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THE USE OF STABILIZED FRYING FAT IN THE PRODUCTION OF POTATO CHIPS

***Olena KOVALENKO[1], Vladimir KOVBASA[1], Irina RADZIEVSKA[1]**
[1] *Department of Bakery and Confectionery Goods Technology, National University of Food Technology*
Volodymyrska str. 68, Kyiv, Ukraine, 01601, alenkala@ukr.net
**Corresponding author*
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Abstract: *The influence of natural and synthetic antioxidants of phenolic nature on the oxidation process of blended fats in deep-frying conditions was studied. It was established that heat treatment leads to accumulation of products of thermal destruction in all investigated samples. To slow the oxidation process down during frying potato chips, antioxidants were added to the investigated samples of frying fat. All the antioxidants used slow down effectively the process of oxidation, but their effectiveness varies. From the analysis of the dynamics of oxidation process it is possible to conclude that the use of the complex additive BHT + BHA-PD 50070-5e as antioxidant in frying fat is a potential advantage.*

Keywords: *antioxidant, chips, frying fat, grease, snacks.*

1. Introduction

Over the past 10 years, persistent adverse changes in the structure of nutrition of the population of Ukraine were observed, including a sharp decline in consumption of biologically valuable products - meat, milk, eggs, fish, vegetables, fruits, vegetable oils, while relatively stable high level of consumption of bread, potatoes and animal fats. Modern trends in nutrition and high pace of life contribute to the growth of consumption of fast food. Deep-fried products, like chips, cakes, donuts, sweet twigs, etc. have great success among consumers. A common product in many sectors of the population, especially the young generation became potato chips, which is a kind of snack. Consumption of potato chips in Ukraine is estimated at 0.5 kg capita per year. In Europe the figure ranges from 1 to 5 kg, in the United States it reaches 10 kg per year [1].

Despite the fact that sunflower oil is commonly used for deep-frying, in its physical, chemical and consuming properties, it is not ideal for this purpose. Prolonged heating, at high temperatures, causes profound changes in its quality. Therefore, in the process of frying it is better to use special heat-resistant oils, which allows preparing five times more products than with the same volume of sunflower oil. The largest suppliers of frying fat on the market of Ukraine are «BEARS Company» and «Trilini International». The raw material for the production of frying fat is vegetable hydrogenated fat, sunflower oil, palm oil and transesterificated grease. Most types of frying fat for frying in an intensive mode are produced from selectively hydrogenized sunflower or other oil, which is determined by the prices of raw materials and its availability in the market. Ukrainian scientific - research institute of oils and fats developed recipes to cooking fat "Frytyurniy", the raw material for the production of which is hydrogenated fat,

palm oil, palm olein and transesterificated grease [2], [3].

Prolonged deep-frying at the temperature of 140 - 180°C is changing the quality of fats: they darken, acquire a sharp odor and a bitter taste [4]. These effects are caused by the formation of primary and secondary oxidation products. The primary ones are peroxides, hydroxides; their content is determined by the peroxide number (PN). They irritate the walls of the digestive tract and liver, resulting in inflammation of these organs in severe forms. Secondary products of oxidation of fats are aldehydes, ketones, epoxides, polymeric compounds; their content is correlated with the value of the anisidine number (AN). Dangerous are the products of radical oxidation, the concentration of which exceeds maximum content standards. Recent studies have found that the high content of products of radical lipid oxidation in the tissues of people provoke diseases such as atherosclerosis, cancer, premature aging, Alzheimer's disease and Parkinson's disease.

Reducing the rate of accumulation of oxidation products is possible by adding antioxidants into fat. Butylated hydroxyanisole, propyl gallate, and polymethyloxane added in amount of 0.5-2.0 mg / kg slow down significantly oxidation and polymerization processes that occur during frying. Inhibition of oxidative processes with antioxidants helps to preserve food and biological value of both the oil and the fried product.

Quality control of frying fat is a crucial element of reducing risks to the health of consumers of these products. Research of deep-frying fat is conducted to confirm its quality and the quality of deep-fried products.

2. Materials and methods

This research is devoted to finding an active antioxidant for frying fat for the production of potato chips. The research was conducted on samples of liquid frying fat of the following composition: №1 - palm olein 40% + corn oil 30% + rapeseed oil 30% and №2 -corn oil 50% + rapeseed oil 50%. As a control sample the sunflower oil, which is widely used in Ukraine for frying was chosen. Experimental and control samples were used for frying potato petals at a temperature of 160°C for 210 ± 30 sec. To prevent the oxidation of fats under thermal impact, antioxidants: TocoblendL 70 IP by company "Bipraym" - a mixture of tocopherols (α-tocopherol 9-20%, β-tocopherol 1-4%, γ-tocopherol 50-65%, δ-tocopherols 20-35 %) in sunflower oil were used; BHT (Butylated hydroxytoluene 100%) of the company "Bipraym"; complex antioxidant BHT + BHA-PD 50070-5e (see composition) of the company «Marisa». The control of oxidation was determined by monitoring the value of the PN and AN by standard methods [5], [6]. Roasting was stopped when PN reached over 10 mmole ½O/kg, and/or AN over 6 conventional units.

3. Results and discussion

Through the influence of a number of factors that initiate thermal oxidation of fats today we do not have a universal method of preventing oxidative deterioration of fat-containing products [7]. For this reason, it is necessary to assess the main factors of oxidation of fats and choose the appropriate measures of their inactivation in each case. Currently, the main way to increase the oxidative stability is the addition of antioxidants and their synergists. However, the approach to the antioxidant protection of each food system should be individual.

Practically, potato chips can contain up to 42% fat [ISO 4608: 2006], which is in contact with air and exposed to high temperatures during frying. Therefore, in this case an effective way to protect

products from oxidation is to add antioxidants into frying fat before the beginning of the process and in the process of frying. Scientific results obtained in previous studies allowed choosing samples of blended frying fats: №1 - palm olein 40% + corn oil 30% + rapeseed oil 30%, and №2 - corn oil 50% + rapeseed oil 50%, which are characterized by high biological value due to the balanced fatty acid composition. To slow the oxidation during frying of potato chips antioxidants were added in grease. Natural and synthetic antioxidants of phenolic nature authorized by the Ministry of Health of Ukraine for use in food in Ukraine and Europe were used.

When deep-frying potato slices weighing 70 ± 15 g in oil with the addition of antioxidants and without them for 5 h, period of possible application of oil in these conditions, at a temperature of 160°C, PN and AN were monitored (Table 1) every 60 minutes. To study the effectiveness of antioxidants of blended oils they were added according to the recommendations of the manufacturer in the amount of 0.02% of weight before frying.

Table 1.

Dynamics of thermal oxidation of samples of frying fats

Sample	The duration of frying, min.							
	PN, [mole½O/kg]				AN, [conventional units]			
	0	60	180	300	0	60	180	300
Control sample – sunflower oil	2.00	4.00	9.04	15.30	4.17	5.60	8.17	11.15
№1 – palm olein 40% + corn oil 30% + rapeseed oil 30%								
Without additives	3.80	6.29	9.36	11.90	0.67	1.96	2.90	6.63
TocoblendL 70 IP	2.72	5.70	9.43	11.11	0.50	2.07	3.29	5.50
BHT+BHA-PD 50070-5e	2.22	4.05	6.75	7.40	0.48	2.13	3.44	4.08
BHT	2.22	4.60	7.53	10.62	0.50	2.09	3.62	5.25
№2 – corn oil 50% + rapeseed oil 50%								
Without additives	4.82	7.24	9.70	14.36	0.74	4.18	6.17	9.25
TocoblendL 70 IP	4.50	6.12	8.60	13.10	0.58	4.18	5.93	6.57
BHT+BHA-PD 50070-5e	4.50	5.21	7.95	10.36	0.46	2.39	3.37	4.37
BHT	4.53	6.39	8.09	12.90	0.46	3.15	4.28	5.69
n=3, Δ±0.5								

By analyzing the results of the above table, we can see that all the additives slow down the oxidation of blended fats, but their effectiveness varies. In our studies the most effective antioxidant appeared to be the BHT + BHA-PD 50070-5e in both studied samples of fat. This comprehensive antioxidant shows the inhibitory effect in the processes of both primary and secondary oxidation, which is set by the values of PN and AN. Obviously, this is explained by inactivation of free radicals, which rate is higher than the processes that occur when adding other antioxidants. Other additives also show high stabilizing properties. Specifically, it was found that BHT and TocoblendL 70 IP, added in the same dose, actively stabilize the thermal oxidation of blended fats, when the first is relatively a more active antioxidant.

It is possible to explain the discovered impact of studied antioxidants in terms of

the chemistry of oxidation. The process of oxidation of vegetable oil is a free radical chain process that can be described by the following stages [8], [9]:

Initiation:

$RH + O_2 \rightarrow R\cdot + OH$

Development:

$R\cdot + O_2 \rightarrow ROO\cdot$

$ROO\cdot + RH \rightarrow ROOH + R\cdot$

Breakage:

$R\cdot + R\cdot \rightarrow RR$

$R\cdot + ROO\cdot \rightarrow ROOR$

$ROO\cdot + ROO\cdot \rightarrow ROOR + O_2$

In the first initiation phase a free radical is formed from the lipid substrate under the influence of the initiator. Branching chain is a result of the radical collapse of the hydroperoxides that are the only primary oxidation products. With the presence of an inhibitor in oils an additional channel of consumption of peroxide radicals appears:

$ROO\cdot + InH \rightarrow ROOH + In\cdot$

$ROO\cdot + In\cdot \rightarrow$ *molecular products*

It is known that antioxidants destroy free radicals in fats, giving them hydrogen and turning into relatively stable radicals with lower recovery potential [10]. Higher stability of the antioxidant radical compared to the radicals of fat is the result of resonance delocalization in the structure of the phenolic ring of the antioxidant, which is lost in the first place [11], [12].

During the oxidation of saturated fatty acids saturated hydroperoxides are formed, while during the oxidation of unsaturated fatty acids - unsaturated hydroperoxides. In this case the oxidation is not due to the addition of oxygen to the double bond of the acid, but as a result of the separation of hydrogen from the methylene group located adjacent to the double bond. During the oxidation of linoleic acid hydroperoxides with the two conjugated double bonds can be formed. The formation of cyclic peroxides happens as a result of addition of oxygen at the place of the double bond of the acid. In the thermal oxidation unstable primary products - hydroperoxides are formed, which break down to form secondary oxidation products - epoxides, aldehydes, ketones and other products. Simultaneous control of the content of oxidation products is possible by a combined indicator of full fat oxidation [13]. TOTOX, the integral indicator of the oxidation that takes into account the total number of primary and secondary oxidation products, was calculated as TOTOX= 2PN+AN. Figure (1) shows the progress of the oxidation of the studied blended frying fats with added antioxidants and without them.

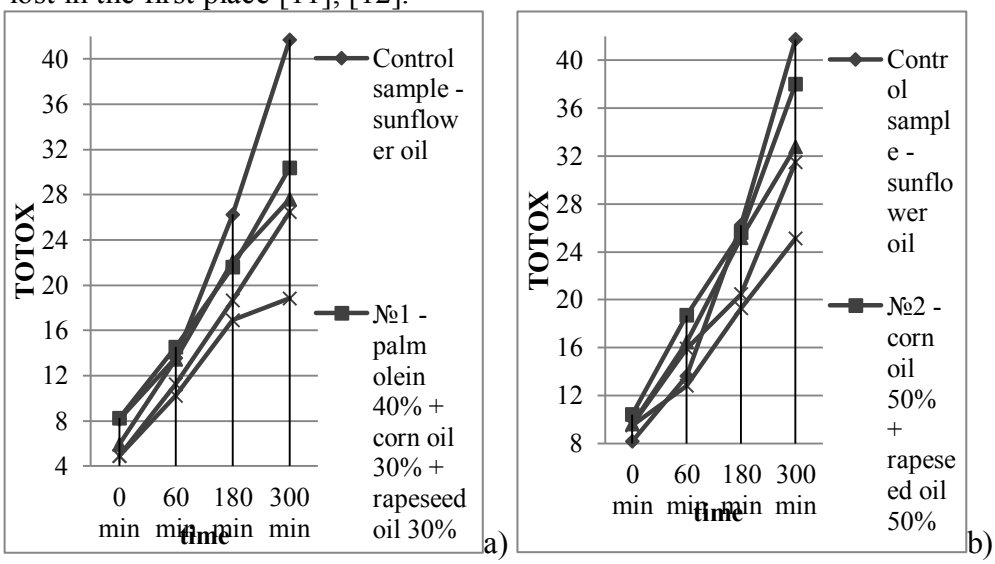

Figure 1. Oxidation of blended frying fats with addition of antioxidants (a), and without them (b).

Figure (1) shows that heat treatment leads to accumulation of thermal degradation in all investigated samples. All applied antioxidants effectively slow down the process of oxidation, but their effectiveness varies. Analyzing the dynamics of the process of oxidation it is possible to conclude about the potential advantage of the use of the complex additive BHT + BHA-PD 50070-5e as an antioxidant for frying fat. In particular, after 300 minutes of heat treatment the rate of accumulation of oxidation products decreased from 41.75 conventional units in the control sample to 18.88 conventional units in the №1 blend and to 25.09 conventional units in the №2 blend. Thus, the effectiveness of the antioxidant impact of this additive when added to a blend №1 is 2.2 times and when added to a blend №2 – 1.7 times. The discovered effects of prolongation of slowing the degradation of blended fats can be explained in terms of the mechanism of processes of oxidation and stabilization of lipids. In our view, a comprehensive antioxidant BHT + BHA-PD 50070-5e inactivates free radical oxidation products in the fat turning at the same time in relatively stable radicals with low recovery potential. Probably, this higher activity of this additive compared to other used antioxidants is the result of mutual influence of atoms in the structure of the rings of phenolic molecules of butylated hydroxytoluene, butylated hydroxyanisole, butylated hydroquinone in its composition [11], [12]. In addition, the high efficiency of inhibiting free radicals can be explained by relatively lower dissociation energy of the O-H phenol connection in the structure of these molecules. Since the antioxidant with low dissociation energy is a more efficient hydrogen donor in the reactions of oxidation chain breakage, therefore he is a more effective antiradical agent [14], [15]. So, higher (better) antiradical activity of the complex antioxidant BHT + BHA-PD 50070-5e is explained by the synergistic effect between the molecules of its active components. This leads to a rapid transfer of electrons from these molecules to peroxyl radicals of fat and as a result to a rapid breakage of the reaction of formation of oxidation products. The observed synergy phenomenon is explained by the ability of molecules of butylated hydroxytoluene, butylated hydroxyanisole and butylated hydroquinone in a complex antioxidant to transfer hydrogen of a phenolic group simultaneously to peroxyl, alkoxyl and alkyl radicals, thus slowing down the formation of both primary and secondary oxidation products.

4. Conclusion

It is shown that one of the ways to increase the quality of potato chips is the use of antioxidant supplements during frying. Mechanisms of oxidation and stabilization of blended frying fats in terms of thermal oxidation were analyzed. It is obvious high efficiency of the complex antioxidant BHT + BHA-PD 50070-5e, consisting of butylated hydroxytoluene, butylated hydroxyanisole, tertiary butylated hydroquinone and ether of citric acid of mono- and diglycerides of fatty acids (E471).

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