ДОСЛІДЖЕННЯ ЯКОСТІ ХАРЧОВИХ ПРОДУКТІВ

UDC 637.181=111 DOI: https://doi.org/10.31617/tr.knute.2020(34)09

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FORMATION OF QUALITY OF MILK ANALOGUE FROM GREEK FENUGREEK SEEDS

The impact of heat treatment on the chemical composition of fenugreek seeds is analyzed. Tests of its amino acid composition and the content of mono- and disaccharides show that the Maillard reaction does not result in essential changes in the taste and aromatic properties of the raw material. It is found that heat treatment changes the fatty acid composition of the seeds, with reducing the quantity of linoleic acid which enzymatic oxidation forms the compound 1-octen-3-ol that may cause the mushroom-specific smell of the seeds.

Keywords: plant-based milk analogues, fatty acid composition, drink, quality, amino acid composition taste, smell, consumer, Maillard reaction.

Мотузка Ю., Кошельник А. Формирование качества аналога молока из семян пажитника греческого. *Проанализировано влияние термической обработки на химический состав семян пажитника греческого. Исследованиями аминокислотного состава семян пажитника греческого и состава моно- и дисахаридов установлено, что протекание реакции Майяра существенно не влияет на изменение вкусовых и ароматических свойств сырья. Установлено, что после термической обработки происходит изменение жирнокислотного состава семян, в частности уменьшение линолевой кислоты, в результате ферментативного окисления которой образуется соединение 1-октен-3-ол, что, вероятно, и обусловливает формирование грибного запаха семян.*

Ключевые слова: аналоги молока растительного происхождения, жирнокислотный состав, напиток, потребительские свойства, жирные кислоты, вкус, запах, потребитель, реакция Майяра.

Background. The consumer choice of food products is subject to many factors of which critical ones are taste and flavor. But these indicators are largely dependent on type and quality of the raw material used in making a food product, and its treatment methods. It is especially important in the production of plant-based milk analogues from a certain type of vegetable raw material, which organoleptic properties may limit the consumption of a finished product.

Thus, drinks made of soya have a specific smell of beans, resulting from the activity of the lipoxeginase enzyme. In the soya beans, aldehydes and ketones are formed, such as hexanal, hexane, ethyl vinyl ketone, which give the products made of soya beans specific herbaceous smacks and smells [1]. The almond bitterness is caused by the content of amygdalin glycoside. Also, there are some plants containing groups of substances such as saponines and tanines, which cause a bitter astringent aftertaste and a specific smack [2]. Today there exist many methods designed to suppress or weaken the feeling of unpleasant taste or smell in food products. Their choice is conditional on a substance that causes bitterness, herbaceous smell, etc.

It should be noted that the demand for plant-based milk analogues tends to grow, which raises the need in searching for new types of raw materials. Considering chemical composition, easiness of cultivation methods, availability of a home-grown raw material and affordable price, plant-based milk analogues can be effectively produced using fenugreek seeds that also contain a number of substances giving it a specific taste and smell. We believe that of all the factors with impact on the finished product quality, an important one is investigating the impact of heat treatment on change in the chemical composition of fenugreek and, eventually, its taste and smell.

Analysis of recent research and publications. The impact of fatty acid compositions of products on the formation of their consumer properties of lipids is highlighted in Grimble R. [3]. The impact of fatty acid composition of lipids on the formation of consumer properties of products is highlighted in Grimble R. [3]. Investigations of the amino acid and fatty acid composition of fenugreek seeds are shown in Al-Jasass F. M., Moneim A. E. S., Beyzi E., Rahman M. M., Feyzi S. et al. [4–10]. But mechanisms behind the impact of selected factors (heat treatment in particular) on the amino acid and fatty acid composition of fenugreek seeds and the resulting impact on organoleptic indicators of fenugreek seeds have been out of the research focus.

The aim of work is to test the impact of heat treatment on the chemical composition of fenugreek seeds.

Materials and methods. The research subject is fenugreek seeds of domestic origin, harvested in the year of 2019. The varietal purity is 99 %.

The mass share of mono- and disaccharides of fenugreek seeds is determined by the method of highly effective liquid chromatography, the mass share of the amino acid composition is determined by liquid-column ion exchange chromatography [11] using the automatic analyzer of amino acids AAA 400 manufactured by "*Ingos – Laboratory Instruments*" (Czech Republic), and the fatty acid composition was determined by the method of gas chromatography, on the chromatograph *HRGC 5300* (Italy) [12].

The computations were conducted for the dry substance of the product, i. e. with account for the evaporated liquid.

Results. Fenugreek seeds contain large quantities of terpenoids that cause its slightly bitter taste. Although terpenoids have some useful properties, their content complicates technologically the consumption of seeds either as constituents of food products or separately. There are various methods to reduce a bitter taste of a vegetable raw material, but most of them are intended to remove the substances that cause a product's smack. However, many of these substances, terpenoids in particular, have biological effects important for the human body. They stimulate the appetite and the function of gastrointestinal tract, and have anti-microbe effects [13]. Therefore, as their total exclusion may have negative consequences for the chemical composition of finished products, other ways for suppressing bitter tastes should be sought for. According to literary sources, most often the bitterness in beans, soya in particular, is suppressed by use of high temperatures [14–17]. As mentioned above, it was decided to subject fenugreek seeds to heat treatment (15 minutes long frying at the temperature of 180°C) with constant stirring. Five minutes later, a persistent mushroom flavor was felt, which increased before by the time of ending heat treatment. Also, the bitter taste was found to be enhanced, whereas for other beans its reduction was observed. Considering the analysis of the chemical composition of the seeds, i. e. large quantities of proteins and carbohydrates, it was assumed that heat treatment of the product could probably result in the formation of melanoidins as chemical reaction products. However, as the color was nearly unchanged, it can be assumed that the quantity of produced melanoidins was insignificant, i. e. they could not have an essential impact on the seeds taste. To obtain reliable evidence for the conditions of the Maillard reaction, we tested the amino acid composition of fenugreek seeds *(Table 1)* and the fractional composition of carbohydrates before and after frying.

18 amino acids were identified in the seeds, with the largest shares of glutamic acid, aspartic acid, arginine, leucine and lysine. The above given data show that the frying of fenugreek seeds resulted in a slight decrease of amino acid concentration (the loss of arginine made 12.1 %; lysine – 11.9 %), which allows us to suggest the reaction of melanoidins formation. The slightly increased quantity of ammonia (from 0.23 to 0.24 g/100 g of product) also confirms the occurrence of such reaction.

Table 1

The amino acid composition of fenugreek seeds before and after heat treatment

Amino acid	Concentration, g/100 g of product	
	before	after
	heat treatment	
Aspartic acid	3.19	2.84
Threonine	0.93	0.84
Serin	1.26	1.18
Glutamic acid	4.65	4.02
Proline	1.18	1.03
Glycine	1.28	1.20
Alanine	1.13	1.03
Cystine	0.19	0.14
Valine	0.95	0.83
Methionine	0.19	0.12
Isoleucine	1.30	1.13
Leucine	1.87	1.75
Tyrosine	0.93	0.74
Phenylalanine	1.19	1.01
Histidine	0.74	0.65
Lysine	1.93	1.70
Arginine	2.90	2.55
Tryptophan	0.39	0.27

We believe that the enhanced bitter taste of the seeds after heat treatment can be attributed to the changing amino acid composition of fenugreek seeds. It is known that arginine has the explicitly bitter taste, whereas amino acids methionine, histidine and lysine contribute in the formation of bitter aftertaste in food products [18]. The reduced quantity of amino acids after heat treatment may indicate that the products of their decay were peptides having bitter taste. There are many bitter peptides containing N-terminal cyclized glutamic acid. Also, it is known that aspartic acid and proline have sweet aftertaste and, in combination with glutamine acid, cause a pleasant taste of food products [19]. It should be noted that the overall quantity of these amino acids essentially reduced in time of frying, in contrast to the amino acids with a bitter aftertaste.

Results of testing mono- and disaccharides for the mass share are given in *Table 2*.

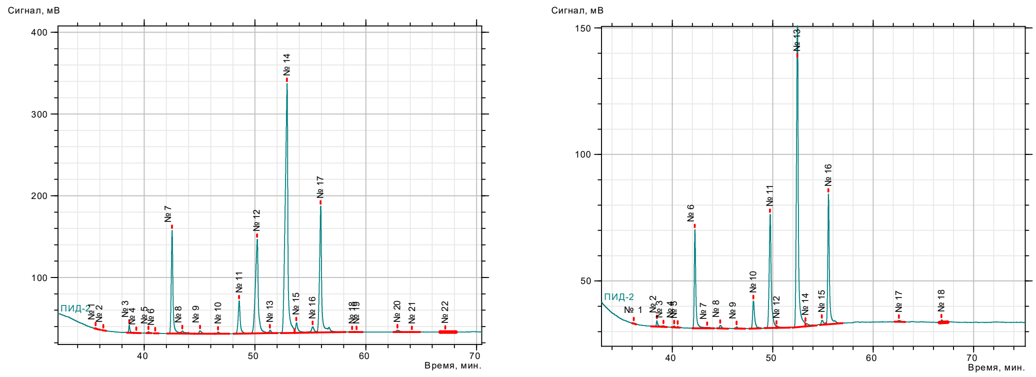
Table 2

The carbohydrate composition of fenugreek seeds before and after heat treatment

Carbohydrate	Concentration, g/100 g of product	
	before	after
	heat treatment	
Sucrose	0.021	0.016
Glucose	0.049	0.045
Galactose	0.038	0.035

It was found that fenugreek seeds contained sucrose, glucose, and galactose involved in the Maillard reaction, with an insignificant reduction in their quantity after heat treatment. However, as these sugars have weak activity, it can be assumed that the Maillard reaction cannot cause essential change in the taste and flavor properties of the raw material. An insignificant change in the fenugreek seeds color can be attributed to the content of galactose in it, which is a hexose with highest ability to form brown pigments.

It is worth to be assumed that change in the product flavor and taste is caused, by far and large, by the fatty acid composition of the seeds and its change in time of heating. The produced chromatograms are presented in *Figure 1*.



a) Before heat treatment *b)* After heat treatment

Figure 1. The fatty acid composition of fenugreek seeds before and after heat treatment

The above given data demonstrate changes of the peaks No 6, 11, 13, 16 upwards, and changes of peaks No 12, 14, 17 downwards. The fatty acid composition of fenugreek seeds is shown in *Table 3*.

Table 3

The fatty acid composition of fenugreek seeds before and after heat treatment

Fatty acid	Concentration, g/100g of product	
	before	after
	heat treatment	
Lauric	0.070	0.065
Lauroleic	0.017	–
Myristine	0.491	0.752
Myristolein	0.068	0.154
Pentadecane	0.113	0.117
Nerve	0.035	0.067
Palmitic	9.823	11.368
Palmitoleic	0.602	0.207
Margarine	0.487	0.498
Heptadecene	0.262	0.384
Stearin	4.215	4.078
Elaidin	17.651	17.790
Oleic	0.354	0.467
Linolelaidine	43.343	41.517
Linoleic	1.579	0.830
Arachinic	1.255	0.851
γ-linolenic	18.643	19.951
α-linolenic	0.073	–
Geneukosan	0.064	–
Behenic	0.469	0.410
Digomo-γ-linolenic	0.092	–
Arachidonic	0.293	0.494

The results of testing show that fenugreek seeds contain 22 fatty acids, which are mostly saturated fatty acids. It should be noted, however, that their quantity is insignificantly higher than the one of mono- and polyunsaturated fatty acids. Monounsaturated fatty acids include lauroleic, myristolein, nerve (omega-9), palmitoleic, heptadecene, elaidin (omega-9), oleic (omega-9) acids. They largest share of them is with elaidin acid (17.7 % of the total mass of all the fatty acids). Polyunsaturated fatty acids include linolelaidine, linoleic, γ-linolenic, α-linolenic, digomo-γ-linolenic and arachidonic acids, with the prevalence of linolelaidine (43.3 %) and γ-linolenic (18.6 %) acids. Of the saturated acids, the following ones were found: lauric, myristine, pentadecane, palmitic, margarine, stearin, arachinic, geneukosan, behenic, with larger shares of palmitic (9.8 %) and stearin (4.2 %) acids. In overall, the content of polyunsaturated fatty acids is nearly twice higher in fenugreek seeds than the content of monounsaturated and saturated ones.

Heat treatment results in the increased content of the following acids: myristine, myristolein, pentadecane, nerve, palmitic, margarine, heptadecene, elaidin, oleic, γ-linolenic and arachidonic acid. A relatively higher quantitative increase was found only for palmitic (from 9.8 to 11.4 %) and γ-linolenic (from 18.6 to 20.0 %) acid. Yet, some of the fatty acids could not be identified after heating, namely: lauroleic, α-linolenic, geneukosan and digomo-γ-linolenic acid. Most part of them is monounsaturated, thus confirming that heat treatment of the seeds prior to making products thereof is not advisable.

It is known that heat treatment leads to the formation of free fatty acids and secondary products of oxidation, which may cause the increasing content of some fatty acids. It should be assumed that the increased content of palmitic acid may result from the interaction of synthetase (palmityl synthetase) contained in higher fatty acids with glucose; the quantity of γ-linolenic acid changed due to the interaction of linoleic and α-linolenic acids [19]. As regards the changed taste and aromatic properties of fenugreek seeds (the occurrence of the mushroom flavor and the enhanced better taste), this may be caused by the enzyme oxidation processes provoked by temperature. It is known that most part of the fatty acids have no specific taste or smell, but their oxidation can result in the formation of aromatic substances that have effects for organoleptic properties of a finished product or raw material. According to data from literary sources, the mushroom smell is caused by the organic compound 1-octen-3-ol formed in the process of oxidetion decay of linoleic acid under the impact of hydroperoxide lipases [20].

Conclusion. Fenugreek seeds contain the substances giving it bitter taste. Technical means often used to reduce the bitterness in beans did not demonstrate the expected results, as the bitterness became even more persistent. It was found, however, that the temperature effect made seeds change their smell that became mushroom-specific.

It is revealed that the reaction of melanoid formation could not have essential effects for the taste and flavor of the seeds.

The assumption that the changed the amino acid composition after heat treatment of the seeds has effects for their organoleptic properties could be confirmed. 22 fatty acids were identified, with the prevalence of elaidin, linolelaidine, γ-linolenic, palmitic and stearin acids. The quantity of polyunsaturated fatty acids exceeds the content of monounsaturated and saturated one by 1.7 times. Heat treatment changed the fatty acid composition by increasing the quantities of palmitic and γ-linolenic acids. The reduced quantity of linoleic acid resulted from its oxidation processes due to the effect of hydroperoxide lipases and the formation of the compound 1-octen-3-ol that might cause the mushroom-specific smell of the product.

Further research is expected to focus on finding ways to produce milk analogues from fenugreek seeds without its heat treatment (frying) and other methods for suppressing specific smell and taste.

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The article submitted to editor's office on 31.05.2020.

Мотузка Ю., Кошельник А. Формування якості аналога молока з насіння пажитника грецького.

Постановка проблеми. На вибір споживачів впливає багато чинників, одними з вирішальних є смак та аромат харчових продуктів. Ці показники, своєю чергою, переважно залежать від виду і якості сировини та способів її обробки.

Особливо це актуально для виробництва аналогів молока рослинного походження з певного виду рослинної сировини, органолептичні властивості якої можуть обмежити вживання готового продукту. Нині доцільним для виробництва аналогів молока рослинного походження є використання насіння пажитника грецького. Саме тому актуальним є дослідження впливу термічної обробки на зміни хімічного складу насіння пажитника грецького та формування його смаку і запаху.

Мета роботи – дослідити вплив термічної обробки на хімічний склад насіння пажитника грецького.

Матеріали та методи. Предмет дослідження – насіння *пажитника грецького* вітчизняного походження врожаю 2019 р. Сортова чистота становить 99 %.

Масову частку моно- та дисахаридів насіння пажитника грецького визначено методом високоефективної рідинної хроматографії, амінокислотного складу – рідинно-колонковою йонообмінною хроматографією із використанням автоматичного аналізатора амінокислот *AAA 400* виробництва фірми *"Ingos – Laboratory Instruments"* (Чехія), жирнокислотний склад – методом газової хроматографії на хроматографі *HRGC 5300* (Італія).

Розрахунки проводили на суху речовину продукту, тобто з урахуванням випаровування вологи.

Результати дослідження. Визначено, що вплив температури обумовлює певні зміни запаху насіння, зокрема продукт набуває вираженого грибного відтінку.

Встановлено, що протікання реакції меланоїдиноутворення не могло суттєво вплинути на смак і аромат насіння.

У насінні ідентифіковано 22 жирні кислоти, з яких переважають елаїдинова, лінолелаїдинова, гамма-ліноленова, пальмітинова та стеаринова. Зміни в жирнокислотному складі після теплової обробки демонструють збільшення пальмітинової та гамма-ліноленової кислот. Відбулося зменшення лінолевої кислоти, що пов'язано з процесами її окиснення під дією гідропероксидних ліпаз та утворення сполуки 1-октен-3-ол.

Висновки. Дослідженнями амінокислотного складу насіння пажитника грецького та складу моно- та дисахаридів визначено, що протікання реакції Майяра суттєво не впливає на зміни смакових і ароматичних властивостей сировини.

Припущення, що зміни у жирнокислотному складі після термічної обробки насіння впливають на його органолептичні показники, підтверджено. Ідентифіковано 22 жирні кислоти. Кількість поліненасичених жирних кислот переважає вміст мононенасичених і насичених у 1.7 раза. Зменшення лінолевої кислоти пов'язане з процесами її окиснення під дією гідропероксидних ліпаз та утворення сполуки 1-октен-3-ол.

Ключові слова: аналоги молока рослинного походження, жирнокислотний склад, напій, якість, амінокислотний склад, смак, запах, споживач, реакція Майяра.