

PAPER • OPEN ACCESS

Biotechnological techniques of the formation of the quality of carotenoid-containing smoothie

To cite this article: E D Rozhnov *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **640** 052018

View the [article online](#) for updates and enhancements.

The 17th International Symposium on Solid Oxide Fuel Cells (SOFC-XVII)
DIGITAL MEETING • July 18-23, 2021

EXTENDED Abstract Submission Deadline: February 19, 2021



SUBMIT NOW →

Biotechnological techniques of the formation of the quality of carotenoid-containing smoothie

E D Rozhnov¹, M N Shkolnikova², A O Kazarskikh¹ and E A Ereemeev³

¹Biysk Technological Institute (branch) of Altay State Technical University, 27, Hero of the Soviet Union Trofimov St., Biysk, 659305, Russia

²Ural state University of Economics, 62, March 8 St., Yekaterinburg, 620144, Russia

³Shukshin Altai State Humanities Pedagogical University, 53, Vladimir Korolenko St., Biysk, 659333, Russia

E-mail: red@bti.secna.ru

Abstract. The data on the possibility of getting drinks enriched with carotenoids have been obtained (a smoothie using pumpkin (*Cucurbita pepo* L.) and sea buckthorn juice (*Hippophaë rhamnoides* L.) as raw materials. Smoothie is a source of micro- and macronutrients, minor components of food – vitamins, provitamins, polyphenolic substances, among them carotenoids, which have a wide range of physiological effects (including antioxidant) and indispensability can be distinguished. The relevance of the study lies in the practical possibility of adding to the diet a carotenoid-enriched drink from local plant materials, which potentially reduces the risks of degenerative diseases. We used in this work a commodity-technological approach, based on a comprehensive study of the quality of raw materials, semi-finished products and drink samples. As a result of this investigation a technology of fruit and vegetable smoothie with high organoleptic characteristics, due to enzymatic hydrolysis of starch contained in the pulp of a pumpkin, was proposed. This biotechnological technique can significantly increase the consumer properties of pumpkin puree by removing the unpleasant taste of starch. In general, the suggested technology allows you to get a smoothie with a pronounced aroma of sea buckthorn, a sweet and sour taste, a homogeneous, non-stratified consistency, with a carotenoid content of 1.98 mg/100 g, which allows satisfying about 40% of the daily need for carotenoids with a single portion of the drink.

1. Introduction

The concept of healthy nutrition means that the most preferable is the use of fresh food or with minimal thermal treatment [1]. In this aspect, an interesting solution is the development of smoothie technology from plant materials containing a large number of biologically active substances (biologically active (bioactive) compounds). Smoothie can be an effective source of micro- and macronutrients, especially for people with specific dietary needs, for example, for children and aged people. A necessary condition for maintaining a high level of metabolism in these age groups is the consuming of a sufficient amount of water, providing the body with energy of different substances (mainly glucose), as well as minor components of food, primarily vitamins, provitamins and polyphenolic substances [2, 3, 4]. Unfortunately, today in the diet of the vast majority of Russians there are not enough products with immunostimulating, general strengthening and radioprotective effects. However, a wide range of products and drinks can be obtained from plant raw materials grown



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

in the country using appropriate technologies, preserving most of the biocomponents necessary for the normal functioning of the body. At the same time, the use of a significant number of fruits, berries, vegetables and products of their processing in the diet is crucial, since they are sources of not only necessary nutrients, but also biologically active compounds [5, 6].

Fat-soluble carotenoids can be distinguished into a separate group from all the components of plant materials due to the wide spectrum of physiological effects, as well as indispensability, since animal organisms are not capable of their biosynthesis. The pronounced antioxidant effect of carotenoids is expressed in their ability to prevent damage by complete or partial dissipation of the energy of singlet oxygen atoms and to react with free radicals formed in the body [7, 8].

2. The purpose of the study

Among plant materials rich in carotenoids and perspective for use in smoothie technology, the fruits of pumpkin (*Cucurbita pepo* L.) and sea buckthorn (*Hippophaë rhamnoides* L.) can be distinguished. The purpose of this study is to obtain a smoothie from pumpkin and sea buckthorn using biotechnological methods and to evaluate the quality of prototypes.

3. The object of the study and methods

The objects of the study were fresh pumpkin pulp of the “Gribovskaya”, “Altai Bush” and “Winter Sweet” cultivars, pumpkin puree, juice from the “Chuiskaya” sea buckthorn berries and smoothie samples.

The organoleptic characteristics of the samples of pumpkin puree, sea buckthorn juice and smoothie were evaluated at a temperature of 22 °C and natural light by the following indicators: taste, color, sweetness, fragrance, and consistency. The physicochemical parameters of the investigated objects were determined by standard methods: the carbohydrate content was determined by the chemical method according to GOST 13192-73, the total titrated acid content was determined by the potentiometric method according to GOST 25555.0-82, and the mass fraction of carotenoids (in β -Carotene terms) was determined according to GOST 8756.22-80.

4. Discussion of the results

The results of the study of physicochemical parameters of the feedstock (raw material) for smoothie are presented in table 1.

Table 1. Physicochemical characteristics of raw materials

Parameter	Recommended intake [9]	Pumpkin cultivars			Fruits of sea buckthorn “Chuiskaya” cultivar
		Gribovskaya	Altai Bush	Winter Sweet	
Mass fraction of carbohydrates, %	257–586 g/day	4.68±0.08	5.21±0.07	6.87±0.05	7.26±0.14
Mass fraction of titrated acids ¹ , %	–	0.11±0.02	0.10±0.01	0.14±0.01	0.94±0.03
Mass concentration of carotenoids, mg/100 g	5 mg/day (β -Carotene)	1.33±0.12	1.49±0.09	1.62±0.11	2.17±0.08

¹In terms of malic acid

Pumpkin mash, as the basis for smoothie, was prepared by grinding and whipping fresh pumpkin pulp. To do this, the pumpkin pulp was separated from the skin, seeds and seed pulp, cut into 3×3 cm pieces and blended. As a series of experiments showed, despite the high degree of grinding of pumpkin pulp with a hand blender with a “knife” nozzle, the product remains with a heterogeneous structure, exfoliating into a liquid fraction and solid particles, without forming a homogenate. The resulting product is slurry with low organoleptic characteristics, pronounced vegetable taste with an

unpleasant taste of starch. To increase the nutritional value and improve the organoleptic characteristics of the smoothie, enzymatic cleavage of starch was carried out with the enzyme preparation Termamil 2XL, which represents thermostable bacterial α -amylase.

Taking into account the absence of β -amylase activity in the preparation, there is no need for a maltose pause at a temperature of 62–63°C. Thus, to conduct starch hydrolysis, the enzyme preparation was added in amounts from 0.1 to 0.5% with an equal concentration range. The duration of hydrolysis at 75°C was estimated by an iodine sample at time intervals of 5 minutes. The iodine sample was studied using microscope to clarify the completeness of hydrolysis (Figure 1).

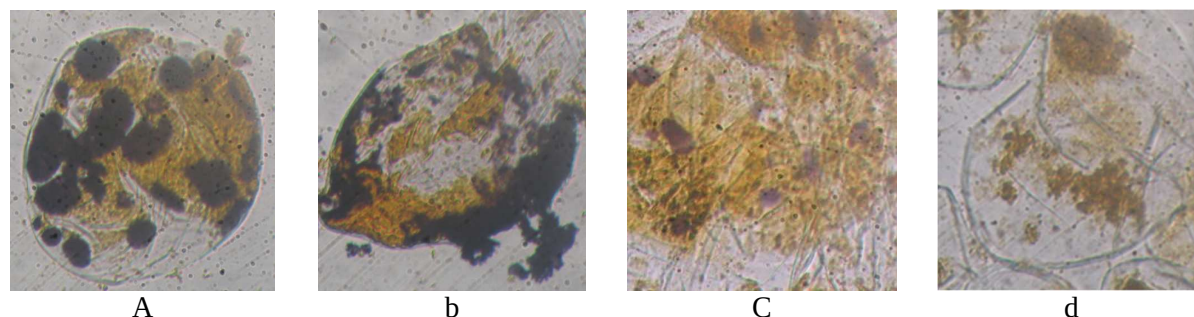


Figure 1. a – pumpkin starch granules before enzymatic treatment; b – partial hydrolysis of starch granules (20 minutes, 0.04% of enzyme preparation); c – partial hydrolysis of starch granules under the action of amylase (40 minutes, 0.04%); d – pumpkin pulp cells with dissolved starch grains (60 minutes, 0.04% of enzyme preparation)

As the organoleptic analysis showed, the unpleasant starchy taste became almost imperceptible, the consistency is partially heterogeneous, but within the framework of the developing concept of the drink, this rheological feature gives a visual feeling of the presence of fruit pulp in the composition of the drink, which is a significant external characteristic for the consumer. Table 2 presents the results of the study of pumpkin pulp after fermentolysis.

Table 2. Physicochemical characteristics of fermented pumpkin puree

Parameter	Pumpkin cultivar		
	Gribovskaya	Altai Bush	Winter Sweet
Mass fraction of carbohydrates, %	5.04±0.11	5.87±0.08	7.18±0.08
Mass fraction of titrated acids (in terms of malic acid), %	0.13±0.02	0.11±0.01	0.17±0.02
Mass concentration of carotenoids, mg/100 g	1.36±0.07	1.51±0.05	1.64±0.07

Taking into account the low sugar content in pumpkin and sea buckthorn, sugar syrup was used as a sweetener, the amount of which was determined by calculation. Smoothie samples were prepared containing 40.0, 50.0 and 60.0% of pumpkin puree, 25% of freshly squeezed sea-buckthorn juice in a basket press, and also 2.5, 5.0 and 7.5% of sugar (the rest volume we filled up with water (up to 1 dm³).

The highest organoleptic rating was given to a smoothie sample containing 60% of pumpkin puree, 25% of sea buckthorn juice, and 50 g/dm³ of sugar. In the drink, a rather strong aroma of sea buckthorn was noted; the taste is sweet and sour without extraneous smacks. The drink had a homogeneous, non-stratified consistency.

Table 3 presents the physicochemical characteristics of the prepared smoothie.

Table 3. Physicochemical characteristics of smoothies

Parameter	Value
Mass fraction of carbohydrates, %	5.02±0.03
Mass fraction of titrated acids (in terms of malic acid), %	0.48±0.03
Mass concentration of carotenoids, mg/100 g	1.98±0.04

Thus, taking into account the recommended rate of daily intake of carotenoids in the human body, the use of 250 ml of smoothie according to the developed recipe and technology will satisfy up to 40% of this need.

5. Conclusion

Pumpkin fruits, in particular the “Winter Sweet” cultivar, as well as the “Chuisakaya” sea-buckthorn juice, can be used as raw materials for getting smoothies rich in carotenoids. The presented technology makes it possible to obtain drinks with high organoleptic characteristics when they contain 25% of sea buckthorn juice, 60.0% of pumpkin puree, which is achieved by improving the consumer characteristics of the last component due to enzymatic hydrolysis of starch with amylase enzyme preparation Termamil 2XL.

The data obtained during the studies allow us to draw reasonable conclusions about the high content of carotenoids in the finished smoothies from sea buckthorn and pumpkin, which provides the functional properties of the finished product. The developed technological concept allows satisfying about 40% of the daily need for carotenoids with the use of one portion of the drink.

References

- [1] Bogonosova I A and Vasyukova A T 2019 Development of vegetable production of prophylactic with protein fortification elements *Proceedings of Voronezh State University of Engineering Technologies* **81** (2) 223–229 (In Russ.) <https://doi.org/10.20914/2310-1202-2019-2-223-229>.
- [2] Dye L, Lluch A and Blundell J E 2000 Macronutrients and mental performance *Nutrition* **16** (10) 1021–1034 [https://doi.org/10.1016/S0899-9007\(00\)00450-0](https://doi.org/10.1016/S0899-9007(00)00450-0)
- [3] Adolphus K, Lawton C L and Dye L 2013 The effects of breakfast on behavior and academic performance in children and adolescents. Review *Front Hum Neurosci* **7** (425) 425 <https://doi.org/10.3389/fnhum.2013.00425>
- [4] Enghardt H B, Pearson M and Becker W 2006 Summary: dietary habits and nutrient intake in Swedish children 4 year old and schoolchildren in grade 2 and 5 *National Food Administration*.
- [5] Boeing H, Bechthold A, Bub A, Ellinger S, Haller D, Kroke A et al. 2012 Critical review: vegetables and fruit in the prevention of chronic diseases *European Journal of Nutrition* **51** (6) 637–663. <https://doi.org/10.1007/s00394-012-0380-y>
- [6] Ovcharenko A S, Rasulova E A, Ivanova O V and Velichko N A 2018 Blended fruit and vegetable juices based on small-fruited apples, pumpkin, mountain ash and honey *Proceedings of Voronezh State University of Engineering Technologies* **80** (3) 111–115 (In Russ.) <https://doi.org/10.20914/2310-1202-2018-3-111-115>
- [7] Terao J, Minami Y and Bando N 2011 Singlet molecular oxygen-quenching activity of carotenoids: relevance to protection of the skin from photoaging *Journal of Clinical Biochemistry and Nutrition* **48** 57–62 <https://doi.org/10.3164/jcbrn.11-008FR>
- [8] Fanny R, Simona B, Stéphan C, Christian T, Jean-Luc R and Michel H 2012 Chemical Quenching of Singlet Oxygen by Carotenoids in Plants *Plant Physiol* **158** 1267–1278 <http://dx.doi.org/10.1104/pp.111.182394>
- [9] 2009 *Norms of physiological needs in energy and food substances for various population groups of the Russian Federation MR 2.3.1.2432-08* (Moscow: Federal center for hygiene and epidemiology of Rospotrebnadzor) (In Russ.)