UDC 636.085.55 - 021.632 : [635.13 : 663.26] : 66.083

# INVESTIGATION OF THE EFFECT OF HEAT TREATMENT ON THE QUALITY OF THE FEED ADDITIVE CONTAINING CARROT POMACE

**B. Iegorov,** Doctor of Technical Sciences, Professor
**I. Cherneha,** Candidate of Technical Sciences, Associate Professor
**L. Fihurska,** Candidate of Technical Sciences, Associate Professor
**O. Tsiundyk,** Candidate of Technical Sciences, Senior Lecturer,
Department of feed technology and biofuel
Odessa National Academy of Food Technologies
112, Kanatnaya Str., Odessa City, Ukraine 65039

DOI: http://dx.doi.org/10.15673/fst.v13i3.1483

**Article history**

Received 05.02.2019
Reviewed 30.03.2019
Revised 22.06.2019
Approved 03.09.2019

**Correspondence:**

O. Tsiundyk
*E-mail*: malik2008ts@gmail.com

**Cite as Vancouver Citation Style**

Iegorov B, Cherneha I, Fihurska L, Tsiundyk O. Investigation of the effect of heat treatment on the quality of the feed additive containing carrot pomace. Food science and technology. 2019;13(3):77-85. DOI: http://dx.doi.org/ 10.15673/fst.v13i3.1483

**Cite as State Standard of Ukraine 8302:2015**

Investigation of the effect of heat treatment on the quality of the feed additive containing carrot pomace / Iegorov B. et al. // Food science and technology. 2019. Vol. 13, Issue 3. P. 77-85. DOI: http://dx.doi.org/10.15673/fst.v13i3.1483



**Abstract**. The main task of the compound feed industry is development and introduction of high-performance equipment and technologies, expansion of the resource base and the range of finished products. Along with this, in the canning industry, a lot of by-products are formed. By their chemical composition, they are as good as the main products. However, by-products of the canning industry are characterized by a high moisture content. They deteriorate very quickly and require immediate disposal. That is why, the purpose of the paper was to study the effect of heat treatment on the physicochemical properties and on the quantitative and qualitative composition of the microflora of the feed additive made with the use of carrot pomace. The physical properties, chemical composition, sanitary quality, and permissible shelf life of carrot pomace have been determined. The optimum quantitative and qualitative composition of the feed additive have been reasoned and researched. It has been established that the process of extrusion improves the physical properties and increases the digestibility of nutrients. It also improves the sanitary condition and extends the shelf life of the additive. As a result of extrusion of the feed additive, the moisture content decreased by 32.2%, the angle of repose increased by 11.8%, the flowability decreased by 33.3%, the damaged starch content decreased by 33.2%, and the amount of water-soluble carbohydrates became 5 times as big. Besides, under the influence of high temperature and pressure, the total number of bacteria decreased by 89%, and that of mould fungi by 83%. During storage of the feed additive for 6 months, the QMAFAnM decreased by 32.5%. The resulting feed additive will solve the problem utilizing canning industry by-products, expand the raw material base and reduce feed consumption.

**Keywords:** carrot pomace, chemical composition, physical properties, microflora, extrusion, additive, storage.

## Introduction. Formulation of the problem

Waste-free and low-waste technologies are among the major directions of industrial production development [1].

Wide introduction of the low-waste and non-waste technologies in the food industry, including the canning one, allows solving a number of environmental problems of the country [2].

Besides, modern development and intensification of animal and poultry farming require a lot of feed. In the production of eggs and poultry meat, up to 70% of total expenses is spent on feed.

At present, in order to improve the feed conversion rate and reduce the production cost, many farms are trying to use non-traditional feed of local origin [3]. As such, by-products of the canning industry can be used.

While manufacturing carrot juice, a lot of carrot pomace is produced. It is rich in carbohydrates and is a source of beta-carotene. Beta-carotene is nutritionally and physiologically significant as provitamin A, and acts as an antioxidant. Also it is one of yellow plant pigments, better known as the pigment that determines the colour of carrots and is insoluble in water [4-6].

A feature of canning by-products is their high moisture content, so they are liable to be easily spoiled by microorganisms [7].

Today in Ukraine, very little attention is paid to the problem of utilizing canning wastes. In most domestic enterprises, this valuable feeding stuff spoils and decays in large amounts. This situation creates a significant environmental threat [8,9].

That is why, to use carrot pomace in compound feed production, it is necessary to find ways of processing it, aiming at reducing microbiological contamination and extending the shelf life of carrot pomace.

## Analysis of recent research and publications

An analysis of the literary data has shown that carrot pomace is a valuable source of fibre, pectin substances, and a vitamin complex, in particular, carotene [6,10].

Like other wastes, carrot pomace gets spoiled quickly due to microorganisms. This spoilage makes it difficult to process them further into food additives, feeds for farm animals and poultry, medical preparations, etc.

It was suggested to use fresh carrot pomace as cattle feed, as raw materials for alcohol production, as a culture medium for microorganisms [4,10,11].

A technology is known of the complex processing of carrots to obtain dry carotene-containing enrichers and concentrated filling agents. They can be used in the canning, confectionery, dairy, meat, and fish industries [5,12,13].

Methods were developed to manufacture powders from carrot pomace in order to expand the range of pastry and improve its nutritional value [14,15].

At different times, scientists improved the methods of pelleting carrot pomace mixed with other by-products of the canning industry. These pellets can be used as food colourants or concentrates. Natural food colourants are used in the production of confectionery and in other food industries [1].

A technology is known of production of carrot-mustard seasonings. They are added to meat and fish, to farinaceous dishes. They are tasty, appetizing, expand the diet, and enrich the human body with beta-carotene [16].

Also there are methods of extruding carrot pomace mixed with different wholegrain cereal crops and wastes of different vegetables. Such supplements can be added into compound feeds when feeding animals [17-18].

Among all the above methods, the extrusion process is the most effective, since one of the reasons for the insufficient domestic feed production is the imperfection of recipes, shortcomings in the production technologies, and high energy cost of the production process. It is possible to solve the problem of improving compound feed recipes by introducing non-traditional types of raw materials and reducing the use of grain raw materials, which will help reduce production costs. The extrusion process is less energy consuming and allows the product to retain its nutrients. Also, using carrot pomace to moisturize the mixtures does not require its preliminary drying and makes it unnecessary to moisten the product prior to the extrusion. Thus, there is a need to improve the technology of animal feed production.

The **purpose** of the research is to study the effect of heat treatment on the physical and chemical properties and the quantitative and qualitative composition of the microflora of the feed additive containing carrot pomace.

To achieve this goal, it is necessary to solve the following **tasks:**

– to determine the physical properties, the chemical composition, and the sanitary quality of the feed additive containing carrot pomace;

– to substantiate the quantitative and qualitative composition of the feed additive containing carrot pomace;

– to determine the physical properties and the chemical composition of the feed additive before and after extrusion;

– to determine the microflora of the feed additive before and after extrusion, to investigate the allowable shelf life of the feed additive.

## Research materials and methods

For our study, the carrot pomace taken was from carrots of the *Olenka* variety, one of the most productive carrot varieties. These carrots are juicy and crispy, and suitable for long-term storage.

The experimental research was carried out on laboratory and technological equipment according to standard methods [19].

The average samples of the raw materials and finished products to be analysed were taken according to ISO 6497:2002 “Animal feed. Sample collection.”

During the experiments, a complex of generally accepted, standard methods was used to determine the physical and chemical quality parameters of the raw materials and finished products (Table 1).

The feed additive containing carrot pomace was produced under the following conditions: the carrot pomace was ground with a grinding machine to obtain the average particle size 3 mm, and after that, it was weighed in doses. The feeding chalk was cleaned from impurities and weighed in doses. The maize grain was cleaned from impurities, ground with a hammermill into particles as large as 3 mm, and weighed in doses. Then a premixture of the components was prepared. For this, the carrot pomace and part of the maize grain (1:1) were mixed in a mincemeat mixer for 180 s.

Then the main mixing was carried out. The premixture was mixed with the rest of the maize and feeding chalk in a batch mixer with the blade-type stirrer for 120–180 seconds. The resulting mixture was extruded (at the temperature +110 – +130°C and the pressure 2–3 MPa). The extruded product was cooled down to the temperature +20 – +30°C and ground into 3 mm large particle.

All feed products must comply with the requirements of the veterinary and sanitary standards. Microorganisms are the main reason for the deterioration of the quality of compound feed products. That is why, it is necessary to have a clear vision of the microflora of the compound feed and to know how it is affected by the production methods and storage conditions of the products [33].

In the experimental samples, the following characteristics have been determined:

– the quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM), colony-forming organisms in 1 gram of the product (CFO/g);

– the presence of mould fungi, CFO/g;

– the presence of micromycetes (fungi and yeast), CFO/g;

– the presence of coliform bacteria in 0.1 g of the product;

– the presence of paratyphoid bacteria (Salmonella) in 25 g of the product.

The study of the dynamics of microflora development in carrot pomace allowed us to estimate the permissible shelf life of the product. Carrot pomace was stored in plastic bags under controlled conditions. Since processing carrots into juices begins in July and lasts until mid-September, the average ambient temperature was calculated, which, according to hydrometeorological centres of Ukraine, was +28 ± 2°C. So the samples under stude were kept at this temperature. The feed additive was stored under unregulated conditions at the temperature 15 ±5°C and the relative air humidity 65–75% for 6 months.

**Table 1 – Parameters and research methods used to determine the physical and chemical properties of the raw materials and finished products**

| Parameters | Principles and features of the methods | Standard | Literature |
|---|---|---|---|
| Moisture content, % | Drying the weighed quantity of the sample in the drying cabinet | ISO 6496:1999 | [20] |
| Bulk weight, kg/m$^3$ | Using a 1 litre graduated cylinder | – | [21] |
| Average particle size, mm | Sifting the product through a set of sieves with holes of different diameters | – | [21] |
| Flowability, cm/s | By the leakage of the product through a hole of a certain diameter | – | [21] |
| Angle of repose, degrees | On R. Zenkov's equipment, by pouring the product out of the funnel | – | [21] |
| Density, kg/m$^3$ | Using a liquid that does not dissolve the particles of the material | – | [21] |
| Extrudate expansion index | The ratio of the extrudate's diameter to the diameter of the extruder outlet | – | [21] |
| Heterogeneity coefficient | The colourimetric method | – | [21] |
| Crude protein, % | The Kjeldahl method | ISO 5983-1:2005 | [22] |
| Crude fibre, % | By treating the weighed quantity of the sample with a mixture of concentrated nitric and acetic acids | ISO 6865:2000 | [22] |
| Crude fat, % | By the method based on the extraction of the fat by petroleum ether | ISO 6492:1999 | [22] |
| Crude ash, % | Burning the sample in a muffle furnace at the temperature 500–600 °C | ISO 5984:2002 | [20, 22] |
| Starch, % | Polarimetric method | ISO 6493:2000 | [20] |
| Water-soluble carbohydrates, % | Method based on the ability of reducing sugars to reduce the alkaline solution of copper oxide into nitrous oxide | – | [22] |
| Calcium, % | Complexometric method | ISO 6490-1:1985 | [22] |
| Phosphorus, % | Photometric method | ISO 6491:1998 | [22] |
| Vitamin C, mg | Photometric method | – | [20] |
| Beta-carotene, mg | Colourimetric method | – | [20] |

## Results of the research and their discussion

To study how practical it is to manufacture a feed additive with carrot pomace, it is necessary, first of all, to investigate the physicochemical properties and microflora of carrot pomace and determine the optimum composition of the feed additive.

**Study of the physicochemical properties and sanitary quality of carrot pomace.** The chemical composition and physical properties of carrots are determined by the structure and composition of their tissues [7].

To study the possibility of processing carrot pomace into feed additives and using it as a component of compound feeds, we have investigated the physical properties of carrot pomace, with the moisture content 74%, the bulk density 778 kg/m$^3$, and the density 1160 kg/m$^3$.

Analysis of Table 2 shows that the physical properties of carrot pomace are unsatisfactory. It has a high moisture content. This fact complicates the processing of the product: it makes it difficult to transport it, and makes metal parts of the equipment stick together and corrode.

The chemical composition of carrot pomace has been studied by many researchers [1,5,6,12-14,17,18]. According to their data, it varies within fairly wide limits. This can be explained by the different varieties and different maturity, as well as by the different ratios of the anatomical parts in the studied products [7,15].

Therefore, to process carrot pomace into feed additives, it is necessary to study its chemical composition (Table 3).

By analysing the data of Table 3, we can conclude that during the production of carrot juices, a significant part of valuable substances, such as vitamins, dietary fibre, and mineral substances, remained in the secondary raw material.

Carrot pomace has a high feed value. It contains enough nutrients required by poultry. Also, these products are high in carotene and vitamin C.

The study of the dynamics of carrot pomace microflora development has allowed us to estimate the product's permissible storage periods (Table 4).

**Table 3 – The chemical composition of the carrot pomace (in terms of dry substance)**, (n=3, P≥0.95)

| Parameters | Content |
|---|---|
| Mass fraction, %, of:moisture | 74.0 |
| crude protein | 1.8 |
| crude fibre | 9.8 |
| crude fat | 0.8 |
| crude ash | 1.1 |
| nitrogen-free extractives<br>among them sugars:<br>reducing sugar<br>sucrose<br>pectin substances<br>among them water-soluble<br>water-insoluble | 12.5<br>9.5<br>4.2<br>5.3<br>3.0<br>0.8<br>2.2 |
| Mass fraction, mg %, of:<br>vitamin C | 52.2 |
| β-carotene | 32.8 |

**Table 4 – Microbiological parameters of carrot pomace during storage** (n=3, P≥0.95)

| Duration of the storage, hours | QMAFAnM, CFU/g | Mould fungi, CFU/g | Yeast, CFU/g | Coliform bacteria, g | Salmonella |
|---|---|---|---|---|---|
| 0 | 4.6*10$^3$ | 0.8*10$^3$ | Not found | | |
| 24 | 150*10$^3$ | 17*10$^3$ | Not found | | |
| 48 | Product's spoilage | | | | |

The research results show that carrot pomace is characterized by significant microbial contamination and a very short shelf life. After 24 hours of storage, the total number of microbiological cells increased 33 times, and the number of mould fungi 22 times, respectively. Yeast, coliform bacteria, and salmonella were not found in the product during the research. After 48 hours of storage, the product spoilage was observed. Such accumulation of microorganisms during the short period of time is due to the high moisture content of the product and the temperature at which it was stored.

So, carrot pomace should be processed during the first 24 hours. It is necessary to apply the optimum processing method that can improve the sanitary condition of the product and increase its shelf life.

**Reasons for a certain quantitative and qualitative composition of the feed additive.** At present, the problem of providing poultry with carotene additives is particularly acute, since grass meal procurement has practically stopped, and besides, only 0.6 % of the carotene contained in it is consumed by poultry. The lack of carotene in animal feed leads to chickens' growth retardation, increased mortality, decreased egg production [23].

It is established that carotene is not only a source of vitamin A, but also a natural antioxidant. It stimulates the immunological status of the body, and enhances the colour of carcasses and the pigmentation of the egg yolk [24-25].

The most common and inexpensive source of carotenoids is carrots. They are notable for their availability, a low price, and relative stability during storage, which allows consuming them throughout the year [4].

Finding unconventional sources of raw materials for new feed additives is one of the most important tasks of the feed industry. To this end, especially in recent years, new feed additives technologies have been developed and introduced [26].

The production of feed additives with carrot pomace is carried out without additional moisturizing, as the moisture content of the pomace is high enough. This reduces the cost of the extrusion compared to traditional raw materials.

Along with this, in our country in recent years, scientific research has been carried out to revise the norms of poultry's mineral nutrition, and to find new effective sources of mineral supplements. Thus, in feeding poultry it has become highly important to use environmentally friendly, biologically active elements and preparations that have a positive effect on their biochemical, immunological, and productive characteristics [27].

The analysis of the effectiveness of using various calcium-containing mineral feed additives in poultry feeding has shown that feeding chalk is the most effective one [28]. It costs little and is high in calcium. And its inclusion in the composition of the feed additive will allow solving the problem of the calcium deficiency in laying hens [9].

Among cereal crops, the most profitable raw material for the production of the feed additive is maize grain. It has a high content of metabolizable energy, and the yellow pigments of maize make broiler carcasses attractive and the yolk of eggs bright [29-31]. Besides, the cost of maize grain extrusion is lower compared with other cereals [32].

To determine the optimum ratio of the components in the feed additive, it has been studied how the introduction of carrot pomace effects on the effectiveness of extrusion, with the minimum specific power consumption and the best quality characteristics of the mixture. One of the main parameters for assessing the quality of an extrudate is the extrudate expansion index and the moisture content.

Five samples of the feed additive were formed:

1 – maize, feeding chalk, and carrot pomace in the ratio by mass 84:5:11, respectively;

2 – maize, feeding chalk, and carrot pomace in the ratio by mass 85:5:10, respectively;

3 – maize, feeding chalk, and carrot pomace in the ratio by mass 75:14:11, respectively;

4 – maize, feeding chalk, and carrot pomace in the ratio by mass 82:10:8, respectively;

5 – maize, feeding chalk, and carrot pomace in the ratio by mass 77:14:9, respectively.

Including a smaller amount of carrot pomace does not fully provide poultry with necessary vitamins and biologically active substances. This also leads to additional expenses, as it is necessary to keep moistening the mixture with water. A higher content of carrot pomace increases the moisture content of the additive and makes it difficult to go through the extrusion process.

Introducing a smaller amount of chalk does not fully provide poultry with calcium, and introducing more of it adversely affects the extrusion process.

That is why, it has been studied how the mass fraction of moisture in the feed additive changes during the extrusion depending on the sample (Fig. 1).

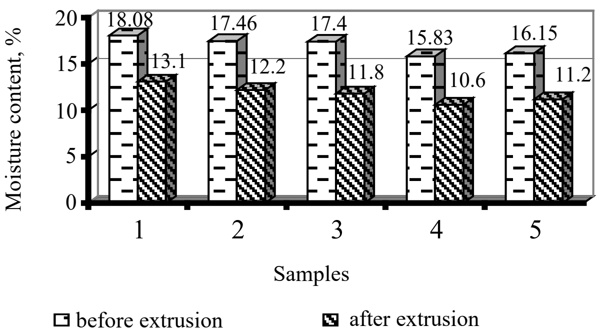


**Fig. 1. Changes in the moisture content in different samples of the feed additive during extrusion**

As a result of extrusion, the moisture content of the experimental samples significantly decreased (Fig. 1). Since the moisture content effects on the shelf life of the product, samples 3, 4, 5 are optimum.

In Fig. 2, it is shown how the specific power consumption and the extrudate expansion index depend on the moisture content in the research samples.

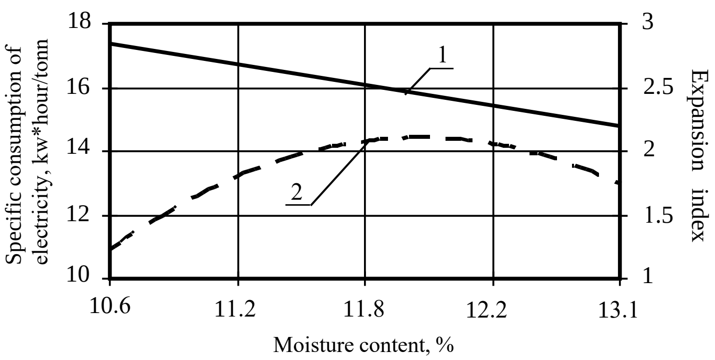


**Fig. 2. Dependence of specific electricity consumption (1) and extrudate expansion index (2) on the moisture content in the feed additive**

The results obtained (Fig. 2) show that, with an increase in the moisture content, the specific power consumption decreases from 17.4 kWh/t to 14.8 kWh/t. An increase of the mass fraction of moisture from 11.8 to 13.1% reduces the extrudate expansion index from 2.2 to 1.8. At the moisture content 10.6 and 11.2%, a low extrudate expansion index is observed.

So, taking into account the results of changing the moisture content, the specific power consumption, and the extrudate expansion index of the experimental samples in the extrusion process, the most effective for further research is to use the 3rd sample of the feed additive.

**Research of the physical and chemical properties, microflora, and the permissible storage time of feed additives.** The research samples were manufactured according to the improved method of production of feed additives with carrot pomace.

The physical properties and chemical composition of the feed additive were determined before and after the extrusion. The sanitary quality and the dynamics of microflora development in the additives during storage were also investigated.

The feed additive was studied according to the parameters that mostly characterize the physical properties of the finished product: angle of repose, flowability, bulk density, average particle size. The efficiency of the extrusion was determined according to the specific power consumption, the extrudate expansion index, and the moisture content (Table 5).

**Table 5 – The effect of extrusion on the physical properties of the feed additive** (n=3, P≥0.95)

| Parameters | Feed additive | | changes, % |
|---|---|---|---|
| | before extrusion | after extrusion | |
| Moisture content, % | 17.4 | 11.8 | -32.2 |
| Angle of repose, degrees | 34 | 38 | +11.8 |
| Flowability, cm/s | 11.4 | 7.6 | -33.3 |
| Bulk density, kg/m$^3$ | 650 | 470 | -27.7 |
| Average particle size, mm | 1.8 | 1.1 | -38.8 |
| Extrudate expansion index | 2.2 | | |
| Specific power consumption, kWh/t | 16.1 | | |

As can be seen from Table 5, the physical properties of the feed additive before the extrusion indicate that it is non-free-flowing. During the extrusion, the moisture content has decreased by 32.2%. After the extrusion, the feed additive had satisfactory physical characteristics. During the extrusion, the angle of repose increased by 11.8%, and the flowability improved by 33.3%. The deep structural and mechanical changes that occurred during the extrusion manifested themselves in the 27.7% decrease in the bulk weight of the additive. The extrudate expansion index was 2.2, with the extruder die diameter 10 mm. This is due to the formation, in the course of extrusion, of amylose-lipid and protein-lipid complexes that affect the dextrinization of starch. The specific power consumption to extrude the mixture was 16.1 kW h/t. Table 6 shows the chemical composition of the feed additive before and after the extrusion.

An analysis of Table 6 shows that while extruding the feed additive, the crude protein content decreased by 3.8%. This is due to the reactions of deamination and melanoidin formation. Also, in the course of extrusion, the crude fibre content decreased by 3.3% due to partial disruption of the cellulose-lignin complex. As a result of the partial breakdown of fat into fatty acids, its amount decreased by 1.01%.

Also, during the extrusion of the feed additive, the starch content decreased by 33.2%, and the amount of water-soluble carbohydrates increases 5-fold. These changes are due to the fact that during the extrusion, the crystal structure of native starch grains is destroyed. This significantly increases the absorption of the feed additive.

The content of macronutrients and vitamins does not change significantly, however, the amount of vitamin C and β-carotene decreases by 5–11% during the extrusion.

**Table 6 – The chemical composition of the feed additive before and after the extrusion (in terms of dry matter) (n=3, P≥0.95)**

| **Parameters** | **Feed additive** | |
|---|---|---|
| | **before extrusion** | **after extrusion** |
| Mass fraction, %, of: dry matter | 82.60 | 88.20 |
| crude protein, % | 7.80 | 7.50 |
| crude fat, % | 3.95 | 3.91 |
| crude ash, % | 1.38 | 1.35 |
| crude fibre, % | 2.76 | 2.67 |
| water-soluble carbohydrates | 3.90 | 18.89 |
| starch, % | 59.60 | 39.80 |
| phosphorus, % | 0.20 | 0.22 |
| calcium, % | 6.54 | 6.55 |
| Mass fraction, mg %, of vitamin C | 5.70 | 5.40 |
| β-carotene | 3.60 | 3.20 |

Besides, due to the introduction of feeding chalk and carrot pomace in the composition of the feed additive, the content of calcium, vitamin C, and β-carotene increased.

In the feed additive made by an advanced technology, the effect of heat treatment on the change of the microflora was determined (Table 7).

The standards of animal feed were taken as regulations on the quantitative and qualitative composition of the microflora, that is, the number of microorganisms should not exceed $5 \cdot 10^5$ CFU/g.

As it is seen from the results, extrusion effects positively on the sanitarily state of the feed mixture. During extrusion, the microbiological characteristics of the feed mixture improve greatly: the quantity of mesophilic aerobic and facultative anaerobic microorganisms reduced by 89%, the quantity of mould fungi by 83%.

All the samples (before and after the extrusion) were checked for the presence of yeast, coliform bacteria, and Salmonella, and the result was negative. This allows us to expect the effective storage of the feed additives.

During storage of compound feed raw materials, mould fungi can grow. Among them, there are toxic species, too, that are producers of metabolites hazardous for the health of poultry.

So, it was necessary to study the changes of the microflora of the feed mixture during storage (Table 8).

**Table 7 – The microbiological characteristics of the feed additive quality after heat treatment (n=3, P≥0,95)**

| Parameters | Feed mixture | | |
|---|---|---|---|
| | before extrusion | after extrusion | decrease, % |
| QMAFAnM, CFU/g | $39\cdot10^2$ | $4.3\cdot10^2$ | -89 |
| Mould fungi, CFU/g | $0.7\cdot10^2$ | $0.2\cdot10^2$ | -83 |
| Yeast, CFU/g. | not found | not found | – |
| Coliform bacteria, gram | | | – |
| Salmonella | | | – |

**Table 8 – Dynamics of microflora development in the feed additives during storage** (n=3, P≥0.95)

| Duration of storage, days | QMAFAnM, CFU/g | Mould fungi, CFU/g | Yeast, CFU/g | Coliform bacteria, gram | Salmonella |
|---|---|---|---|---|---|
| 0 | $4.3\cdot10^2$ | 10 | not found | | |
| 30 | $3.9\cdot10^2$ | 10 | not found | | |
| 60 | $3.8\cdot10^2$ | 10 | not found | | |
| 90 | $3.6\cdot10^2$ | 20 | not found | | |
| 120 | $3.3\cdot10^2$ | 10 | not found | | |
| 150 | $3.1\cdot10^2$ | 10 | not found | | |
| 180 | $2.9\cdot10^2$ | 10 | not found | | |

The data obtained show that during storage of the test samples, no yeast, coliform bacteria, and Salmonella were detected throughout the entire storage period, and the QMAFAnM decreased by 32.5%.

Thus, the feed additive is recommended to be stored in dry rooms at the relative humidity 65–75% and the ambient temperature 15 ± 5°C for 6 months.

## Conclusions

1. In the study, the physical properties, chemical composition, sanitary condition, and shelf life of carrot pomace have been researched. It has been established that carrot pomace is characterized by unsatisfactory physical properties: the moisture content is 74%, and the bulk weight is 778 kg/m$^3$. The results of the study of the chemical composition have shown that carrot pomace, because of its essential nutrient content, is a valuable feed product. However, it is characterized by significant microbial contamination and a short shelf life. The QMAFAnM is $4.6\cdot10^3$ CFU/g, and the number of mould fungi is $0.8\cdot10^3$ CFU/g. After 48 hours of storage, the product spoiled. This is due to the high moisture content of the product and the temperature at which it was stored.

2. The quantitative and qualitative composition of the feed additive has been explained. To determine the optimum ratio of the components in the feed additive, it has been found how the effectiveness of the extrusion process depends on introduction of carrot pomace. It has been established that the optimum ratio of the components of the feed additive, maize, feeding chalk, and carrot pomace, is 75:14:11 by weight, respectively. To do this, the results of changes in the moisture content, the specific power consumption, and the extrudate expansion index of the samples have been taken into account.

3. The influence of extrusion on the physical properties and chemical composition of the feed additive has been determined. As a result of extrusion of the feed additive, the moisture content decreased by 32.2%, the angle of repose increased by 11.8%, and the flowability decreased by 33.3%. The bulk density of the additive also decreased by 27.7%. In the course of the extrusion, in the feed additive, the whole starch content decreased by 33.2%, and the amount of water-soluble carbohydrates increased 5-fold. Thus, heat treatment improves the physical properties and increases the digestibility of the nutrient supplements.

4. The influence of the extrusion process on the sanitary quality of the feed additive has been determined, and the permissible shelf life of the feed additive has been studied. As a result of extruding the feed additive, the total number of bacteria decreased by 89%, and that of mould fungi by 83 %. During storage of the feed additive for 6 months, the QMAFAnM decreased by 32.5%.

**References:**

1. Oleksiienko VO, Fuchadzhy NO, Chervotkina OO. Ratsionalne vykorystannia vidkhodiv vyrobnytstva morkvianoho soku. Pratsi TDATU. 2012;12(4):216-221.
2. Gorun EG. Bezotkhodnaya tekhnologiya ryboperarabatyvayushchikh proizvodstv. M.: MGUTU; 2004.
3. Yehorov BV, Cherneha IS. Rozrobka i vykorystannia netradytsiinykh kormovykh dobavok pry hodivli kurei-nesuchok. Zernovi produkty i kombikormy. 2016;1(61):39-46.

4. Wadhwa M, Bakshi MPS. Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value-added products. India: FAO; 2013.
5. Malezhyk IF ta in. Doslidzhennia protsesu sushinnia morkvianykh vychavok pry oderzhanni sukhoi karotynovmisnoi dobavky. Visnyk Kharkivskoho natsionalnoho tekhnichnoho universytetu silskoho hospodarstva imeni Petra Vasylenka. 2014;152:150-156.
6. Knockaert Gr et al. Changes in в-Carotene During Processing of Carrots. Processing and Impact on Active Components in Food. 2014;11-16. DOI: 10.1016/B978-0-12-404699-3.00002-0
7. Kolobov SV, Pambukhchyiants OV. Tovarovedenye i ekspertiza plodov i ovoshchei. M.: Izdatelskotorhovaia korporatsyia «Dashkov i K°»; 2012.
8. Volkova N ta in. Ekolohichna problema suchasnosti. Kharchova i pererobna promyslovist. 2009;9-10:(356-357):25-26.
9. Yegorov B, Malaki I. Effect of heat treatment on quality of feed additive using tomato pomace. Eastern-European Journal of Enterprise Technologies. 2014;4:10(70):48-53. DOI: 10.15587/1729-4061.2014.26229
10. Utylizatsiia vidkhodiv kharchovoi promyslovosti. [Internet]. 2013 Ber. [tsytuietsia 13 Ber. 19]:[blyzko 8 str.]. Dostupno za adresoiu: http://2balla.net/Ekologiya/Util-zac-ya-v-dhod-v-harchovo-promislovost.html
11. Manzhesov VY, za red. Tekhnolohyia pererabotki produktsii rasteniievodstva. SPb: HYORD; 2016.
12. Bandurenko HM, Levkovskaia TN. Tekhnolohiia polucheniia karotinsoderzhashchikh obohatitelei. Nauka sehodnia: teoriia, metodolohiia, praktika, problematika: sbornik nauchnykh dokladov. 2014 iiul;7:34-36.
13. Bandurenko HM, Levkivska TM, Bezusov AT. Kompleksna resursozberihaiucha pererobka morkvy z otrymanniam polifunktsionalnykh kharchovykh dobavok. Naukovi pratsi ONAKhT. 2010;37:211-214.
14. Perfilova OV, Mitrokhin MA. Ispolzovanie poroshkov iz plodoovoshchnykh vyzhimok s tseliu rasshireniia assortimenta muchnykh konditerskikh izdelii. Dostizheniia nauki i tekhniki APK. 2008;8:48-50.
15. Mironov MI, Kudrina AN. Primenenie rastitelnoho syria v tekhnolohii muchnykh konditerskikh izdelii. Innovatsionnaia tekhnika i tekhnolohiia. 2017;4:36-40.
16. Chuiko AM. Opornyi konspekt lektsii z navchalnoi dystsypliny «Innovatsiini tekhnolohii» dlia studentiv za napriamom pidhotovky 7.14010101 «Hotelna i restoranna sprava», haluzi znan 1401 «Sfera obsluhovuvannia». Khark. Torh.-ekonom. inst. kyiv. nats. torh.-ekonom. un-tu. [Internet]. 2013 [tsytuietsia 15 Kvit. 19]:[blyzko 42 str.]. Dostupno za adresoiu: https://studfiles.net/preview/5647497/
17. Shapovalenko OI, Yevtushenko OO, Ulianych IF. Ekstruduvannia zerna z dodavanniam ovochevykh komponentiv kormu. Khranenye i pererrabotka zerna. 2012;11:62-63.
18. Shapovalenko O, Evtushenko O, Ulianich Y. Svoistva smesi yachmenia i ovoshchnykh komponentov pri ekstrudirovanii. Kombikorma. 2013;8:40-42.
19. Iegorov B. et al. The study of production regimes and quality parameters of extruded feed additive based of corn seed and substandard egg mass. Eureka: Life Sciences. 2016;:3(3):26-35.
20. Braterskii FD. Otsenka kachestva syria i kombikormov. M.: Kolos; 1983.
21. Yehorov BV, za red. Tekhnolohiia kombikormovoho vyrobnytstva: metod. Vkazivky. Odesa: ONAKhT; 2010.
22. Yehorov BV, za red. Orhanizatsiia tekhnokhimichnoho i tekhnolohichnoho kontroliu na pidpryiemstvakh haluzi: metod. vkazivky. Odesa: ONAKhT; 2011.
23. Huliaeva L, Erisanova O. Effektivnost ispolzovaniia v ratsionakh kur Lipovitama Beta. Ptitsevodstvo. [Internet]. 2010 [tsytuietsia 16 Ber 19]; 12:[blyzko 11 str.]. Dostupno za adresoiu: http://webpticeprom.ru/ru/articles-veterinary.html?pageID=1302799623
24. Reznichenko LB. Beta-karotin i eho rol v orhanizme ptitsy. Ptitsevodstvo. 2003;1:20-22.
25. Reznichenko LB. Effektivnost v ratsionakh kur beta-karotina raznoho proiskhozhdenyia. Zootekhniia. 2003;1:18-19.
26. Briukhno OIu i dr. Effektivnost ispolzovaniia premiksov v kormlenii teliat. Izvestiia Nizhnevolzhskoho ahrouniversitetskoho kompleksa. 2014;33(1)163-169.
27. Arnautovskii ID, Huseva SA. Znachenie balansiruiushchikh BVMD i tseolitov v ratsionakh korov dlia polucheniia ekolohicheski chistoho moloka v usloviiakh Priamuria. Zootekhniia. 2009;4:9-11.
28. Yehorov BV, Malaki IS. Analiz effektivnosti ispolzovaniia razlichnykh kaltsiisoderzhashchikh mineralnykh kormovykh dobavok v kormlenii selskokhoziaistvennoi ptitsy. Naukovi pratsi ONAKhT. 2013;44(1):38-40.
29. Panin I. Kukuruza kak komponent kombikorma. Kombikorma. 2006;6:67-68.
30. Kokić B et al. Influence of thermal treatments on starch gelatinization and in vitro organic matter digestibility of corn. Food & Feed Research. 2013;40(2):93-99.
31. Tica NLj et al. The effect of extruded corn on the economic results of broilers production. Food & Feed Research. 2009;36(3-4):59-64.
32. Yehorov B et al. Development of technology of using substandard eggs in farm poultry feeding. Eastern-European Journal of Enterprise Technologies. 2016:4:11(82):4-14. DOI: 10.15587/1729-4061.2016.76106
33. Birh MO, za red. Spravochnik po mikrobiolohicheskim i virusolohicheskim metodam issledovaniia. M.: Meditsina;1982.

# ДОСЛІДЖЕННЯ ВПЛИВУ ТЕПЛОВОЇ ОБРОБКИ НА ЯКІСТЬ КОРМОВОЇ ДОБАВКИ З ВИКОРИСТАННЯМ МОРКВЯНИХ ВИЧАВКІВ

**Б.В. Єгоров,** доктор технічних наук, професор, *E-mail*: bogdanegoroff58@gmail.com
**І.С. Чернега,** кандидат технічних наук, доцент, *E-mail*: ilonamalaki@gmail.com
**Л.В. Фігурська,** кандидат технічних наук, доцент, *E-mail*: fihurska@gmail.com
**О.Г. Цюндик,** кандидат технічних наук, ст.викладач, *E-mail*: malik2008ts@gmail.com
Кафедра технології комбікормів і біопалива
Одеська національна академія харчових технологій, вул. Канатна, 112, м. Одеса, Україна, 65039

**Анотація.** Головним завданням галузі комбікормової промисловості є розробка та впровадження високопродуктивного обладнання та технологій, розширення ресурсної бази та асортименту готової продукції. Поряд з цим у консервному виробництві утворюється велика кількість побічних продуктів. За хімічним складом вони не поступаються основним продуктам. Однак побічні продукти консервної промисловості характеризуються високим вмістом вологи. Вони дуже швидко псуються і вимагають негайної утилізації. Тому метою роботи було вивчення впливу термічної обробки на фізико-хімічні властивості, кількісний та якісний склад мікрофлори кормової добавки з використанням морквяних вичавків. Визначено фізичні властивості, хімічний склад, санітарну якість та допустимий термін зберігання морквяних вичавків. Досліджено обґрунтований кількісний та якісний склад кормової добавки.

Встановлено, що проведення процесу екструдування покращує фізичні властивості, підвищує засвоюваність поживних речовин, а також покращує санітарний стан та подовжує термін зберігання кормової добавки. Внаслідок процесу екструдування кормової добавки вміст вологи зменшився на 32,2%, кут природнього укосу збільшився на 11,8%, сипкість зменшилась на 33,3%, вміст зруйнованого крохмалю зменшився на 33,2%, а кількість водорозчинних вуглеводів зросла в 5 разів. Крім того, під впливом високої температури та тиску загальна кількість бактерій зменшилася на 89%, а пліснявих грибів – на 83%. Під час зберігання кормової добавки протягом 6 місяців кількість МАФАнМ зменшилась на 32,5%. Отримана кормова добавка вирішує проблему утилізації побічних продуктів консервної промисловості, розширює сировинну базу та зменшує витрати кормів.

**Ключові слова:** морквяні вичавки, хімічний склад, фізичні властивості, мікрофлора, екструдування, добавка, зберігання.

**Список літератури:**

1. Олексієнко В.О., Фучаджи Н.О., Червоткіна О.О. Раціональне використання відходів виробництва морквяного соку // Праці ТДАТУ. 2012. Вип. 12, Т. 4. С. 216-221.
2. Горун Е.Г. Безотходная технология рыбоперерабатывающих производств. М.: МГУТУ, 2004. 80 с.
3. Єгоров Б.В., Чернега І.С. Розробка і використання нетрадиційних кормових добавок при годівлі курей-несучок // Зернові продукти і комбікорми. 2016. №1 (61). С. 39-46.
4. Wadhwa M., Bakshi M. P. S. Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value-added products. India: FAO, 2013. 58 p.
5. Дослідження процесу сушіння морквяних вичавок при одержанні сухої каротиновмісної добавки / Малежик І.Ф. та ін. // Вісник Харківського національного технічного університету сільського господарства імені Петра Василенка. 2014. Вип. 152. С. 150-156.
6. Changes in в-Carotene During Processing of Carrots/Knockaert Griet et.al. // Processing and Impact on Active Components in Food. 2014. P. 11-16. DOI: 10.1016/B978-0-12-404699-3.00002-0
7. Колобов С.В., Памбухчиянц О.В. Товароведение и экспертиза плодов и овощей. М.: Издательскоторговая корпорация «Дашков и К°», 2012. 400 с.
8. Екологічна проблема сучасності / Волкова Н. та ін. // Харчова і переробна промисловість. 2009. № 9-10 (356-357). С. 25-26.
9. Yegorov B., Malaki I. Effect of heat treatment on quality of feed additive using tomato pomace // Eastern-European Journal of Enterprise Technologies. 2014. Vol. 4, № 10 (70). P. 48-53. DOI: 10.15587/1729-4061.2014.26229
10. Утилізація відходів харчової промисловості. 2 балла.net: веб-сайт. URL: http://2balla.net/ (дата звернення: 13.03.2018).
11. Технология переработки продукции растениеводства / за ред. В.И. Манжесова. СПб.: ГИОРД, 2016. 816 с.
12. Бандуренко Г.М., Левковская Т.Н. Технология получения каротинсодержащих обогатителей//Наука сегодня: теория, методология, практика, проблематика: сборник научных докладов, 30-31 июл. 2014 г./Сопот «Diamond trading tour», 2014. Ч. 7. С. 34-36.
13. Бандуренко Г.М., Левківська Т.М., Безусов А.Т. Комплексна ресурсозберігаюча переробка моркви з отриманням поліфункціональних харчових добавок // Наукові праці ОНАХТ. 2010. Вип. 37. С. 211-214.
14. Перфилова О.В., Митрохин М.А. Использование порошков из плодоовощных выжимок с целью расширения ассортимента мучных кондитерских изделий // Достижения науки и техники АПК. 2008. №8. С. 48-50.
15. Миронов М.И., Кудрина А.Н. Применение растительного сырья в технологии мучных кондитерских изделий // Инновационная техника и технология. 2017. № 4. С. 36-40.
16. Чуйко А.М. Опорний конспект лекцій з навчальної дисципліни «Інноваційні технології» для студентів за напрямом підготовки 7.14010101 «Готельна і ресторанна справа», галузі знань 1401 «Сфера обслуговування»//Харк. Торг.-економ. інст. київ. нац. торг.-економ. ун-ту. Харків, 2013. 42 с. URL: https://studfiles.net/preview/5647497/ (дата звернення 15.04.2018).
17. Шаповаленко О.І., Євтушенко О.О., Улянич І.Ф. Екструдування зерна з додаванням овочевих компонентів корму // Хранение и перерработка зерна. 2012. №11. С. 62-63.
18. Шаповаленко О., Евтушенко О., Улянич И. Свойства смеси ячменя и овощных компонентов при экструдировании // Комбикорма. 2013. № 8. С. 40–42.
19. The study of production regimes and quality parameters of extruded feed additive based of corn seed and substandard egg mass / Iegorov B. et.al. // Eureka: Life Sciences. 2016. Vol. 3 (3). P. 26–35.
20. Братерский Ф.Д. Оценка качества сырья и комбикормов. М.: Колос, 1983. 320 с.
21. Технологія комбікормового виробництва: метод. Вказівки / за ред. Б.В. Єгорова. Одеса: ОНАХТ, 2010. 60 с.
22. Організація технохімічного і технологічного контролю на підприємствах галузі: метод. вказівки/за ред. Б.В. Єгорова. Одеса: ОНАХТ, 2011. 82 с.
23. Гуляева Л., Ерисанова О. Эффективность использования в рационах кур Липовитама Бета // Птицеводство. 2010. №12. URL: http://webpticeprom.ru/ru/articles-veterinary.html?pageID=1302799623 (дата обращения 16.03.2018)
24. Резниченко Л.В. Бета-каротин и его роль в организме птицы // Птицеводство. 2003. № 1. С. 20-22.
25. Резниченко Л.В. Эффективность в рационах кур бета-каротина разного происхождения // Зоотехния. 2003. №1. С. 18-19.
26. Эффективность использования премиксов в кормлении телят/Брюхно О.Ю. и др. // Известия Нижневолжского агроуниверситетского комплекса. 2014. Т. 33. № 1. С. 163-169.
27. Арнаутовский И.Д., Гусева С.А. Значение балансирующих БВМД и цеолитов в рационах коров для получения экологически чистого молока в условиях Приамурья // Зоотехния. 2009. № 4. С. 9-11.
28. Егоров Б.В., Малаки И.С. Анализ эффективности использования различных кальцийсодержащих минеральных кормовых добавок в кормлении сельскохозяйственной птицы // Наукові праці ОНАХТ. 2013. Вип. 44. Том 1. С. 38-40.
29. Панин И. Кукуруза как компонент комбикорма // Комбикорма. 2006. № 6. С. 67-68.
30. Influence of thermal treatments on starch gelatinization and in vitro organic matter digestibility of corn/Kokić B. et.al. // Food & Feed Research. 2013. Vol. 40. № 2. C. 93-99.
31. The effect of extruded corn on the economic results of broilers production / Tica N.Lj. et.al. // Food & Feed Research. 2009. Vol. 36. № 3-4. P. 59-64.
32. Development of technology of using substandard eggs in farm poultry feeding / Egorov B. et.al. // Eastern-European Journal of Enterprise Technologies. 2016. Vol. 4 № 11 (82). P. 4-14. DOI: 10.15587/1729-4061.2016.76106
33. Справочник по микробиологическим и вирусологическим методам исследования / за ред. М.О. Бирга. М.: Медицина, 1982. 178с.