoleptic properties of meat products (Utama et al., 2019).

Water in meat products is held by different types of effects, but the nature and strength of those effects vary. The strongest effects are attributed to the adsorption moisture, whereas the least strong effects are attributed to water absorbed by protein systems through hydration. Since the water content affects the economic intensity of food production, it is concerning to both the manufacturer and government agencies that control the quality of food (Alamri et al., 2021).

At present, the water-holding capacity of meat is defined as the ability of meat to retain its own water and/or bind extra water added to a product. The immobilized or bound water is held within a network of muscle membranes and fibers by a net charge attraction and is hard to remove. Free water, which can be found between cells, is loosely bound and thus can be easily separated through common meat processing treatments. This leads to losses of juice during refrigerated storage and defrosting of meat, on the one hand, and facilitates the drying of meat, on the other hand. Depending on the state of muscle proteins, the ratio between immobilized and free water changes. When the amount of immobilized water increases, the amount of free water decreases and vice versa. This affects the water-holding capacity.

Recently, the moisture profile of a product has been characterized not only by water content and water-holding capacity, but also by water activity. This indicator describes the potential of water to participate in chemical/biochemical reactions (such as lipid oxidation, enzymatic and non-enzymatic activity, and hydrolytic reactions) and growth of microorganisms both during the manufacturing process and during storage. Since water activity of the product and relative air humidity are the driving force for weight and moisture exchange during meat treatments and storage, data on water activity are necessary to decide on the best treatment regime. The water activity (aw) represents the ratio of the water vapor pressure of the given food product to the water vapor pressure of pure water under the same conditions.

Some specific characteristics of sausages should be considered. Thus, sausages are popular all over the world due to the combination of several properties. Firstly, they have high nutritional and calorie values (406.96 kcal (or 1703 kJ) per 100 g, the average value for semi-smoked sausages). This amount is ¼ of the protein daily norm and up to half of the fat diet, based on the daily norm of 2000 kcal per 1 day. Secondly, sausages require no initial heat treatment (Wang et al., 2018). A long shelf life is another important property of sausages, which determines the possibility of their transportation over considerable distances without loss of quality. Nevertheless, the quality of sausages largely depends on origin, the breed of cattle, and on the quality of animals diet (Malekian et al., 2014). The quality of an enterprises' technical equipment is also considerably importance. It should be noted that the quality of products depends on the conformity of meat raw materials to generally accepted standards. Particularly, sausages made from imported frozen meat may have low quality, influencing nutritive, organoleptic, structural and mechanical properties of the product (Özbay Özbaş and Ardıç, 2016).

Therefore, despite the number of modern technologies listed above, it is necessary to develop new ones, to increase the efficiency of the semi-smoked sausages production. New recipes should use both a high-quality meat raw materials and food additives in a correct dosage. The use of new additives will reduce the cost of the product, expand the range of sausages offered, improve their quality, and also make the end product healthier due to improved hygiene. Certainly, the regular use of healthy products will positively affect one's physiology.

Kazakhstan is one of the world leaders in meat production due to the large number of cattle. However, Kazakhstan meat industry is not sufficiently developed, despite active use of modern technologies. Therefore, Kazakhstan can be a model territory for modern research on the development and implementation of new technologies to the semi-smoked sausages production.

The study presents a new technology for the semi-smoked sausages production using goji berry powder as an additive. According to ISO 2253, goji berries belong to universal spices containing up to 85% spices in their composition (ISO, 1999). The hypothesis of this study is that the use of goji berries will significantly improve the mechanical, organoleptic and taste qualities of semi-smoked sausages.

Goji berries (Lycium barbarum) come from China, based on dried berries. Goji berries are black (red when dried), have a characteristic smell and nice taste (bitter-sweet flavour), according to organoleptic characteristics. The use of goji berry gives dishes a specific taste and smell. Thus, goji berries have a complex effect on the body, primarily on the digestive and immune, system. We assume that the use of goji berries can decrease the potential carcinogenic effect, that is characteristic of all products obtained by smoking, and significantly reduce the possibility of developing cancer with regular use of semi-smoked sausages. Moreover, the improvement of digestive system will have positive effect on assimilation of a difficult to digest product like semi-smoked sausage. However, goji berries are not recommended for pregnant and nursing mothers.

Additionally, the use of goji berries can solve a number of technological problems – namely, due to its ability to absorb fats and water. At the beginning of the process, water decreases its activity, and sausage with goji berries as an additive will dry faster. Moisture will be more equally distributed from the centre to the periphery of the product, and the fibrous structure of the proposed additives will allow avoiding emulsifier. The fatty taste of sausage will disappear due to its fat absorption property. The main task of the study is to confirm all above hypotheses.

The purpose of the study is to develop and study the technology for the semi-smoked sausages production using goji berries as an additive, to assess the technological risks.

2. Materials and methods

The studies were carried out at the largest the enterprise for the semi-smoked sausages production "Pervomayskiye Delikatesy", in Kazakhstan, 2019.

Study samples were made according to the recipe below (Table 1).

We used the original technique, excluding smoke. As an alternative, we used smokeless method. During the cooking process, the mass of semi-finished products was covered with a thin layer of special liquid smoke. Then, the semi-finished product was subjected to heat treatment at temperatures same for hot smoking.

Samples were divided into 4 groups (Table 1). The first, control group included samples made according to the standard recipe (the "Krakowska" recipe), without goji berries. The remaining three groups had different among of dried goji berries per 100 kg of raw meat.

Animals involved in the production came from the same farm where were kept under the same conditions and given the same food. The sausages were made from frozen meat. Freezing, especially at −6 to −12 °C, kills up to 99% of the microflora.

The composition of all four groups was identical besides goji berries powder amount. There were 100 sausage samples in each group weighing 85 g; the total number of samples studied was 400.

The sausages production was carried out according to the following technology. 1. The acceptance of raw materials – at a temperature of −18 °C. 2. The unfreezing – at temperature of + 22 °C. 3. The grinding of raw meat using a cutter, with simultaneous salting. The process takes 2–5 min, at temperature of + 3 °C. 4. The production of minced meat using a meat mixer at temperature of −2 °C. 5. Simultaneously, the other components were preparing – salts, spices, as well as sausage casing. 6. The stage of manual filling the casing with minced meat with salts and spices. 7. The stage of deposition of raw materials and its structuring in casing. The temperature was 0 °C; deposition time took from 4 to 8 h. 8. The stage of heat treatment. It took 1–1.5 h at temperature of 90 °C. 9. The process of cooling the sausage at a temperature of up to 20 °C for 2–3 h. 10. The final stage is smoking at 70–80 °C for 2–4 h. Then, the products were packaged, labelled and sent for storage. Meanwhile, microbiological control was carried out.

Generally accepted methods for water-holding ability were used for all four groups: a) the water content was measured using PS-VChM Food Moisture Meter (Chizhova's device); b) the water activity was measured using Conway's dish method; c) the water-holding capacity was measured using the Grau Hamm filter paper press.

Statistical data was processed using the Microsoft Excel 2013 (Microsoft Inc., USA). The mean values were calculated for each of the groups, in % and other units of measures. The significant difference was calculated using the two-sample *t*-test; the differences were significant at $p \leq 0.05$.

3. Results

The best physical and chemical indicators were obtained for the 3rd group, which used 50 g of goji berry per 100 kg of raw meat (Table 2).

Table 2
The mean values of the main indicators for the studied samples in 4 groups.

Group	The water content, %	The water activity	The water-holding capacity, %
1	(control)	33.5	0.887
32.0			
2	42.5	0.905	39.8
3	43.4	0.830	41.0
4	42.1	0.730	39.9

According to Table 2, there was a decrease in water activity among experimental samples by 1.2 times comparing to the control ($p \leq 0.05$ between the first and fourth groups). The positive correlation has been noted between an increase of goji berry and a decrease in water activity (Pearson correlation coefficient of 0.87). Consequently, increasing concentration of goji berry contributes to faster drying of sausages.

A similar trend was noted for water-holding capacity. Thus, the control group parameter only slightly differed from the experimental groups (differences are not significant). The significant difference was obtained for the water-holding capacity between control and the 3rd group (by 1.2 times, with $p \leq 0.05$). Thus, sausages production with 50 g of goji berry per 100 kg of raw meat has maximum water-holding capacity. A similar trend is observed for the water content, which is max for the 3rd group (1.3 times more than in the control, at $p \leq 0.05$). Thus, it can be concluded that production with 50 g of goji berry per 100 kg of raw meat is most optimal, as it minimize technological risks (high water activity) and have high water-holding ability, despite the high water content. This contributes to the preservation of a certain supply of moisture, and protection from excessive drying of the product.

Meanwhile, we observed an increase in the solidity of the product, which indicates its best quality. That is due to the moisture and fat retention function that goji berries perform with increasing concentrations. On the other hand, starting from a certain concentration of goji berries, there is a decrease in water content and water-holding capacity.

4. Discussion

The production of sausages should implement the main task of the food industry, namely satisfying the needs of the population. It becomes increasingly difficult to meet the criteria for increasing production (following a growing population) while maintaining quality with years (Serikkaisai et al., 2014). Markets, especially in developing countries, are filled with uncertified and substandard products (Sofi et al., 2017). Sausages of such production will not pass any sanitary-microbiological or organoleptic verification. Therefore, the meat industry is in a constant need of new developments and technologies (Ham et al., 2016). The main problem is

Table 1
Production of semi-smoked sausages according to the original recipe.

Meat raw materials	Concentration (in kg) per each 100 kg of meat materials			
	Standard (control, or 1st group)	2nd group	3rd group	4th group
Trimmed beef, 1st grade	46.0	46.0	46.0	46.0
Chicken fillet	29.0	29.0	29.0	29.0
Broadtail fat	25.0	25.0	25.0	25.0
Additive, g/100 kg of meat materials				
NaCl (sodium chloride)	2650.0	2650.0	2650.0	2650.0
NaCl + $NaNO_2$ (nitrite salt)	8.0	4.0	4.0	4.0
Dried garlic	110.0	110.0	110.0	110.0
Ground black pepper	70.0	70.0	70.0	70.0
Goji berry powder	0	30.0	50.0	70.0

meat substitute additives that can preserve or even improve the taste and physical–mechanical qualities of the product (Sánchez-Zapata et al., 2013). Commonly, new sausage production technologies ends up crating combined products, using plant fillers, and the microelements and vitamins (Ores et al., 2018). Thus, a complex effect is achieved – the product contains a number of useful substances that can offset the carcinogenic risk of smoking, some of the substances may even have a therapeutic effect. Moreover, with reduce of the fat content, a greater emulsification is achieved, which improves the quality of the product (Donskova et al., 2018).

The study proposes a new technology of adding a certain concentration of goji berry to the semi-smoked sausages. The antibacterial properties of goji berry increase the shelf life of sausages.

Recently, along with increased meat prices, a natural decrease in the semi-smoked sausages production has been observed. Firstly, sausages contain less beef, as well as, pork however to a lesser extent. Thus, chicken meat, as well as various offal like pork and chicken skin, salted pork fat, etc. substituted it (Nayeem et al., 2017; Saygi et al., 2018). However, the study didn't consider such aspects, and the recipe was adhered to standard ratios of ingredients. Thus, further studies could be carried out considering the market value of pork and beef meat and its partial replacement with other components.

The study showed that for goji berries (and, possibly, for other spices), there is a limit of 50 g per 100 kg of meat materials, above which there is no significant increase in water-holding capacity and water content. However, there is a decrease in water activity, which ultimately leads to an increase in the shelf life of the product. Applied recipe with the addition of goji berries seems suitable primarily for higher grades of sausages, with the meat content corresponding to the declared one.

One of the most effective ways to prevent microbiological spoilage of food and chemical reactions that can reduce the quality of food during storage is to reducing the water activity of the given food. For this, specific meat treatments can be used, such as drying, seasoning (sugar, salt, etc.), and freezing are.

Ayandipe et al. found that the addition of cassava and coconut composite flour in chicken sausages can increase the protein composition of the product and fatty acid composition (because non-dairy flour was used), increase the elasticity and stickiness of the meat. In addition, coconut flour reduces moisture loss during cooking and freezing (Ayandipe et al., 2020). Goji berries, on the contrary, contribute to faster removal of water. The work of Popescu et al. (2020) indicates that the addition of blueberries and sea buckthorn leads to a decrease in fat content and an increase in the moisture content of the product by 2–2.5 times, but in the present study only by 27%, as the concentration of water in the control is 3 times higher than the control sample in the study of Popescu et al. (2020).

The use of goji berries in sausages has been shown to reduce the peroxide number by 10–20%. It was also found that the berries do not affect the amount of fats, proteins and ash in sausages. At the same time, water removal is reduced by 30%, compared with the control, which is exactly the opposite of the current study results (Mitev et al., 2018).

5. Conclusions

A new technology for the production of semi-smoked sausage adding goji berries powder at a concentration of 0.3, 0.5, and 0.7 % to meat (or 30, 50, 70 g per 100 kg) was proposed and tested. Sausage samples with goji berries showed greater water-holding capacity, but lower water activity (by 1.3 times, with $p \leq 0.05$) compared with the control, which provides better drying. Increased (1.2 times in comparison with the control, at $p \leq 0.05$) water-holding capacity of sausages with goji berries reduces the risk of excessive drying. Histological analysis did not reveal significant structural differences between the experimental and control samples. The addition of goji berries provides solidity to the sausage samples, as well as better organoleptic and structural-chemical properties compared to the control.

There is a need for a more detailed study of the antioxidant properties of goji berries in a similar composition of products. In addition, it is possible to investigate what characteristics of a product of a different composition change when berries are added.

6. Data statement

Data will be available on request.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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