Technology of the food additives enriched with CO$_2$-extractions of dry homonymous spices

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Abstract. The article considered the issues of technology development for the food additives enriched with CO$_2$-extractions of dry homonymous spices. Using various instrumental methods the conditions for sorption of volatiles of CO$_2$-extractions were studied on the preparations of animal proteins as applicable for meat and fish industries. For the construction of “visual prints” the following methods were used: profile analysis, cluster analysis, and the key component method. Based on the results of experimental studies, the recommended dosages of CO$_2$-extractions were developed for animal proteins used in the meat and fish industry calculated per 1 kg, which averaged 25-35 / 65-75 ml / kg of protein.

1. Introduction

The Russian market of food ingredients is developing both qualitatively and quantitatively. Changes in the living standards of Russians and the influence of Western food markets determine the involvement of innovative food technology and the use of modern high-tech ingredients. Today the market for food ingredients is one of the most dynamic and fastest growing in the global food industry. Statistics show that there is a real boom in the international market for ingredients, the production growth of which is much faster than the output of food products per capita. One of the marks of this sector is the increase in the complex additive production, which are mixtures of dyes, sweeteners, emulsifiers and preservatives [1, 2]. Food ingredients include substances of animal, plant, microbiological or mineral origin, as well as natural or synthesized food additives used in the preparation or production of a food product and remain in the finished product in its original or modified form [3, 4]. The characteristic feature of modern food products is the complexity of their prescription formulations, i.e. presence of a large number of food ingredients of various chemical nature in the product. Today, almost no product can be produced without food additives - emulsifiers, aromatic bases, thickeners, dry functional mixtures, and other ingredients [5, 6].

The production of food ingredients is a knowledge-based industry that solves such problems as: the need not only to obtain an ingredient, but also to develop a technology for its use. When addressing issues related to the problems of aromatization of food and balanced nutrition, special attention is paid to the development of methods for making spicy-aromatic additives for food products.
2. Materials and methods

The experimental studies were performed using an installation consisting of a detection cell, piezoresonance sensors, a frequency meter, and a compressor. To expand and reduce the detection limits and increase the selectivity of quartz resonators with respect to aroma, they were previously modified with active sorbents. To modify the surface of the resonator electrodes in order to determine the aroma of food additives and the seven-piezoelectric quartz microweighting method, active polar phases were used as stationary phases in gas chromatography. Qualification modifiers are chemically pure (CP) of analytically pure (AP). When choosing modifiers, their belonging to different classes of compounds was taken into account, as well as selectivity criteria with respect to the components of the studied food additives. Besides, the modifiers we studied, with the exception of Triton X - 100, fracionitrile, and polyethylene glycol adipate, were not previously used as modifiers of mass-sensitive piezoresorption sensors. For the preparation of modifier solutions, distilled water and organic solvents — acetone and isopropyl alcohol, in AP qualification, were used. The choice of solvent is determined by the nature of the modifier, besides, the solvent should have low boiling point, good dissolving power with respect to sorbents and low detection limit. Sorbent solution (C = 1 mg/cm$^3$) was prepared by dissolving a weight dose of it (25 mg) in 25 cm$^3$ of solvent. To apply the exact volume of the sorbent solution to the resonator electrodes, a chromatographic dosing syringe with a capacity of 10–2 cm$^3$ was used. The method of applying the sorbent solution to the surface of the resonator electrodes was as follows. The syringe was first intensively washed with a suitable solvent and distilled water, then with the sorbent solution, in order to eliminate the remnants of the previous modifier solution. The syringe was filled with the required volume of modifier solution and carefully applied to the resonator electrodes, preventing it from spreading over the surface of the piezoelectric element. When air is passed through the syringe, the remaining sorbent solution is visible in the graduated glass cylinder of the syringe, which allows controlling the amount of sorbent applied.

3. Results

Given the wide range of food systems, the particularities of the technology for their preparation and pursuing the goal of creating an additive of multifunctional action, provision of the stabilization of organoleptic indicators and imparting preventive properties to the final product, it is of great interest to expand the assortment of carriers, among which proteins occupy a special place as irreplaceable food components, the source of which are commercial preparations and domestic intermediates of collagen nature. At the same time, studies of recent years have established a number of the most important biologically active properties of spices on the human body. Spices are various parts of plants, each of which has its own specific taste and aroma, varying degrees of severity, and aftertaste. The same parameters can be attributed to CO$_2$-extractions as well, but they are not considered as synthetic products which is especially essential for developing the food rations for school children [7]. CO$_2$-extractions, compared to dry spices, are very valuable due to their bactericidal action, CO$_2$-extraction concentration is 15-20 higher than that of the dry spices; they are sterile, stable in storage, and they can homogeniously spread the flavour throughout the product. To build a “visual imprint”, profile analysis was used. The profile method is based on the fact that individual olfactory and other parameters of gasoline, when combined, give a qualitatively new characteristic of the product. Identification of the most characteristic odor elements for a given product allows studying the influence of various factors (initial raw materials, production conditions, etc.). First, the odor profile of the reference sample is determined. As a reference, we chose a mixture of hexane and toluene. According to the standard, the sequence of occurrence and the intensity of individual pulses are specified. Then one assesses the intensity of sensations on a conventional scale. To assess the intensity of characteristic features, various scales can be used: 0 - there is no sign; 1 - just recognizable or felt; 2 - low intensity; 3 - moderate intensity; 4 - strong; 5 - very strong intensity.

Judging by the obtained results (Figure 1), it was found that the intensity of the aroma of the product with the addition of CO$_2$-extraction of white pepper to the animal protein Promil-G95 increases with the increase in the dosage of the extract from 25 μl / g of protein to 35 μl / g of protein.
Then, when the dosage of the CO₂-extraction is increased to 70 μl / g of protein, decrease in the intensity of aroma is observed, besides, the duration of the analysis is proportional to the dosage of the CO₂-extraction.

![Figure 1](image1.png)

**Figure 1.** Radar chart of animal protein Promil-G95 depending on the concentration of CO₂-extraction of white pepper.

From the diagrams for the animal protein Promil-G95 it can be seen that their nature depends on the type of dosed CO₂-extraction. This is due to different chemical composition. For example, the active substance of the CO₂-extract of red pepper is capsaicin (8-methyl-6-nonenonic acid vanillamide), of cardamom - borneol (1,7,7-trimethylbicyclo heptan-2-ol), of white pepper - eugenol (4- allyl-2-methoxyphenol); of CO₂-extract of black pepper - pinene, sabinen, limonene, piperine; of anise CO₂-extract - anethole, methylchavicol; cumin CO₂-extract - carvone, limonene, dihydrocarvone, carveol isomers. According to the experimental results, it was found that the intensity of the product aroma with the addition of CO₂-extraction of red pepper to Promil-G95 protein increases with the growth in the extract dosage from 45 μl / g protein to 55 μl / g protein (Figure 2).

Then, with an increase in the dosage of the CO₂-extraction to 70 μl / g protein, decrease in the intensity of aroma is observed. Similar dependences were detected for the animal protein Promil C 95 and CO₂-extracts of cardamom, white and red pepper. The obtained results make it possible to recommend CO₂-extract dosages for animal proteins Promil-G 95 and Promil-C95, which are presented in Table 1.

![Figure 2](image2.png)

**Figure 2.** Radar chart of aroma for animal protein Promil-G 95 depending on concentration of CO₂-extraction of red pepper: a – 30 mcl/g; b - 50 mcl/g; c – 70 mcl/g.

The dependence of the signal intensity on the concentration of CO₂ extracts was studied to develop technical and technological recommendations for the use of meat and fish products in technology (Figure 3).
The results obtained make it possible to recommend dosages of CO₂ extracts for animals, Promil-G 95 and Promil-C95, which are presented in the table 1.

![Graphs](image-url)  
**Figure 3.** The dependence of the signal intensity on the concentration of CO₂-extract on the protein Promil G-95: a - white pepper; b - cardamom; c - red pepper

**Table 1.** Recommended dosages of CO₂-extractions for animal proteins Promil-G 95 and Promil-C95 calculated per 1 kg of animal protein

| CO₂ extraction          | Promil-G 95       | Promil-C95       |
|-------------------------|-------------------|------------------|
| White pepper, ml/ kg of protein; | 25-35/65-75       | 25-35/65-75      |
| Cardamom, ml/ kg of protein;    | 25-35             | 25-35            |
| Red pepper, ml/ kg of protein;  | 25 ÷ 55           | 65-75            |

Other methods for determining the conditions for the sorption of volatile substances of CO₂-extractions on animal protein preparations are the cluster method and the key component method. Cluster analysis is the task of splitting a given sample of objects (situations) into disjoint subsets called clusters, so that each cluster consists of similar objects, and the objects of different clusters are significantly different. The key component method is one of the main ways to reduce the dimensionality of data by losing the least amount of information.

Using these methods of studying sorption, we present an example of cumin CO₂-extract and animal protein Probelcon 140.

Graphical interpretation of the cluster analysis method is shown in Figure 3, as follows from the dendrogram of the sorption of volatile substances-flavors of cumin CO₂-extract, the optimal concentration of the extract is 50 μl / g of protein, increase in concentration to 70-100 μl / g of protein does not lead to any noticeable intensity of the aroma, concentration between 10 and 30 μl / g of protein is not sufficiently manifested.

Another confirmation is graphical interpretation of the key component method (Figure 4), from which it also follows that the concentration of 50 μl / g of protein with coordinates axis 1 - 1.382, axis 2 - 1.031 is the closest to the center i.e. coordinates 0-0, which is consistent with the data obtained by the cluster method.

Similar dependences of the sorption of volatiles on the animal protein Probelcon 140 are formed for CO₂-extracts of anise and black pepper and their recommended dosages for the preparation of the animal protein Probelcon 140 are presented in Table 2.
Using the data obtained by studying the conditions for the sorption of volatile substances of aromas on animal proteins provides sufficient information to obtain a multifunctional additive based on animal protein preparations Promil G95, Promil C95, Probelkon 140 and CO\textsubscript{2}-extracts of white, red and black pepper, cardamom, cumin, and anise, which, on one hand, improves the functional and technological properties of model food systems for both the meat and fish industries, and on the other hand improves organoleptic characteristics.

4. Conclusion
The developed dosage recommendations make it possible to obtain products with desired properties. Decrease in the recommended norm of the multifunctional additive leads to decrease in aroma, and increase leads to the growth in the cost of the finished product.

Based on the obtained experimental data, it can be concluded that the animal proteins Promil-C95, Promil-G95, and Probelkon 140 are used as carriers of CO\textsubscript{2}-extracts in the manufacture of not only meat, but also fish products. The use of the obtained multifunctional additives allows restoring the traditional consumer properties of the product, its calorie content, increase storage period, get a product with completely new consumer properties.

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