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Study of the chemical composition of carrot powder and its effect on the nutritional value of sausage products

Bahytkul Assenova[1], Eleonora Okuskhanova[1], Farida Smolnikova[1*], Natalia Nikolaeva[2], Kristina Vlasova[2], Alexei Gayvas[3], Sergey Konovalov[3], Dmitry Vorobyev[2], Evgeny Rotanov[2]

[1]Shakarim University of Semey, Semey city, Kazakhstan
[2]K.G. Razumovsky Moscow State University of technologies and management (the First Cossack University), Moscow, Russian Federation
[3]Omsk State Agrarian University named after P.A. Stolypin, Omsk, Russian Federation

smolnikovafarida@mail.ru.

Abstract

Plant ingredients in the formulation of meat products allow enriching with valuable nutrients, which are absent or contained in small amounts in meat raw materials. In this paper firstly, the nutritional value of carrot powder, secondly, its influence on the change of chemical, mineral composition and organoleptic characteristics of sausage products was studied. The studies were performed on 4 variants (V) of sausages with different addition of carrot powder: V1 (0%), V2 (5%), V3 (7%), V4 (10%). In terms of chemical composition, carrot powder contains 19.76 mg/100g protein, 8.55 mg/100g dietary fiber, 2.38 mg/100g fat and 8.38 mg/100g ash. Among the mineral composition, calcium (78.0 mg/100g), magnesium (94.5 mg/100g), and phosphorus (610.0 mg/100g) were prominent. The addition of 7% of carrot powder (V3) to the formulation of the sausage revealed positive changes in the chemical composition of sausage with the addition of. An increase in protein, carbohydrates ($P<0.001$) and ash ($P<0.001$) content was observed, while fat content decreased ($P<0.001$). The amount of potassium ($P<0.01$), calcium ($P<0.01$), magnesium ($P<0.01$), phosphorus ($P<0.01$) increased significantly in the experimental samples compared to the control sample. Organoleptic analysis revealed better characteristics in variant 3 with the addition of 7% carrot powder to the sausage formulation. Thus, the replacement of lamb with carrot powder allows to improve the nutritional and biological value and organoleptic properties of the sausage.

Keywords: lamb, carrot powder, sausage, nitrogen-free extractive substances, mineral

1. Introduction

At present, the market for meat products is represented by a wide variety of products, including meat products combined with plant ingredients. The main purpose of adding plant ingredients is first, to replace meat (as a more expensive ingredient) with a cheaper ingredient (plant raw materials), and second, to enrich with nutrients that are not present in meat (dietary fiber, carbohydrates, vitamins, etc.) [1,2,3]. The deficiency of biologically active components in food leads to the reduction of the human body's resistance to the environment and its effects. To compensate for biologically active components in food, such as vitamins and dietary fiber, there are two ways - the addition of plant foods to daily human diets and the development of new foods enriched

with as natural plant components as possible [4, 5]. The common feature of all dietary fiber is that it is not broken down by human digestive enzymes, but indirectly through stabilization of the medium in the digestive tract, it has a positive effect on various body functions [6, 7].

At the same time, the researchers noted that many such ingredients do not worsen the organoleptic characteristics of meat products. The antioxidant properties of many natural plant ingredients could allow to produce meat products with their addition, preserving high quality for a longer time without significant oxidation of fats and bacterial spoilage effects while retaining functional properties for a longer period of time [8, 9].

Vegetable additives and fillers are widely used in many sectors of the food industry, for example, in the production of canned meat for children. The introduction of carrot powder into the recipe is due to the fact that carrot contains a number of useful substances that are almost absent in animal products: dietary fiber, essential oils, tannins and aromatic substances, organic acids, phytoncides, vitamins C, beta-carotene, calciferol [10, 11]. Carrots contain organic acids that facilitate the absorption of hard-to-soluble compounds of calcium, phosphorus and iron, contribute to the creation of a certain composition of microflora, inhibit the process of putrefaction in the gastrointestinal tract [12, 13].

The positive health effects of carrots are due to their carotenoid (vitamin A) content. Carrots contain several phytochemicals with antioxidant and anti-inflammatory effects that help reduce the risk of heart disease. The antioxidants in variegated carrots work all over the body to help prevent cancer [14, 15].

Carrots are one of the main sources of pectin substances that are known to have detoxifying and radioprotective properties. By the presence of free carboxyl groups, they are able to bind ions of heavy metals (lead, mercury, cadmium, zinc, etc.) in the gastrointestinal tract and form insoluble complexes that are not absorbed and are removed from the body [16]. Vitamin C increases the body's resistance to infections, regulates cholesterol metabolism in the body and functions of the endocrine and nervous systems. In addition, vitamin C and beta-carotene are natural antioxidants that can destroy free oxidative radicals generated when the body is exposed to various damaging factors [17, 18]. The addition of carrot powder to the recipe enriches the product with natural vitamins, and also makes it possible to partially reduce the amount of sodium nitrite in the recipe due to the content of the coloring pigment β-carotene.

The purpose of this work is to study the chemical composition of carrot powder and its effect on the chemical and mineral composition and organoleptic characteristics of sausage products.

2. Materials and Method

2.1. Preparation of carrot powder

Pre-weighed carrots were washed and grinded to a homogeneous mixture. Then dried at 100 - 105 ° C for 90 minutes and crushed to a fine powder.

2.2. Method of preparation of cooked sausage

Beef and lamb, as well as lamb fat, are ground on a grinder with 2 mm hole diameter, mixed with salted agents, kept at 4 ° C for 10 hours. Then the carrot powder is added and the stuffing is made according to the recipe (Table 1).

Table 1. Recipe of cooked sausage with carrot powder, %

Ingredient	Variants of sausages			
	V1	V2	V3	V4
Beef	48	48	48	48
Lamb	44	39	37	34
Lamb fat	7	7	7	7
Carrot powder	0	5	7	10
Garlic	0.2	0.2	0.2	0.2
Sugar	0.2	0.2	0.2	0.2
Salt	0.4	0.4	0.4	0.4
Black pepper	0.1	0.1	0.2	0.1

The process of cutting is carried out for 8-15 minutes, then ready-made stuffing is squeezed, the sausage links, then carry out heat treatment, depending on the diameter of the sausage - frying at 50-120 ° C for 60-80 minutes until the temperature in the center of the sausage is 40 ° C. Steamed sausages are cooked in a steam cooker at 70-75 °C until they reach a temperature of 70 °C in the center.

The finished sausages are cooled to a temperature of 0 °C. The shelf life and sales of cooked sausages at 0 to 6 ° C and relative humidity (75 ± 5%) % shall not exceed 72 hours from the end of the technological process.

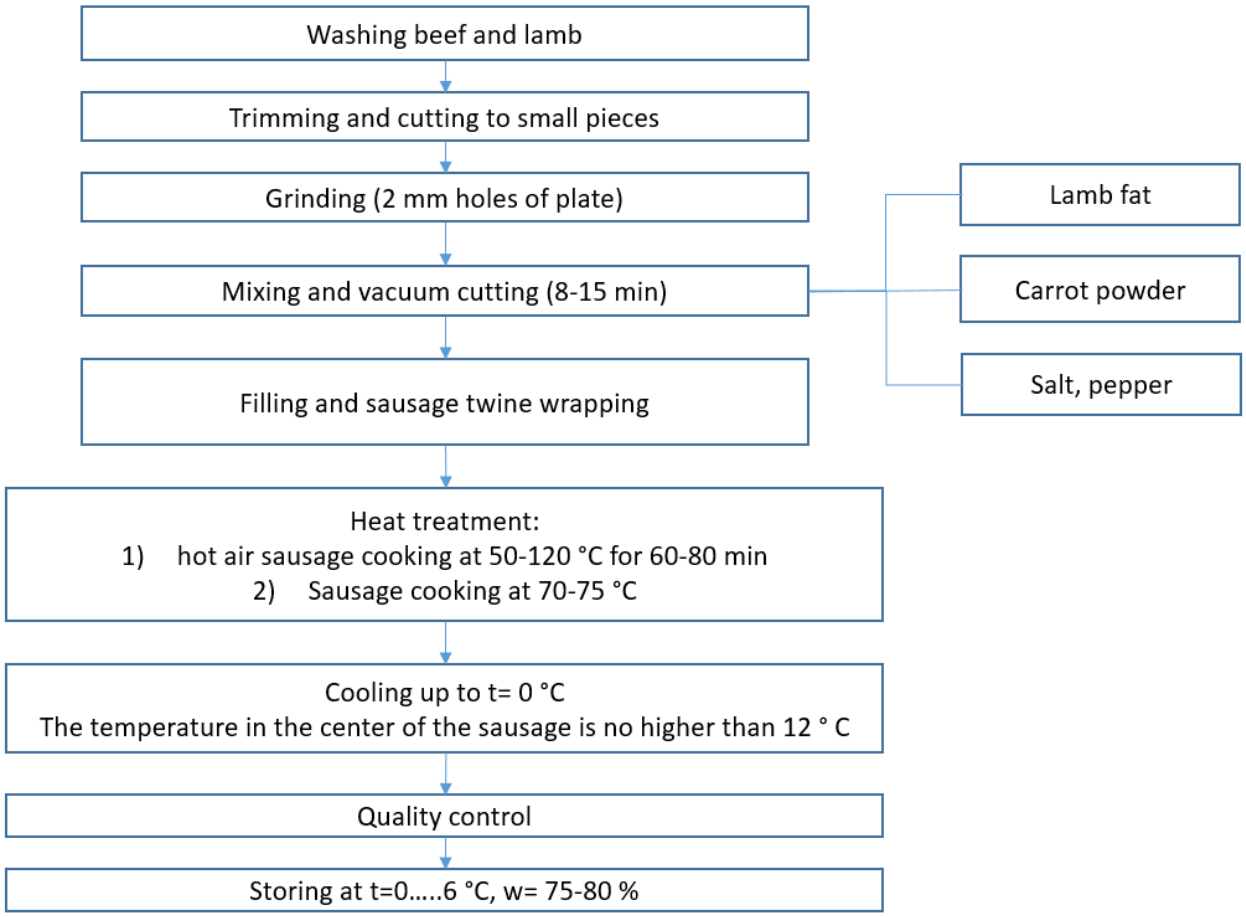

Figure 1. Technological flowchart of production of cooked sausage with carrot powder

2.3. Determination of the chemical composition

Determination of the mass fraction of moisture was performed by dehydration of the sample in a drying oven at 105 ± 2 ° C to constant weight [19].

A sample weight of 3-5 g taken with an accuracy of 0.0002 g is placed in a pre-weighed beaker and dried in a drying oven at t 100-105 C until a constant mass of the dried sample is established, i.e. until two subsequent weighings of the sample have almost the same mass. The difference in weight between two subsequent weighings should be no more than 0.001 g.

The mass fraction of moisture W (%) is calculated according to the formula:

$$\mathbf{W} = (m_1 - m_2)\ /100/(m_1 - m) \qquad (1)$$

Where: W is the moisture content (%), m_1 is the weight of the sample with cup before drying (g), m_2 is the weight of the sample with cup after drying (g), m is the weight of the cup alone (g).

2.4. Determination of mineral elements

The content of elements in samples was determined with the inductively coupled plasma–mass

spectrometric method (ICP-MS, Varian-820 MS, Varian Company, Australia). The method was validated with certified reference materials. Calibration standards Var-TS-MS, IV-ICPMS-71A (Inorganic Ventures Company, USA) were used for calibrating the mass-spectrometer. The sensitivity of the mass-spectrometer was tuned up using a diluted calibration solution Var-TS-MS with concentration of Ba, Be, Ce, Co, B, Pb, Mg, Tl, Th of 10 µg/L. Three calibration solutions were used for the detector calibration. They were IV-ICPMS-71A of Cd, Pb, Cu, Zn elements diluted to 10, 50 and 100 µg/L. Discrepancies between the certified values and concentrations quantified were below 10 %. The operating parameters of the inductively coupled plasma mass spectrometer Varian ICP 820–MS were as follows: plasma flow 17.5 L/min; auxiliary flow 1.7 L/min; sheath gas 0.2 L/min; nebulizer flow 1.0 L/min; sampling depth 6.5 mm; RF power 1.4 kW; pump rate 5.0 rpm; stabilization delay 10.0 s.

All analyses were performed in triplicate, and the results are presented in Table 1 as the means of measurements expressed in mg/kg wet weight [20].

2.5. Statistical analysis

Statistical analysis was performed using Statistica 12.0 (STATISTICA, 2014; StatSoft Inc., Tulsa, OK, USA). The differences between samples were evaluated using ANOVA method. The differences were considered to be statistically significant at $p \leqslant 0.05$.

3. Results

The chemical composition of the carrot powder under study (Table 2) presents a rich content of essential nutrients. Thus, the protein content was 19.76 mg/100g, which is equal to the protein content of meat. The content of ash up to 8.38 mg/100g indicates a rich mineral composition. Total dry matter in carrot powder is 87.34 mg/100g, including nitrogen-free extractive substances (48.27 mg/100g), fiber 8.55 mg/100g.

Table 2. Chemical composition of carrot powder, mg/100g

Indicator	Content
Protein	19.76
Fat	2.38
Fiber	8.55
Dry matter	87.34
NFES (nitrogen-free extractive substances) incl. sugar	48.27 2.47
Ash	8.38

In terms of mineral composition, carrot powder is rich in phosphorus (610 mg/100g), magnesium and calcium (78.0 mg/100g) (Table 3).

Table 3. Mineral composition of carrot powder, mg/100g

Element	Content
Calcium	78.0
Phosphorus	610.0

Magnesium	94.5
Copper	0.98
Zinc	1.06
Manganese	4.03
Cobalt	0.015
Chrome	0.015
Iron	0.653
Cobalt	0.0015
Nickel	0.009
Lead	0.086
Selenium	0.0032

At the next stage of research the effect of carrot powder on the change of chemical and mineral composition of sausages with different content of carrot powder was studied. The results of chemical composition determination (Table 4) show a significant change of carbohydrate content in the experimental samples with the addition of carrot powder. Due to the high content of carbohydrates in carrot powder significantly increased ($P<0.001$) in variants 2, 3 and 4. In addition, the amount of ash and protein also increases. Ash increases from 1.13% (variant 1) to 1.68% (variant 4). The content of fat and moisture decreases with increasing amount of carrot powder in the sausage. Thus, while the fat content in the control sample (variant 1) was 15.25%, in variants 3 and 4 significantly decreased ($P<0.05$) to 13.92% and 13.55%, respectively.

Table 4. Chemical composition of cooked sausages with different amounts of carrot powder, %

Indicator	V1	V2	V3	V4
Moisture	66.52±1.61	63.37±1.91	62.11±1.73	60.22±1.55*
Protein	16.91±0.32	17.91±0.43	18.16±0.34	18.44±0.35*
Fat	15.25±0.34	14.16±0.39	13.92±0.25*	13.55±0.34*
Ash	1.13±0.01	1.30±0.03*	1.45±0.03**	1.68±0.03**
Carbohydrate	0.190±0.001	3.27±0.08**	4.36±0.09**	6.11±0.12**

*P<0.05; **P<0.001

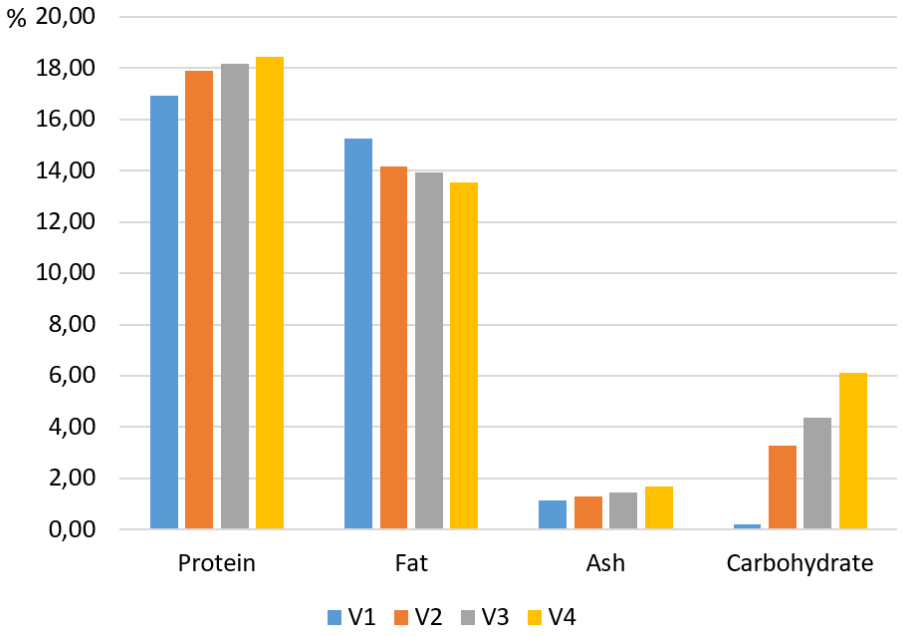

Figure 2. Variation of the chemical composition of sausage products depending on the amount of carrot powder.

Because of the rich content of minerals in carrot powder therefore the content of some elements increases when adding it to the sausage recipe. The addition of 7% carrot powder (variant 3) significantly increases the content of potassium (P<0.01), calcium (P<0.001), magnesium (P<0.01), phosphorus (P<0.01), manganese and copper (P<0.001) (Table 5). It should be noted a decrease in the concentration of sulfur, sodium and zinc in the experimental variants.

Table 5. Mineral content in sausage with carrot powder, mg/100g

Element	Variants			
	V1	V2	V3	V4
Potassium	295.72±3.17	324.07±5.77*	335.41±6.88*	352.42±7.29**
Calcium	18.20±0.35	21.60±0.23**	22.96±0.46**	25.00±0.39**
Magnesium	22.10±0.32	23.65±0.49	24.27±0.29*	25.20±0.53*
Sodium	66.99±1.56	65.44±0.93	64.82±1.28	63.89±1.47*
Sulfur	179.14±3.87	170.89±2.82	167.59±2.53*	162.64±2.98*
Phosphorus	178.64±3.23	199.99±3.75*	208.53±3.85*	221.34±4.48**
Iron	1.75±0.04	1.79±0.03	1.81±0.04	1.83±0.02
Manganese	0.020±0.001	0.220±0.004**	0.300±0.007**	0.420±0.009**
Copper	0.140±0.002	0.180±0.002*	0.190±0.004**	0.210±0.003**

Selenium	0.020±0.001	0.030±0.001	0.040±0.001*	0.050±0.001*
Zinc	3.23±0.05	3.14±0.03	3.10±0.04	3.05±0.04

*P<0.01; **P<0.001

According to the organoleptic evaluation the highest total score was for variant 3 (with the addition of 7% carrot powder). This variant has better consistency, appearance, color, odor, taste and juiciness. The surface is clean, dry, with no damage to the shell. When cutting the sausage, it is visible that the pink stuffing is evenly mixed, has a homogeneous consistency. Smell and taste typical of this type of product with aroma of spices, slightly sweet. The addition of carrot powder in an amount greater than 7% does not worsen the taste and smell of the sausage, but affects the consistency: the powder can be sensed in the mouth when chewed.

Table 6. Organoleptic analysis of cooked sausages

Variant	Score (maximum 5 points)							Total points
	Appearance	Consistency	Sectional view	Colour	Odour	Taste	Juiciness	
Control Variant 1 (0% CP)	4,7	4,8	4,7	4,8	4,4	4,6	4,2	32,2
Variant 2 (5% CP)	4,7	4,8	4,6	4,8	4,5	4,6	4,3	32,3
Variant 3 (7% CP)	4,8	4,8	4,6	4,9	4,7	4,8	4,6	33,2
Variant 4 (10% CP)	4,7	4,5	4,5	4,8	4,6	4,7	4,6	32,4

4. Discussion

The strategy concept of food production is to find new resources of micronutrients, the use of non-traditional types of raw materials, the development of new technologies to improve the nutritional and biological value of the product, to provide it with given properties, to increase shelf life [21, 22]. The use of carrot powder in the recipe of a meat product has its advantages. Firstly, the drying of plant foodstuffs removes most of the moisture, increases the concentration of cell juice and raises the osmotic pressure several times, which makes it impossible for the microflora growing. Secondly, plant powders are well assimilated by the body and serve as an important source of energy, since carbohydrates (fructose and glucose) have a major portion in their composition [23, 24].

The effectiveness of the integrated use of various types of animal and plant ingredients is determined by their functional and physicochemical properties that predetermine the degree and nature of the interaction of introduced proteins with other components, such as protein-protein, protein-water, protein-fat [25, 26].

Adding carrot powder to the recipe gives a sausage that contains carbohydrates (3,27 -6,11 %) and reduces the fat content (up to 13,55 %). The fat lowering is a positive fact, while the presence of carbohydrates in the meat system does not cause undesirable effects. The presence of dietary fiber in the sausage has a beneficial effect on the metabolism of carbohydrates, fats in diabetes, cholelithiasis, the prevention of many diseases of

the colon, the cardiovascular system [27].

In the work [28] when adding 4% carrot powder to the recipe of meat pâtés the protein and fat content was 19.7% and 12.57%, respectively. At the same time, the authors note the same trend of increasing protein and decreasing fat as obtained in this work. In the work [29] the authors studied the effect of adding dried carrot fiber on the nutritional value of meat semi-finished products. According to the results it was found that the content of protein, fat and carbohydrates was 14.2%, 22.3% and 7.4%, respectively, when adding up to 20% of carrot fiber. The carrot fiber has an antioxidant effect. The ability of carrot fiber to absorb significant amounts of water makes them effective for use as a stabilizer of the minced meat structure during the manufacture of products containing hydrated animal and vegetable proteins and emulsions [30].

Conclusion

Thus, a method of preparation of cooked sausage with improved nutritional and biological value and good organoleptic indicators was developed. Adding carrot powder in an amount of 7% enriches the sausage with carbohydrates, dietary fiber, reduces the amount of fat and moisture, compensating them by increasing the amount of protein and minerals.

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Conflict of interest

The authors declare that there is no conflict of interest.

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