Variety of canned pastes from cod and its liver with improved quality

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Abstract. A series of canned pastes based on cod and its liver has been developed by choosing and optimizing its formulation. There are canned pastes from cod with mustard sauce and sour cream, from cod liver and carrot, from cod liver, vegetables and mushrooms, from cod liver and chicken meat. The chemical and fatty acid compositions of last paste have been determined, they have shown ratio of ω-3 to ω-6 about 1:2.5 which can have preventive and therapeutic effect.

1 Introduction

Fish products are very popular due to both their pleasant flavour and high nutrition value; some of them contains a high content of valuable substances [13]. One of the ways of fish and marine products processing is producing canned pastes [14]. This way is mostly actual for raw material with not very pleasant appearance but without other defects. So, it is reasonable to improve the assortment of canned pastes from fish raw materials. Canned foods are safe, convenient, and can store for a long time [6].

One of the well-known fish is cod. Cod (*Gadus morhua*) is one of the white fishes with valuable meat rich in proteins. Despite cod is widely used in the form of fillets or pieces, sometimes it is reasonable to produce minced cod (for example, from residues, from damaged fillets, from cuts, etc.). To improve the quality characteristics of the minced product, it can be reasonable to add other ingredients (e.g., sour cream, sauce, garlic, mustard, etc.), to improve the taste by using semi-smoking, and to produce the canned pastes from these raw materials.

Among the whole series of by-products of cod cutting, liver is very valuable ingredient. Despite some potential safety expectations [11], the cod liver contains potentially dangerous substances in quite low amount, and safe for normal diet [12], especially if it is consumed not in very large amounts daily (as usual). Using cod liver in a human diet is especially important for maintaining health due to its high content of ω-3 polyunsaturated fatty acids (PUFA) [1], [2]. ω-3 and ω-6 PUFA have multiple positive effects on different systems of the human organism, especially being essential for decreasing the risk of cardiovascular diseases [3]. The exact optimal ratio between these valuable nutrients is under the consideration of different scientists [3], [4], [5], but the most common opinion about this ratio

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is that it should be from 1:4 to 4:1. The common diet of a continental person is commonly less balanced and includes much more ω-6 PUFA than ω-3 ones. So, including components rich in ω-3 PUFA is very reasonable.

The main source of ω-3 PUFA for the diet is fish and marine products. As for fish, oil rich in ω-3 PUFA can be found both in muscle tissue and in by-products. Meat from oily fish is commonly used in different food technologies, but it is not so easy to save ω-3 PUFA from hydrolysis and oxidation. As for by-products of fish processing, the most common source of ω-3 PUFA is liver, mostly cod liver [1]. Cod liver oil is a very well-known food additive and (sometimes) medical preparation, but it is not always optimal to use it after common storage. It is known that commercially used cod liver oil has an unpleasant smell that can either be masked or blocked by using it in encapsulated form. It is also unstable; due to its rapid oxidation, toxic products are formed, and some steps must be taken to prevent this process [7]. As a contrast, cod liver itself (if it is fresh, or chilled for 2-4 days, or sterilized and stored up to 2 years) has quite pleasant smell despite containing about 60-70 % of fish oil.

So, it could be reasonable to either use the processed cod liver itself or to obtain oil from it and use it just after extraction. The first way is quite common in former USSR countries (and some other ones), as there was a widespread canned food called “natural cod liver”. But this canned food is not the only way to use cod liver, and even it could not be optimal for a human diet due to its extremely high oil content. Even though this oil is extremely healthy in small amounts, it could result in problems if overconsumed (for example, eating the full content of one can of 230 g for a time for one or even two people is not so healthy). So, it could be better to decrease the oil content in the foodstuffs based on the cod liver [5].

Another problem with excess oil content in the raw cod liver is the tendency to lose oil during almost any processing. It is quite common that the can of “natural cod liver” contains more free oil than desired, and sometimes its proportion is even greater than the proportion of the main product, sterilized (solid) cod liver. The excess oil can also occasionally be separated from other products. So, it can be reasonable to use a method of controlled separation of excess oil.

The remaining part of the cod liver can be used for making a series of food products, and one of them is canned multicomponent pastes.

So, the purpose of the current work is to develop the formulation of the series of canned pastes from cod or its liver with other food ingredients.

2 Materials and methods

2.1 Materials

The Atlantic cod (*Gadus morhua*) caught in Russian economic zone of Barents Sea has been used for experiments has been used as the main raw material in chilled and frozen state, as well as its liver which was used only in the chilled state. The vegetables, mushrooms, pork and other ingredients have been achieved from the local market.

2.2 Methods of analysis

Fatty acid composition has been determined using the high-performance liquid chromatography method (HPLC) with Agilent 1100 (USA) after saponification of triglycerides with an alcohol solution of 2 N KOH and modification of fatty acids with bromophenacyl bromide after adding triethylamine [8].

The protein content has been determined using Selecta Bloc Digest and Selecta Pro-Nitro modules (Spain) based on the Kjeldahl method [9]. The total nitrogen determined by this method has been recalculated for the raw protein with a recalculation coefficient.

The total amount of lipids has been determined by the Soxhlet method using the extractor Selecta DET/GRAS (Spain) [9]. Sensory methods have been carried out using estimation scales [10]. The generalized sensory score (%) has been calculated by this method.

2.3 Experimental design and data analysis

The methods of experimental design (including central composition rotatable design) have been used in the current studies. The regression analysis has been carried out using Oakdale Datafit 9.1.

Some experiments' data has been processed using the fuzzy logic method with the Fuzzy Logic Toolbox in the Matlab environment.

3 Results and discussion

3.1 . Optimizing the technology of canned pastes from cod with mustard sauce

A series of preliminary experiments had shown that the formulation of the canned paste should contain the following ingredients: the slightly smoked cod mince; the mustard sauce; the guar gum; salt; dried dill; garlic; onion; and sour cream. Some ingredients are well-known and have exact sensory or/and technologic effects (including salt, guar gum, garlic, and onion), but other ratios should be optimized. The sensory score has been used as the optimization parameter. The mustard sauce to minced fish (X1) and sour cream to fish (X2) ratios have been taken as the optimization parameters. The experimental plan and results are shown in Table 1.

The results of Table 1 have been processed using the FuzzyLogic toolbox in the Matlab environment; the response surface is shown in Fig. 1. The results indicate that the optimal dosage of sauce is 15.7% of the net mass, while the optimal dosage of sour cream is 12.2%.

Table 1. Plan and results of optimization of canned pastes from cod with mustard sauce.

X_1	X_2	Sensory score (Y)
0.088	0.0644	83.78
0.088	0.3758	93.95
0.513	0.0644	90.02
0.513	0.3758	84.54
0.300	0.220	91.94
0.000	0.220	96.35
0.600	0.220	92.42
0.300	0.000	89.68
0.300	0.440	94.66

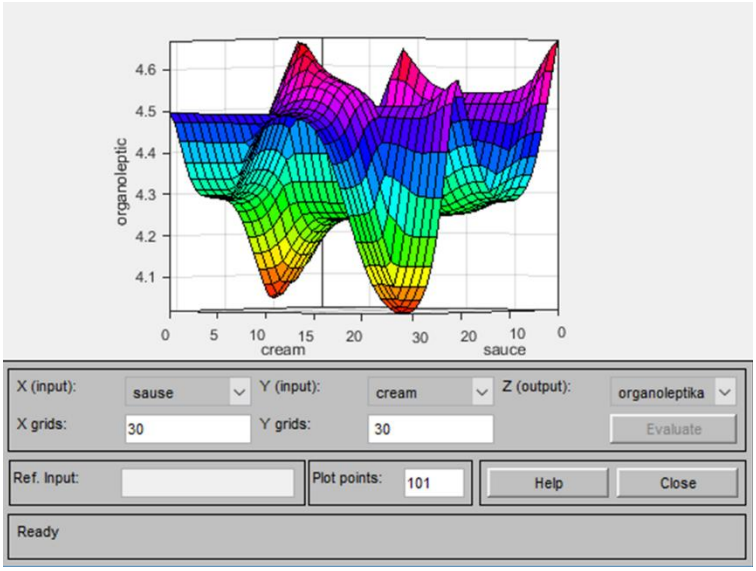

Fig. 1. Response surface of optimizing sauce and sour cream dosages.

The optimal formulation of the canned paste from slightly smoked cod with mustard sauce and sour cream is shown in Table 2.

Table 2. Optimal formulation of canned pastes from slightly smoked cod.

Ingredient	Dosage, % of net mass
Slightly smoked cod mince	67.7
Mustard sauce	15.7
Guar gum	2.5
Salt	1.25
Dried dill	0.020
Garlic	0.010
Onion	0.625
Sour cream (22 %)	12.2

3.2 Optimizing the technology of canned pastes from cod liver

Another valuable raw material which can be obtained from cod is cod liver. It is also can be used for producing canned pastes, but it needs the oil content regulating. The preliminary microwave treatment has been used for such regulation. As the results of such processing, two kinds of semi-products have been obtained: the microwave-treated cod liver and cod liver oil. Both can be used for developing a variety of foodstuffs. One group of such foodstuffs is the group of canned pastes with cod liver and other ingredients.

One of such ingredients is meat (non-fatty pork). The single-factor experiment of exploring the influence of meat-to-liver (semi-product) ratio (X) on sensory score (Y) has been carried out. This dependency is described by the 3rd order polynomial equation:

$$Y = 30.5\,X^3 - 94.88\,X^2 + 73.16\,X + 77.39, \quad (1)$$

The F-ratio is 221 which means that the equation is adequate at the confidence level of 0.95.

The graph of the regression equation (1) is shown in Fig. 2.

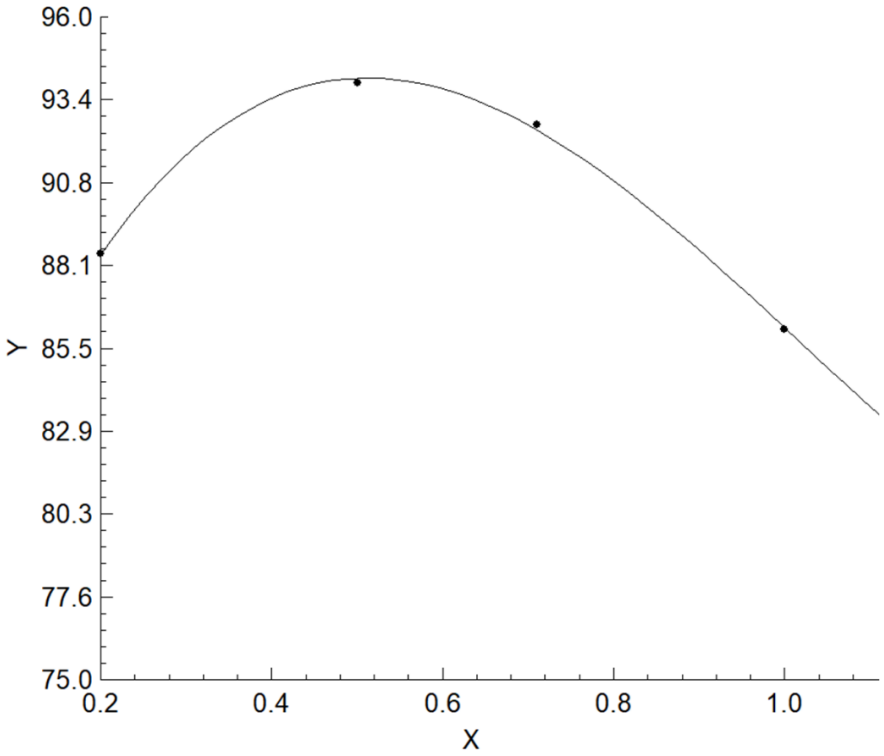

Fig. 2. Plot of regression equation of sensory score on meat-to-liver ratio.

The optimal meat-to-liver ratio is 0.512, but there is a tendency to form better product at the ratio above 2. The last situation describes a series of quite interesting products, but they can't be called as based on cod liver pastes, the cod liver turns into just an additive in such products. So, the optimal result corresponds to the ratio of 0.512 which means 20.35% of meat, 39.65% of microwave-processed cod liver. For practical purposes, this ratio might be changed to 20% of meat and 40% of cod liver semi-product.

Next product is cod liver with vegetable paste. It contains microwave processed cod liver, carrot, tomato and sour cream sauce, and onion. The cod liver to carrot ratio has been chosen as the factor (X) for the formulation optimization. The sensory score (Y, %) has been chosen as the optimization criteria. The following regression equation (2) has been obtained after data processing:

$$Y = \frac{69.96}{1-0.2726\,X+0.06722\,X^2} \quad (2)$$

The graph of the regression equation is shown in Figure 3. The F-ratio is 139, so the equation is adequate at the confidence level of more than 0.99. All the regression coefficients are significant at the same confidence level.

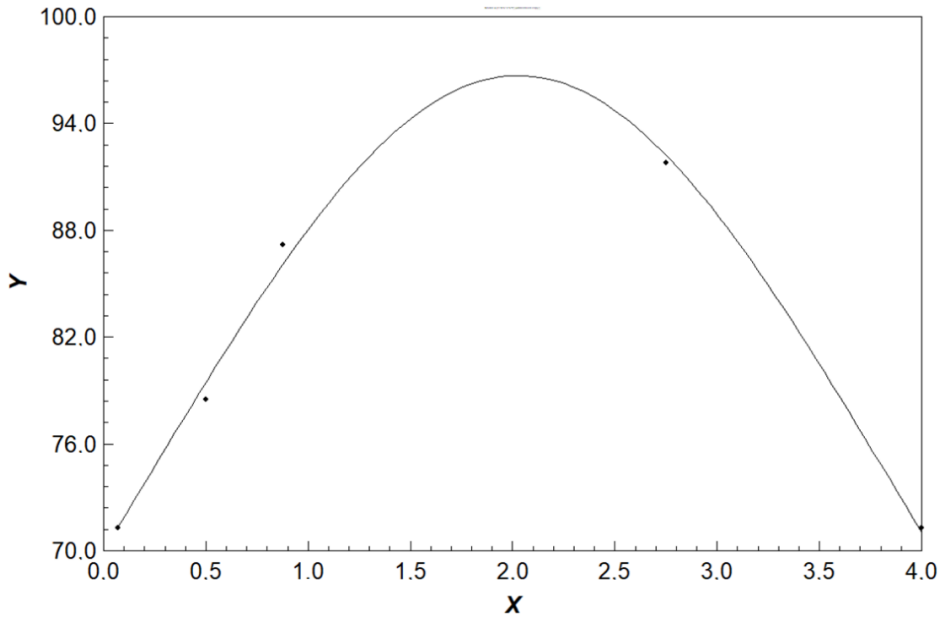

Fig. 3. Plot of regression equation of sensory score on liver-to-carrot ratio.

The maximum of this equation has been found at X = 2.03 which means that the liver content is 50.25 while carrot content is 24.75 % of the formulation. For practical purposes, it is better to assume that the microwave processed cod liver content is 50 %; carrot content is 25 % of the formulation.

Next example of the canned pastes is multicomponent; it includes vegetable, mushrooms (champignons), and liver paste; the dosages of tomato and sour cream sauce and onion have been taken constant. Two-factor experimental design has been carried out with the following factors: cod liver to mushrooms ratio (X_1), cabbage-to-mushrooms ratio (X_2). The sensory score (Y, %) has been used as an optimization parameter. The following regression equation has been obtained after processing the results of this experimental design.

$$Y = 84.3 + 7.6\,X_1 - 2.07\,X_1^2 + 0.140\,X_1^3 - 7.58\,X_2 + 2.56\,X_2^2 - 0.224\,X_2^3 \quad (3)$$

The F-ratio is 466 which means that the equation is adequate at the confidence level of more than 0.99. All the regression coefficients are significant at the same confidence level.

The response surface ¬– graph of the equation (3) – is shown on Figure 4.

It is not possible to find an ultimate maximum on the selected intervals of factors. There is an exact maximum with X_1 = 2.44, X_2 =5.60 (Y = 91 %). But this point is not the only best variant, as there are variants at the borders of intervals which are not worse. They are: X_1 = 10, X_2 =5.60 (Y = 91 %); X1 = 2.44, X2 = 0.0 (Y = 92.5). So, there is the following almost the same good variant of multicomponent paste: 6.1 % of mushrooms, 14.8 % of cod liver, 34.1 % of cabbage; 3.3 % of mushrooms, 33.1 % of cod liver, 18.6 % of cabbage; 16 % of mushrooms, 39 % of cod liver without cabbage.

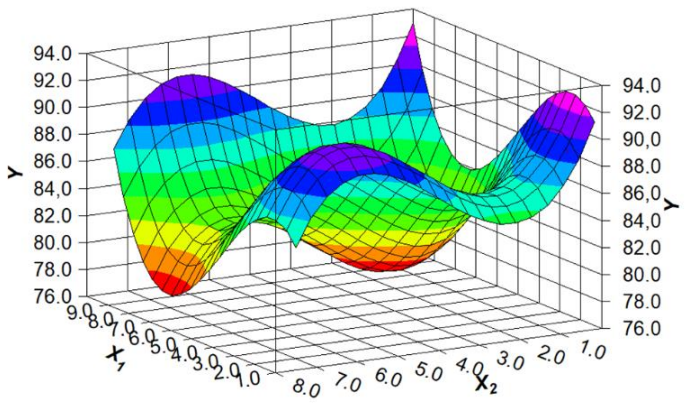

Fig. 4. Response surface of optimizing multicomponent paste.

The last example of canned pastes was the poultry and cod liver paste. It included microwave processed cod liver, fillet of chicken, vegetables (carrot and onion), tomato paste, wheat flour, egg yellow, salt, and black pepper. The chicken meat to cod liver ratio has been chosen as a varying factor (x). The sensory score has been chosen as the optimization criteria. The following regression equation has been obtained:

$$Y = 71{,}8 - 46{,}9\, x^2 \ln x + 17{,}4\, x^3 \quad (4)$$

The F-ratio is 7.9 which means the adequacy of the equation at the confidence level of 0.95. The optimal value of x is 1.15 which means 29 % of chicken meat and 25% of microwave processed cod liver. This product has been studied by the parameters shown in the Table 3.

Table 3. Characteristics of canned paste with cod liver and chicken.

Characteristic	Value
Chemical composition	
Water, %	47.7
Lipids, %	30.1
Starch, %	4.7
Raw/true protein, % (K =6.25)	10.6/9.1
Minerals, %	2.4
Fatty acid composition, % of fatty acid sum	
Octadecatetraenoic	1.73
Eicosapentaenoic	5.87
Docosahexaenoic	7.34
Myristic	2.42
Palmitoleic	6.65
Linoleic	28.02
Palmitic	9.96

Oleic	28.10
Stearic	6.58
Gadoleic	3.33

The results of this table show that ω-3 to ω-6 ratio is about 1:2.5 which is close to the recommended value of therapeutic and preventive products.

4 Conclusion

A series of formulations of canned pastes based on cod and its liver has been developed; optimal dosages of ingredients have been determined. The following products technologies thus have been developed:

- Paste from cod with mustard sauce and sour cream.
- Paste from cod liver and meat (pork).
- Cod liver and carrot paste.
- Cod liver with mushrooms and vegetables paste.
- Cod liver and chicken paste.

The fatty acid composition of the last product (which practically was one of the best by sensory characteristics) has been determined and shown potential therapeutic and diseases-preventive effects due to good ω-3 to ω-6 ratio.

Acknowledgements

This research was funded by the Russian Science Foundation, project 23-64-10020.

References

1. Food Enrichment with Omega-3 Fatty Acids. Woodhead Publishing (2013) ISBN: 978-0-85709-428-5
2. V. Volchenko, V. Grokhovsky, L. Kuranova [et al.] *Food products with ingredients rich in ω-3 polyunsaturated fat acids*, in IOP Conference Series: Earth and Environmental Science: 12th International Scientific Conference on Agricultural Machinery Industry, INTERAGROMASH (2019). DOI 10.1088/1755-1315/403/1/012003.
3. S. Marventano, P. Kolacz, S. Castellano, F. Galvano, S. Buscemi, A. Mistretta, G. Grosso. *A review of recent evidence in human studies of n-3 and n-6 PUFA intake on cardiovascular disease, cancer, and depressive disor-ders: does the ratio really matter?* in Int. J. Food Sci. Nutr. **66** (6): 611-622 (2015)
4. A.P. Simopoulos. *Evolutionary Aspects of Diet: The Omega-6/Omega-3 Ratio and the Brain*. Molecular Neurobiology 44, 203–215
5. V. A. Grokhovsky, V. Volchenko, L. K. Kuranova, O. N. Krasulya, *Developing functional sterilised products technology using microwave-cooked semi-finished cod liver products* in Agronomy Research **17**, No. 1 (2019)
6. S. M. ElShehawy, Z. S. Farag. *Safety assessment of some imported canned fish using chemical, microbiological and sensory methods* in Egyptian Journal of Aquatic Research 45 (2019)

7. Jacobsen C. *Some strategies for the stabilization of long chain n-3 PUFA enriched foods: A review.* in Eur. J. Lipid Sci. Tech. 117(11): 1853-1866 (2015).
8. Gratzfeld-Huesgen, Analysis of hydrolyzed fatty acids in dietary fat using HPLC. Agilent technologies, Publication number 5966-0635E, 1997.
9. Food energy - methods of analysis and conversion factors. Food and Agriculture Organization of the United Nations (FAO), (2003). Available at: ftp://ftp.fao.org/docrep/fao/006/y5022e/y5022e00.pdf
10. ISO 4121:2003 Sensory analysis - Guidelines for the use of quantitative response scales. ISO TC 34/ SC 12, Buenos Aires. 9 p.
11. J. Falandysz, F. Smith, A.R. Fernandes *Dioxin-like polybrominated biphenyls (PBBs) and ortho-substituted PBBs in edible cod (Gadus morhua) liver oils and canned cod livers* in Chemosphere, **248** (2020)
12. M. Smutna, K. Kruzikova, P. Marsalek, V. Kopriva, Z. Svobodova. *Fish oil and cod liver as safe and healthy food supplements* in Neuroendocrinology Letters, **30**, 1 (2009)
13. H.-D. Yoon, L. V. Shulgina, S. P. Kasyanov, R. M. Sultanov, Yu. P. Shulgin, ・J.-Gi Min, D.-H. Park, J.-G. Kim *Processing and quality characteristics of new canned fish products contained omega-3 fatty acids* in Journal of Fisheries and Marine Sciences Education **31** (2019)
14. L. Kuranova,, V. Grokhovsky, M. Ershov, A. Pilipenko. *Use of marine biological resources of the arctic region for creation of combined fish and vegetable canned pastes* in KnE Life Sciences, **5** (2020)