Effect of dihydroquercetin on the stability of the properties of rendered fats

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Abstract. To reduce the negative effects of the oxidative effects of oxygen during fat storage, the use of antioxidants is provided, but currently the synthetic ones are mainly used, and some of them can have a toxic effect on the human body if proper concentration is not maintained. The article presents data on the effect of an antioxidant of natural origin - dihydroquercetin – on the stability of the properties of rendered fats during storage. As the material for the study, we used rendered elk fat and beef fat with dihydroquercetin (control) and without dihydroquercetin (experiment). Dihydroquercetin was administered in a 1% alcohol solution in the amount of 0.01%, 0.03%, 0.05%, 0.07% and 0.09% of the mass of raw materials. In the process of work, the generally accepted methods of studying the development of oxidative spoilage were used by determining the acid, peroxide and thiobarbituric numbers. The conducted research led to the conclusion that the inhibitory property of dihydroquercetin is directly dependent on its concentration, the higher its proportion in the product, the lower the indicators of oxidative spoilage. Depending on the type of fat, this additive in the amount of 0.01% allowed to prolong the shelf life of the product by a factor of 1.7 to 3.7 on average.

1. Introduction

To give meat and meat-containing products the necessary tenderness, juiciness, nutritional and energy value, a variety of fat-containing raw materials is used. Edible rendered fat is used in meat production as a substitute for such raw materials.

During the storage of fats, complex chemical processes occur in them, which are characterized by the fact that fats acquire a specific smell and unpleasant, sometimes bitter taste.

When fats become rancid volatile low molecular weight compounds are formed, causing the peculiar rancid smell. These compounds are ascertained to include aldehydes, ketones, and low molecular weight acids.

The oxidation process, which is typical for rendered fats, can be significantly suspended with the help of antioxidants that have the property of prolonging the induction period, i.e. the period when the oxidation processes in fat have not yet developed.
Antioxidants are administered in extremely small doses – usually in thousandths and hundredths of a percent of fat mass. The effect of antioxidants is due to their ability to interact differently with intermediate products of the oxidation reaction – hydroperoxides of hydrocarbons (- ROOH), free radicals (R+) and peroxide (RO2+) radicals, as well as to break the reaction chains by capturing active organic fat radicals [1,2,3].

This paper presents the results of the study of the antioxidant capacity of dihydroquercetin produced by Ametis JSC (Russia, Amur region, Blagoveshchensk) when it is added to rendered elk and beef fat when stored at a temperature of -18°C in consumer containers made of polymer materials.

Dihydroquercetin (DHA) is a natural bioflavonoid, a vitamin of the P group, obtained by extracting the crushed butt log portion of Siberian, Daurian and Gmelin larch, which is the richest in extractive substances and is a waste product of logging and wood processing enterprises.

The chemical name of dihydroquercetin is 3,5,7,3,4-Penta-hydroxyflavanone. The IUPAC nomenclature name is (2R,3R)-2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxy-2,3-dihydrochromene-4-one. The chemical formula is C_{15}H_{12}O_{7}. The molecular weight is 304.25 g/mol.

In Russia, this substance is included in the list of permitted food additives and is recommended for use in the production of food products as one of the recipe components.

2. Materials and methods

As the material for the study, we used elk fat, beef fat (control) and elk fat, beef fat with dihydroquercetin (experiment). Dihydroquercetin was administered in a 1% alcohol solution in the amount of 0.01%, 0.03%, 0.05%, 0.07% and 0.09% of the mass of raw materials.

According to the current regulatory documentation (GOST 25292-2017), the recommended shelf life of rendered fat is 6 months, in this regard, the development of oxidative spoilage in the presence of additives was estimated by the values of acid (GOST R 55480-2013), peroxide (GOST 34118 – 2017) and thiobarbituric (GOST R 55810 – 2013) lipid numbers of the fats under study compared to control samples (samples of fat without dihydroquercetin added) on the 0th, 90th, 180th and 216th days of storage. Reserve ratio is 1.2.

There is no normative technical documentation for elk fat, so it was decided to adhere to Sanitary Regulations and Standards (SanPiN) 2.3.2.1078-01 "Hygienic requirements for safety and nutritional value of food products” in estimation of quality. For beef fat, GOST 25292-2017 “Rendered edible animal fats. Technical conditions” was used as well.

3. Investigation of the effect of dihydroquercetin on the stability of the properties of rendered fats during storage

The study of oxidative changes in elk fat (Figure 1-3) established the inhibitory effect of dihydroquercetin on the oxidation process. In all the experimental samples, regardless of the DHA concentration added, there was an inhibition of the spoilage present.

At the beginning of elk fat storage, the amount of free fatty acids (acid number (AN)) in all the samples was 1.16 mg KOH/kg. During subsequent storage, the control sample showed an increase in the acid number: on the 216th day there was an increase by a factor of 4.7 with respect to day 0, while the sample with a concentration of 0.01% – by a factor of 2.1, and the one with a concentration of 0.03% – by a factor of 1.5. There is no established difference between the AN of samples with 0.05%, 0.07% and 0.09% DHA. The AN increase averaged 1.3 times. The comparison of the studied samples parameters to those of the control sample on day 216 established a decrease in the growth of the acid number by a factor of 2.2 (0.01%), 3.1 (0.03%), 3.5 (0.05%) and 3.7 (0.07%) and 3.8 (0.09%).
The content of primary oxidation products (peroxide number (PN)) on day 0 in all samples amounted to 2.40 mmol of active oxygen/kg. Throughout the whole storage period the samples demonstrated growth in peroxide value: on day 216 day as compared to day 0 in the control sample PN increased 3.3 times, in the sample with a concentration of 0.01% – 1.6 times, with a concentration of 0.03% – 1.5 times. The difference between the PN of samples with a concentration of 0.05% and 0.07% was within the limits of experimental error and the PN growth amounted to 2.8 times, and in the 0.09% sample – to 2.9 times. The data obtained for the samples with the antioxidant indicate its pronounced inhibitory effect. The comparison of the studied samples parameters to those of the control sample on day 216 established a decrease in the peroxide number 2.0 (0.01%), 2.3 (0.03%), 2.7 (0.05%) and 2.8 (0.07%), and 2.9 (0.09%) times.

The amount of malonic aldehyde (thiobarbituric number (TN)) during storage in all samples also increased. On day 216, the thiobarbituric number increased 6.5 times compared to day 0 for the control sample, 2.4 times for a sample with the concentration of 0.01%, 2.1 times for a sample with the concentration of 0.03%, 2 times for a sample with a concentration of 0.05% and 1.9 times on average for samples with concentrations of 0.07% and 0.09%. The difference between the TN of samples with 0.07% and 0.09% of DHA was within the error range. The comparison of the studied samples parameters to those of the control sample on day 216 established a decrease in TN 2.7 (0.01%), 3.1 (0.03%), 3.3 (0.05%) and 3.4 (0.07%), and 3.7 (0.09%) times.

Figure 1. The dynamics of the acid numbers of elk fat during its storage

Figure 2. The dynamics of the peroxide numbers of elk fat during storage
At the end of the storage period, the acid number of the control sample did not meet the requirements of regulatory and technical documentation, while the samples with dihydroquercetin did and did not exceed 4 mg KOH/g. The peroxide number of the control sample was of questionable freshness, the samples with DHA were fresh. Analyzing the data obtained, it can be noted that the use of such an antioxidant can extend the shelf life of rendered elk fat 2 – 3.8 times.

The results of the study of oxidative changes in beef fat (Figure 4-6) also allow us to note the negative effect of dihydroquercetin on the oxidation process in all the studied samples with its presence.

Also, as in the previous study, all samples showed an increase in the amount of free fatty acids (acid number (AN)). The acid number of the control sample for the entire storage period compared to day 0 increased by 4.5 times, the sample with a concentration of 0.01% - 2.7 times, with a concentration of 0.03% -2.3 times, with a concentration of 0.05% - 1.9 times, with a concentration of 0.07% - 1.7 times and with DHA 0.09% - 1.5 times consequently. The comparison of the studied samples parameters to those of the control sample on day 216 established a decrease in AN by 1.7 (0.01%), 2.0 (0.03%), 2.4 (0.05%) and 2.7 (0.07%), and 2.9 (0.09%) times.

Similarly, in the content of primary oxidation products (peroxide number (PN)), there was a tendency to the increasing of this indicator in the control sample by day 216 compared to day 0 - 3.2 times, while in the samples with the concentration of DHA from 0.01% to 0.09% the process of inhibition of the spoilage process was observed. The growth of peroxide numbers in the experimental samples was 1.6,
1.5, 1.2, (0.01 – 0.05%) and 1.1 times (0.07 – 0.09%), respectively. The comparison of the studied samples parameters to those of the control sample on day 216 established a decrease in PN 2.0 (0.01%), 2.2 (0.03%) and 2.7 (0.05%). The difference in the samples with the 0.07% and 0.09% concentration of DHA is not reliable, it averaged 2.9 times.

Figure 5. The dynamics of the beef fat peroxide numbers during storage

On day 216, the amount of Malone aldehyde (thiobarbituric number (TN)) in the samples increased 4.5 times compared to day 0 in the control sample, and 2.6 times in the sample with a concentration of 0.01%. In samples with a concentration of DHA of 0.03%, 0.05% and 0.07%, the difference between the values of thiobarbitur numbers was not detected. On average, TN increased 1.7 times, therefore, the conclusion can be made about the expressed inhibitory ability of the antioxidant. In the 0.09% DHA sample TN increased 1.5 times. The comparison of the studied samples parameters to those of the control sample on day 216 established a decrease in TN 1.2 (0.01%), 2.1 (0.03%), 2.5 (0.05%) and 2.8 (0.07%), and 3.0 (0.09%) times.

Figure 6. The dynamics of the thiobarbituric numbers of beef fat during storage

All the tested samples at the end of the storage period according to the acid number indicators in accordance with the requirements of the current regulatory documentation were attributed: the control sample – to below the first grade, samples with 0.01% and 0.03% DHA – to the first, samples with 0.05%–0.09% – to the highest. According to the indicators of peroxide number, the control sample was of questionable freshness, close to spoiled, samples with the concentration of 0.01% and 0.03% – fresh, non storage, the remaining samples with DHA were fresh. All tested samples met the requirements of
SanPiN 2.3.2.1078-01 "Hygienic requirements for food safety and nutritional value". Analyzing the data obtained, it can be noted that the use of such an antioxidant can extend the shelf life of rendered beef fat 2–2.9 times.

4. Conclusion

Studies of the effect of dihydroquercetin on the stability of the properties of food fats during storage have allowed making the conclusion that the inhibiting property of DHA is directly dependent on its concentration, the higher the proportion of dihydroquercetin in the product, the lower the indicators of oxidative spoilage.

Taking into account the maximum permissible concentration of antioxidants for rendered fats – 0.02% according to the recommendations of FAO/WHO, restrictions TRCU 029/2012, GOST 25292-2017, it can be noted that the use of dihydroquercetin in the amount of 0.01% allows to prolong the shelf life of fat on average 1.7 – 3.7 times, depending on the type of fat.

Special attention should be paid to the fact that some permitted antioxidants in the fat and oil industry (butyloxyanisol, butyloxytoluene, butylhydroquinone, etc.) at high concentrations in the product can have a toxic effect on the human body, while DHA is a non-toxic food additive [4].

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