KnE Life Sciences

BRDEM-2019
International applied research conference
«Biological Resources Development and Environmental Management»
Volume 2020

Knowledge E
enriching | engaging | empowering

Conference Paper

Developing New Foodstuffs Using Microwave-cooked Cod Liver and Its Oil

Olga Kovaleva, Christina Dvoryankina, and Vasily Volchenko

Department of Food Production Technology, Murmansk State Technical University, Murmansk, Russia

Abstract

The non-sterilized cooked cod liver has been used as a novelty in the technology of culinary and making of sausage products. This cod liver has been cooked using microwave processing. The semi-finished cod liver oil separated during such microwave treatment has been also used for preparing such production. As for cooked boiled sausages, pork heart and venison have also been used in the composition with a view to enrich the nutritional value.

Keywords: Microwave cooking, cooked sausage, microwave cooked cod liver, semi-finished cod liver oil, complex quality estimation.

Corresponding Author:
Olga Kovaleva
sh1molga@yandex.ru

Received: 24 December 2019
Accepted: 9 January 2020
Published: 15 January 2020

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the BRDEM-2019 Conference Committee.

1. Introduction

Nowadays the efforts of specialists of the food industry are aimed at producing foods balanced by biological value but still having traditional customer characteristics [1, 2]. Cod liver (with or without heat treatment) is a source of fish oil. Cod liver contains up to 70% (and sometimes even more) of oil and some amount of protein (which is not significant) [3]. Cod liver should be recommended for prophylactic and even therapeutic nutrition due to the high levels of indispensable omega-3 fats, fat soluble vitamins A, D, E, and some water-soluble B vitamins (including folic acid) [4, 5].

Pork heart, which was also included into formulation of sausage, contains high content of essential amino acids like threonine, leucine, lysine, and tryptophan [6]. Moreover, it contains all the macro elements and the full complex of vitamins PP, E, A, C, and B. Thus, nutritionists often recommend this product in case of anemia or a low level of hemoglobin [7, 8].

Venison added in the formulation of sausage contains valuable proteins, vitamins B, and PF [9]. Its anatomical structure is more tender than that of the beef, it contains low cholesterol, and it is more digestible in the gastrointestinal tract [10].

Green leaves of onion contain sugars, proteins, phytoncides, and vitamins. Rice is rich with vitamins B (including folic acid), vitamin E and polysaccharides (which can satisfy the human with food for a long time as well as provide with energy). The egg whites are a source of ovalbumin and some other easily digestible proteins.

Using the cod liver oil as a fatty fraction in making the sausage is relevant, and using microwave-cooked cod liver in culinary products is a novelty in developing the products of public catering [11, 12].

2. Methods and Equipment

Microwave cooking of cod liver for making culinary products and sausages was provided at the specific power of 2000 W/kg for the period of 3 minutes.

The fatty acid composition of lipids of culinary products with cod liver and sausages with cod liver oil extracted during microwave cooking was determined by high performance liquid chromatography (HPLC) method [13]. The sample of lipids was previously processed using saponification [14].

Water content in sausages and culinary products was determined using device for drying food samples (analogue of Chizhova's device). Salt content was determined using Mohr's method (argentometric method). Content of lipids was determined using Soxhlet's method. Protein content (and total nitrogen amount) was determined using Kjeldahl method. The amount of starch was determined using the ferrocyanide method of hot titration [15].

3. Results

The new formulation of the sausage cooked with pork heart, venison, and cod liver oil has been developed (Table 1). The formulations of zrazy and salad with microwave-cooked cod liver have also been developed (Tables 2, 3).

The results of studying of culinary product with microwave-cooked cod liver and cooked sausages with semi-finished cod liver oil, pork heart, and venison are shown in Table 1.

Finished sausage product has a nice smell, its texture is elastic and it has a rather salty taste. The cross-section of sausage shows that the mince is mixed equitably from dark pink colour into pink.

Table 1: Formulation of sausage with cod liver oil.

Ingredients	Quantity, kg/100 kg non-salted raw materials
Venison (chilled, 1st grade)	30
Pork heart (chilled)	20
Semi-fatty pork (chilled)	50
Cod liver oil (semi-finished, after microwave cooking)	3
Egg yolks	3
Dried milk	2
Salting mixture (with sodium nitrite), 0.6%	2
Spices extract	0.85
Yield	110.85

Table 2: Formulation of zrazy with microwave-cooked cod liver.

Ingredients	Unit of measuremer	Gross weight	% of wastes during cold processing	Net weight	% of wastes during thermal processing	Finished product weight
Microwave cooked cod liver	kg	0.312	19	0.253		0.253
Chicken egg	kg	0.061		0.061	13.1	0.053
Potato	kg	1.178	41	0.695		0.695
Salt	kg	0.014	2	0.014		0.014
Bread crumbs	kg	0.080	2	0.078		0.078
Vegetable oil	kg	0.093	12	0.082		0.082
Yield						1

The central composite rotatable plan of two-factor experiment has been used to optimize the formulation of zrazy with cod liver. The following regression equation was obtained as the result of experiments by this plan:

$$Y = a + \frac{b}{X_1} + \frac{c}{X_1^2} + d \cdot \ln X_2 + e \cdot \ln X_2^2 + f \cdot \ln X_2^3 + g \cdot \ln X_2^4$$

where a=4640; b = 120.5; c= --21.92; d=7673; e=4584; f=1191; g= 113.7 -- regression coefficients.

F-ratio of this equation is 53.9 which proves the adequacy of the regression equation with the probability level of 0.95 or higher. The response surface is shown in Figure 1.

The analysis of this equation made it possible to find an optimum which corresponds the dosages of ingredients in the formulation presented in Table 3.

The sensory estimation has been used to develop the formulation of the salad with microwave-cooked cod liver. This estimation has been carried out using the unify estimation points method; the result of this method is a sensory score (from 0 to 100

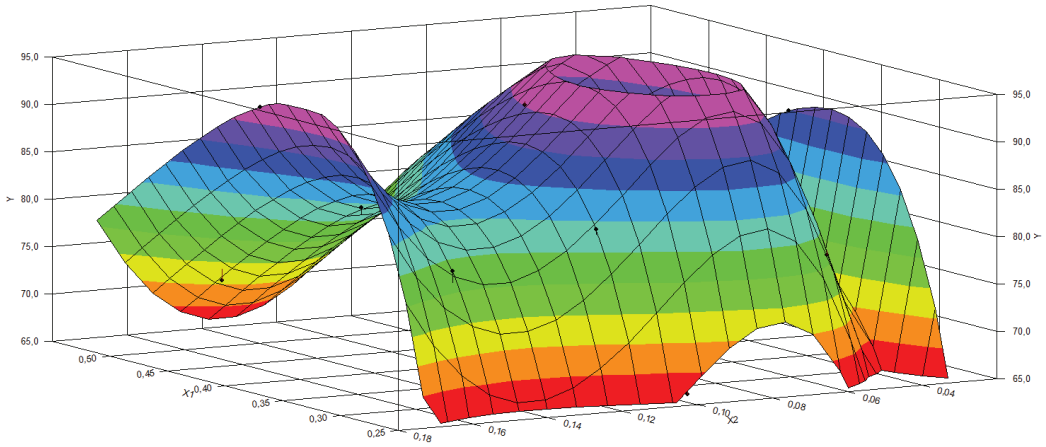

Figure 1: Response surface of zrazys' composition optimization.

Table 3: Formulation of salad with microwave-cooked cod liver.

Ingredients	Units of measure-ment	Gross weight	% of wastes during cold processing	Net weight	% of wastes during thermal processing	Finished product weight
Microwave cooked cod liver	kg	0.469	19	0.390		0.390
Green onion	kg	0.078	10	0.070		0.070
Boiled chicken egg	kg	0.346		0.346	13.1	0.301
Rice	kg	0.089		0.089	-175	0.245
Salt	kg	0.006	2	0.005		0.005
Yield						1

%). The sensory score for this formulation has been 89.76 %, which shows optimal and successful variation of ingredients for salad.

Table 4: Chemical composition of culinary products and cooked sausage.

Characteristics	Salad	Zrazy	Sausage
Water content,%	53.95	56.59	69.76
Salt content, %	1.06	1.54	2.2
Lipid content,%	22.35	17.42	5.33
Total nitrogen (TN),%	0.74	1.57	3.44
Raw protein, % (TN·6.25)	4.62	9.81	21.5

The studies also shown that starch content in the salad has been 6.34 % and 16.87 % in zrazy. The digestibility of the protein in the salad with the microwave-cooked cod liver is from 46 to 49 %, and in zrazy -- from 33 to 35 %.

The sausage contains 21.5 % of protein which is almost twice more than that of other cooked sausages available on Russian market (10-12 %).

Table 5: Fatty acids concentration units in 100 g of sausage and culinary products.

Fatty acid	Concentration in zrazy	Concentration in salad	Concentration in a boiled sausage product
Octadecatrienoic	0.27	0.53	0.01
Eicosapentaenoic (EPA)	0.89	1.92	0.36
Linolenic	0.11	0.25	0.05
Docosahexaenoic (DHA)	1.20	2.61	0.34
Docosapentaenoic	0.05	0.12	0.01
Palmitoleic	0.39	-	0.26
Myristic	0.68	2.58	0.13
Linoleic	2.16	1.42	0.45
Palmitic	1.27	2.93	1.09
ОлеиНовая	2.90	5.53	1.69
Oleic	0.29	0.64	0.93
Gadoleic	0.98	2.27	-
Erucic	0.66	1.55	-

Results of physical and chemical studies have proved that the finished products have high nutritional value due to using all nutrients from the raw materials.

Moreover, the fatty acid composition of the cooked sausage and the culinary products has been determined in the current research which is presented in Table 5.

Results of fatty acid composition analysis shown in Table 5 say that the new functional products contain more omega-3 polyunsaturated fats (PF) such as EPA, DHA, and less omega-6 PF such as linolenic. This is one more proof that the developed culinary and sausage products are functional and balanced food supplies.

The next stage was the developing a complex quality estimation scale for the new functional production. The qualimetric method has been used for developing such a scale which made it possible to include the results of both objective and subjective methods. Thus, the complex quality estimation scales have been developed for the culinary products with microwave-cooked cod liver as well as the boiled sausage products (Tables 6-8).

Data from Tables 6-8 has been used to calculate the complex quality indices which appeared to be: for the salad -- 0.786; for the zrazy -- 0.844; for the sausage -- 0.812. This is a good proof of quite high quality of the developed products.

TABLE 6: Complex quality estimation scale for functional culinary fish product ``Salad with microwave-cooked cod liver''.

Group of consumer properties (quality indicators)	Group significance coefficient	In-group quality indicators	In-group significance coefficient	Etalon value
Safety record	1.0	QMAFAnM, CFU/g, not higher	1.0[1]	$1 \cdot 10^4$
		Coliforms, in 1 g	1.0[1]	Not acceptable
		S. aureus, in 1 g	1.0[1]	Not acceptable
		Pathogens, incl. salmonella in 25 g	1.0[1]	Not acceptable
		Proteus, in 0.1 g	1.0[1]	Not acceptable
Sensory indicators	0.4	Taste	0.15	10 points
		Odor	0.15	10 points
		Texture	0.1	10 points
		Appearance	0.3	10 points
		Extraneous inclusions	0.3	10 points
Nutritional Status indicators	0.4	Protein content	0.33	1.5 % from daily consumption
		Lipid content	0.33	10 % from daily consumption
		Omega-3 PUFA content	0.34	40 mg %
Physico-chemical properties	0.15	Salt content	0.3	1 %
		Fat content	0.7	22 %
Aesthetic and other qualities	0.05	Form of customer package	0.7	10 points
		Net weight of customer package	0.3	10 points

[1] means unconditional requirement of MPC, even if only one of characteristic does not fit, the following estimation has no sense.

4. Discussion

Finished culinary products and cooked sausage prepared using optimal formulation have pleasant sensory indicators which are typical of such production. The microwave-cooked cod liver and the freshly separated cod liver oil (rich in omega-3 PF) have great biological values and positive sensory characteristics of the finished product including smell, taste or after-taste.

Table 7: Complex quality estimation scale for functional culinary product ``Zrazy with microwave-cooked cod liver''.

Group of consumer properties (quality indicators)	Group significance coefficient	In-group quality indicators	In-group significance coefficient	Etalon value
Safety record	1.0	QMAFAnM, CFU/g, not higher	1.0[1]	$1 \cdot 10^4$
		Coliforms, in 1 g	1.0[1]	Not acceptable
		S. aureus, in 1 g	1.0[1]	Not acceptable
		Pathogens, incl. salmonella in 25 g	1.0[1]	Not acceptable
Sensory indicators	0.4	Taste	0.15	5 points
		Smell	0.15	5 points
		Texture	0.1	5 points
		Appearance	0.3	5 points
		Extraneous inclusions	0.3	5 points
Nutritional Status indicators	0.4	Protein content	0.33	1.5 % from daily consumption
		Lipid content	0.33	10 % from daily consumption
		Omega-3 PUFA content	0.34	30 mg %
Physico-chemical properties	0.15	Salt content	0.3	1,5 %
		Fat content	0.7	20 %
Aesthetic and other qualities	0.05	Form of customer package	0.7	5 points
		Net weight of customer package	0.3	5 points

[1]means unconditional requirement of MPC, even if only one of characteristic does not fit, the following estimation has no sense.

5. Conclusion

The developed products are excellent nutritive sources of omega-3 and omega-6 fats. Zrazy and the salad made with the microwave-cooked cod liver and the cooked sausages with the cod liver oil are enriched with PF which is proven by experimental results (fatty acid composition), which make it possible to relate them to ``the functional products''. The particular compositions of raw materials for producing the cooked sausage and the culinary products are close to be optimal. The omega-3 to omega-6 ratio is even more than recommended due to using the cod liver and its oil in the formulations. These new kinds of products have the prophylactic and dietary properties and the good sensory characteristics. Calculating the complex quality indices has made

Table 8: Complex quality estimation scale for sausages with pork heart and cod liver oil.

Group of consumer properties (quality indicators)	Group significance coefficient	In-group quality indicators	In-group significance coefficient	Etalon value
Safety record	1.0	QMAFAnM, CFU/g, not higher	1.0*	$1 \cdot 10^3$
		Coliforms, in 1 g	1.0*	Not acceptable
		Sulphite-reducing clostridia, in 0.01 g	1.0*	Not acceptable
		S.aureus in 1 g	1.0*	Not acceptable
		Salmonella, L.monocitogenes in 25 g	1.0*	Not acceptable
		Toxic elements: lead, no more than	1.0*	0.5 mg/kg
		Arsenic		0.1 mg/kg
		Cadmium		0.05 mg/kg
		Mercury		0.03 mg/kg
		Pesticides, no more than	1.0*	0.1 mg/kg
		Antibiotics	1.0*	Not acceptable
		N-nitrosamines, no more than	1.0*	0.002 mg/kg
		Dioxins, no more than	1.0*	0.000001 mg/kg
Sensory indicators	0.5	Taste	0.5	2.5 points
		Smell	0.15	2.5 points
		Texture	0.2	2.5 points
		Appearance	0.15	2.5 points
Nutritional Status indicators	0.35	Protein content	0.5	20 %
		Fat content	0.5	10 %
Physico-chemical properties	0.1	Salt content	0.3	2.5 %
		Sodium nitrite	0.2	0.005%
		Residual Acid Phosphatase Activity	0.10	0.006%
		Water holding capacity, %	0.15	55%
		Aldehyde value	0.05	1 mg / 100 g
		Peroxide value	0.05	1 mmol ½ O/kg
		Amine nitrogen (AN)	0.05	0.5 mg/100 g
		Volatile fatty acuds	0.05	0.5 mg KOH (up to 4)
		Iodine value	0.05	70%
Aesthetic and other qualities	0.05	Form of customer package	0.5	5 points
		Net weight of customer package	0.5	5 points

* - means unconditional requirement of MPC, even if only one of characteristic does not fit, the following estimation has no sense.

it possible to conclude that all these products are competitive on food markets, and they are rich in omega-3 PF.

Funding

This work was carried out with the help of the Russian Science Foundation, project 16-16-00076.

Acknowledgement

The authors would like to thank their colleagues for their contribution and support of the research. They are also thankful to all the reviewers who gave their valuable inputs to the manuscript and helped in completing the paper.

Conflict of Interest

The authors have no conflict of interest to declare.

References

[1] Powers, M., Scheule, B., Israeli, A., Gordon, K., Powers, M. (2017). College students' health attitudes, perceptions of restaurant menu items, and purchase intentions. *Journal of Foodservice Business Research,* vol. 20(4), pp. 464 -- 488

[2] Rebezov, M., Zinina, O. (2015). Functional-techno-logical indices of combined meat minced halffinished goods from the ferment raw material. 7th International Symposium on Recent Advances in Food Analysis. Prague: Prague Press, p. 363.

[3] Blasbalg T., Hibbeln J., Ramsden C., Majchrzak S. et al. (2015). Changes in consumption of omega-3 and omega-6 fatty acids in the United States during the 20th century. *Am. J. Clin. Nutr.*, vol. 93, pp. 950-962.

[4] Gruenwald, J., Graubaum, HJ., Harde, A.(2002). Effect of cod liver oil on symptoms of rheumatoid arthritis. *Advances in Therapy,* vol. 19(2), pp. 101-107.

[5] Ormarsson, O., Geirsson, T., Bjornsson, E., Jonsson, T., Moller, P., Loftsson, T., Stefansson, E. (2012). Clinical Trial: Marine Lipid Suppositories as Laxatives. *Marine Drugs*, vol. 10(9), pp. 2047-2054.

[6] Seong, P. et al. (2014). Characterization of Edible Pork By-Products By Means of Yield and Nutritional Composition. *Korean Journal for Food Science of Animal Resources*, vol. 34(3), pp. 297-306.

[7] Decker E., Park Y. (2015). Healthier meat products as functional foods. *MeatSci.*, vol. 86, pp. 49-55.

[8] Irshad, A., Sharma, B. (2015). Abattoir By-Product Utilization for Sustainable Meat Industry: A Review. *Journal of Animal Production Advances*, vol. 5(6), pp. 681-696.

[9] Keeton, J. (1994). Low-fat meat products - technological problems with processing. *Meat Science*, vol. 36(1-2), pp. 261-276.

[10] Ireland T. (2017). The artificial meat factory - the science of your synthetic supper. *Manufacturing meat in vitro*, pp. 3-6.

[11] Richter Reis, F. (2017). Novel Blanching Techniques. In: Richter Reis F. (eds) New Perspectives on Food Blanching. *Springer, Cham*.

[12] Jacobsen, C., Skall Nielsen, N., Frisenfeldt Horn, A., Moltke Sorensen, A-D. (2013). Food Enrichment with Omega-3 Fatty Acids. *Woodhead Publishing*. ISBN: 978-0-85709-428-5

[13] Gratzfeld-Huesgen, A. (1997). Analysis of hydrolyzed fatty acids in dietary fat using HPLC. *Agilent technologies*, Publication number 5966-0635E, p. 2.

[14] Chakrabarty, M. (2003). *Chemistry and Technology of Oils and Fats*. Allied Publishers Pvt. Ltd. ISBN: 81-7764-495-5

[15] Ilievska, B., Loftsson, T., Hjalmarsdottir, M., Asgrimsdottir, G. (2016). Topical Formulation Comprising Fatty Acid Extract from Cod Liver Oil: Development, Evaluation and Stability Studies. *Marine Drugs*, vol. 14(6), p. 105.