Yacón and Scorzonera as functional enrichment of food

Alla Bashta[1], Nadija Ivchuk[1], Olexandr Bashta[2]
1 - National University of Food Technologies, Kiev, Ukraine
2 - National Aviation University, Kiev, Ukraine

Introduction. The aim of this work was to determine the polysaccharides composition such non-traditional plant materials as Salsify and Yacón and enrichment of food with selected raw materials.

Materials and methods. Determined content of polysaccharides in the roots of the Yacón and Scorzonera rhizomes, purees and powders from them by known methods. The content of pectin substances recognized by the gravimetric method, inulin content was determined by the method of Bertrand. Determination of the mass fraction of cellulose based on the decomposition of all other organic compounds concentrated nitric acid in a mixture of acetic and trichloracetic acids.

Results and discussion. Scorzonera hispanica and Yacón - valuable enough root vegetables for their nutritional and biological properties. In our researches used Yacón variety Udine, of about 20 cm length, diameter 10 cm, dry substances – 16% and the content of inulin 7 %, fructose 5 %, cellulose 0.6 %.

Scorzonera rhizomes are used with dry substances – 15 %, the content of inulin 5.7 %, pectin 0.9 %, and cellulose 0.8 %.

As in purees and powders of analyzed raw materials the general trend of the high content of inulin, for Yacón (41.5 – 42.3 % on dry substances) and Scorzonera (37 – 38.2 % on dry substances) and cellulose for Yacón (2.8 - 3.4 % on dry substances) and (3.1 – 3.7 % for Scorzonera on dry substances), is kept. This proves the feasibility to using of processed products to the Yacón and Scorzonera as functional supplements in the technology of wellness products.

At the same time, the results showed the complexity of implementing functional enrichment of certain food products by making the puree recipe, because it contains only 15 to 18% dry substances, and 6.3 to 7.5 % inulin accordingly, and 0.7 to 1.2 % cellulose. Therefore, in most food technologies, the use of puree in the less amount of than 15% by weight of the product do not give reason to expect functional enrich effect.

The use of selected raw materials powder for food products can significantly improve the content of dietary fiber, because powder as Scorzonera, as Yacón with a high content of dry substances (89 - 90%) contains a significant amount of polysaccharides.

Possibility of Yacón and Scorzonera powder using for the ice cream of healthy destination obtaining was examined.

Based on the results of researches, the best dose to make creamy ice cream functional fortificant are 3-4% powder of Scorzonera or Yacón.

Conclusions. As Scorzonera hispanica as Yacón contain significant amounts of polysaccharides, in particular inulin which has a prebiotic properties, and makes them a valuable raw material for use in the field of healthy nutrition.

Keywords: *polysaccharides, Scorzonera hispanica, Yacón, inulin*.

Introduction. Recent studies have shown that in the whole world there is a deficit of polysaccharides, which leads to the development of various diseases, such as cardiovascular, gastrointestinal tract, diabetes mellitus. This is due to the lack of food consumption rich in polysaccharides - raw vegetables and fruits; excessive content in food, refined foods, almost deprived of cell membranes (sugar, rice, flour).

The majority of nutritionists believe that the ration should contain at least 30-40 grams of dietary fiber, while the average person consumes about 13 grams, so a deficiency of these nutrients is about 15-20 grams a day.

Of great interest in theoretical and practical terms, is studying the possibility of using non-traditional supplements rich in polysaccharides. One of the most important polysaccharides that have prebiotic properties is inulin. Sources of inulin have such plant material as the Jerusalem artichoke (Helianthus tuberosus), Yacón (Polymnia sonchifolia), Dandelion (Taraxacum officinale), Burdock (Arctium lappa), Chicory (Cichorium intybus), Salsify or Kozelets (Scorzonera hispanica), and Dahlia (Dahlia pinnata) [1-13].

Nutritionists and endocrinologists are increasingly paying their attention to such inulin rich plant as Yacón. It is uncommon for Europe and little-studied vegetable. The root tubers of Yacón contain up to 60% of inulin in terms of dry substance. Fresh tubers to Yacón after harvesting and curing for several days on the sun with the purpose of accumulation of sugars may contain about 19% hydrolyzed to fructose inulin [7-14].

In addition, Yacón in large quantities contains such valuable macro - and micronutrients, as potassium, calcium, sodium, phosphorus, iron, copper, zinc and vitamins C, E, B_1, B_2 and B_{12}. The composition of the root tubers are all noncontiguous amino acid. Content of noncontiguous amino acid in Yacón protein is considerably larger than the protein of wheat, corn, soybean [2, 7, 10, 14, 15, 16, 17].

Today Yacón introduced in the United States, New Zealand, southern Europe, Iran, Japan, Uzbekistan and Moldova.

In the analysis of fresh root tubers from plants to Yacón grown in the region of natural origin, American researchers have found content 69-83 % water, 0.4 to 2.2% protein and 20 % sugar. Dried root tubers contain 6-7 % protein, 0.4 to 1.3% of fats, 4-6% cellulose and about 65% of sugars. Yacón leaves contain flavonoids, sesquiterpenoid and other substances that are characterized by antioxidant and anti-stress properties, and are the cytoprotectors [14, 15].

The high yield of Yacón (28-100 t/ha) and high content of inulin and other BAS (Biological active substances) makes it a valuable raw material for the food and pharmaceutical industry [18-19]. This culture is multi-use, namely: 1 - vegetable (the use in food of root tubers and young shoots); 2 - fodder (using all parts of the plant for animals food); 3 - technical (production of natural syrups with high fructose) and fuel alcohol; 4 - medical (in root tubers with a high content of fructose in the form of oligofructan that is useful for people suffering from diabetes) [20].

The Salsify belongs to the family astrina. There are 170 species of this plant. Scorzonera homeland is the coast of the Mediterranean Sea. This plant is famous in

the countries of Western Europe and the USA. Unfortunately, in our country this is a root almost forgotten [18, 21, 22]. The Salsify or Kozelets is the very valuable for its nutritional and medicinal properties plant. Rhizomes valuable content of polysaccharides in an amount of about 17 %, which presents inulin - 13-16 %, pectin - 3-5%, and fiber – 1.5 -2.5 %. The amino acid composition represented by the following amino acids (mg/100g): arginine – 14.97, glutamine - 238, lysine - 127, leucine - 151, phenylalanine - 86, valine - 76. Biological value of protein root Scorzonera due to the high content of arginine 1497 mg/100g and the amount of proline, alanine and threonine 1031 mg/100g [21-27].

The aim of this work was to determine the polysaccharides composition such non-traditional plant materials as Salsify and Yacón and exploring the possibilities for its further use to obtain wellness products.

Considering the fact that currently organism modern population there is a shortage of polysaccharides, which leads to the development of many "diseases of civilization" such as cardiovascular disease, atherosclerosis, obesity, diabetes, selection and study of this material, is relevant. Selected non-traditional raw materials, Yacón and Salsify are a significant source of polysaccharides, but also contain a number of minerals, vitamins, flavonoids, and amino acids.

Materials and methods. The subjects of research are the roots of Yacón and rhizomes of Scorzonera, purees and powders from them.

In our researches used Yacón variety Udine. Externally, the root tubers of Yacón are from darken to purple-brown, but inside they are white, yellow, and sometimes slightly purple. Taste - crisp, refreshing, slightly sweet, like fresh-picked apples with a soft scent in combination pears with melon. Used root tubers have length of about 20 cm, diameter 10 cm, dry substances – 16% and the content of inulin 7 %, fructose 5 %, cellulose 0.6 %. From root tubers of Yacón received puree and powder, in which determined the content of the main polysaccharides and fructose.

Scorzonera rhizomes are used with dry substances – 15 %, the content of inulin 5.7 %, pectin 0.9 %, and cellulose 0.8 %. From the Scorzonera rhizomes, as well as from roots to Yacón received puree and powder, which determined the content of valuable BAS, in particular polysaccharides.

Obtaining powder from Scorzonera and Yacón conducted by convective drying pre-cut into the plate rhizomes and then crushed to a particle size of 0.5 - 0.7 mm.

Puree was obtained by rubbing through a sieve with the hole diameter is not more than 0.4 mm pre-cleaned and steamed for 15-20 min from rhizomes of Scorzonera and Yacón.

According to traditional methods there was defined content of polysaccharides, inulin, pectin, cellulose in them [28-31].

The content of pectin substances recognized by the gravimetric method, which is based on the determination of mass fraction of pectic acid with the mass number of pectate calcium, resulting from the interaction under certain conditions, calcium chloride with pectic acid.

Inulin content was determined by the method of Bertrand, which is based on the ability of the aldehyde group of sugars to interact with Fehling's reagent and restore the oxide of copper to cuprous oxide, which cipitate in the form of a red precipitate.

Determination of the mass fraction of cellulose based on the decomposition of all other organic compounds concentrated nitric acid in a mixture of acetic and trichloracetic acids [28, 29, 31].

Results and discussion. The Salsify and Yacón are quite valuable root vegetables for their nutritional and biological properties, chemical compositions of which are rich in biologically active substances, which are represented by polysaccharides, macro - and microelements, vitamins, flavonoids, and essential amino acids.

Particularly rich the selected raw materials on valuable polysaccharides: inulin, pectin, cellulose.

The value of inulin is in its effects on metabolism during all time while in the human body. Inulin improves lipid metabolism, and therefore reduces the risk of cardiovascular disease, promotes the development of bacteria, contributing to the normal functioning of the gastrointestinal tract, stimulates contractility of the gut wall, has immunomodulatory effect.

Important compounds are also pectic substances. One of the main effects of the therapeutic influence of pectin is a detoxifying effect in respect to cations of heavy and radioactive metals.

Fiber improves digestion, stimulates peristalsis, increases the rate of passage of food through the gastrointestinal tract, absorbs fats, toxins and mucus from the stomach and intestines, and improves the absorption of nutrients. Fibers free from toxins not only the gastrointestinal tract, but also lymphatic system [1-7].

It was performed the analysis of the new non-traditional raw materials rich in polysaccharides because these biologically active substances are important for the normal functioning of the body with a view to expanding the range of products with a high level of dietary fibers.

Selected raw materials are a valuable source of polysaccharides, such as inulin, pectin, cellulose. Therefore, a study to determine the content of these BAS within the selected objects and processed foods.

The content of the BAS in the products of Yacón processing presented in table 1.

Studies have shown that the products of Yacón contain significant amounts of polysaccharides, in particular inulin that has prebiotic properties.

Table 1

Content of the BAS in the of Yacón processing products

№	Index	Yacón puree	Yacón powder
1	Dry substances, %	18	89.8
	Weight part, % on dry substances:		
2	Inulin	41.5	42.3

3	Fructose	30.8	29.9
4	Cellulose	3.4	2.8

The healing properties of Scorzonera are also due to the presence of significant amount of inulin. The use of this root in food has a hypoglycemic action, which can be used for the prevention and treatment of diabetes. Also in Salsify contains flavonoid glycosides and vitamins C, E, carotenes, which provide antioxidant properties of plant.

Mineral composition of Scorzonera (table 2).

Table 2

Mineral composition of the Scorzonera root

№	Index	Value
Macroelements (mg/100g)		
1	Phosphorus	84
2	Potassium	140
3	Sodium	148
4	Magnesium	81
5	Calcium	153
Microelements (mcg/100g)		
6	Copper	42
7	Zinc	28
8	Manganese	250
9	Nickel	0.7
10	Iron	420

Vitamin composition represented by such vitamins (mg/100g): E – 6, carotene – 0.02, PP – 0.35, C from 2.1 to 8.2.

In medicine Kozelets used in gastro-intestinal diseases, as a sedative, anticonvulsant, analgesic agent [23-27].

The specific content of polysaccharides in the scorzonera processing products presented in table 3.

As can be seen from table Scorzonera processing products contain significant amounts of inulin, pectin, cellulose, which proves that it can be used to fortify foods.

This proves the expediency of Yacón and Scorzonera processing products application as functional fortifying in technologies for health products.

Table 3

Content of polysaccharides in the Scorzonera processing products

№	Index	Scorzonera puree	Scorzonera powder
1	Dry substances, %	15.1	89.6
	Weight part, % on dry substances:		
2	Inulin	37	38.2
3	Pectin	5.3	5.2
4	Cellulose	3.7	3.1

As in purees and powders of analyzed raw materials the general trend of the high content of inulin, for Yacón (41.5 – 42.3 % on dry substances) and Scorzonera (37 – 38.2 % on dry substances) and cellulose for Yacón (2.8 - 3.4 % on dry substances) and (3.1 – 3.7 % for Scorzonera on dry substances), is kept. This proves the feasibility to using of processed products to the Yacón and Scorzonera as functional supplements in the technology of wellness products.

At the same time, the results showed the complexity of implementing functional enrichment of certain food products by making the puree recipe, because it contains only 15 to 18% dry substances, and 6.3 to 7.5 % inulin accordingly, and 0.7 to 1.2 % cellulose. Therefore, in most food technologies, the use of puree in the less amount of than 15% by weight of the product do not give reason to expect functional enrich effect.

The use of selected raw materials powder for food products can significantly improve the content of dietary fiber, because powder as Scorzonera, as Yacón with a high content of dry substances (89 - 90%) contains a significant amount of polysaccharides in semi-finished product.

At this stage of the research proposed to use the powder of Scorzonera and Yacón to receive ice cream for healthy use.

Dairy products occupy a large proportion of food products market. One of the leading places in Ukraine in the dairy market belongs to ice cream. We conducted a series of trial tests of the ice cream manufacturing with different percentages and modes of functional supplements insertion.

The results of the organoleptic evaluation are shown in table 4.

Table 4

Organoleptic characteristics of the studied ice cream variants

Name of the indicator	Feature			
	The taste and smell	Structure consistency	Color	Assessment
Creamy ice cream	Pure, without foreign tastes and odors	Homogeneous, dense	Uniform throughout the mass of ice cream	Ice cream has a smooth consistency, nice color and taste

Ice cream with 2% of Scorzonera powder	Pure, without foreign tastes and odors	Homogeneous	Uniform throughout the mass of ice cream	Finished product has a pleasant taste and texture
Ice cream with 3-4% of Scorzonera powder	Pure, without foreign tastes and odors	Homogeneous, dense	Creamy, uniform throughout the mass of ice cream	Ice cream has a smooth consistency, nice color and taste
Ice cream with 6% of Scorzonera powder	Tangible taste additives	Uniform throughout the mass of ice cream	Creamy, uniform throughout the mass of ice cream	Finished product has a tangible flavor of additives
Ice cream with 2% of Yacón powder	Pure, without foreign tastes and odors	Homogeneous, dense	Creamy, uniform throughout the mass of ice cream	Cream has a good structure and texture, attractive color and flavor
Ice cream with 3-4% of Yacón powder	Pure, without foreign tastes and odors	Homogeneous	Creamy, uniform throughout the mass of ice cream	Finished product has a high organoleptic characteristics
Ice cream with 6% of Yacón powder	Pure, distinct vegetable flavor	Uniform throughout the mass of ice cream	Greyish, uniform throughout the mass of ice cream	Finished product has a tangible taste of additives

When conducting organoleptic evaluation for the control sample it was taken Creamy ice cream. With addition the powder as Yacón as Scorzonera in an amount up to 6% the finished product has a high organoleptic characteristic, and when you add the powder in a larger amount (more than 6%) worse structural and taste characteristics. On organoleptic indicators best fortificant option is the addition of powder in the amount of 3-4% by weight of the product.

A series of experiments for determination the physicochemical characteristics of the ice cream with prebiotics with different fortificant content were conducted, the results of which are shown in table 5.

Table 5

Physicochemical characteristics of ice cream with different fortificant content

Name of the indicator	Ice cream with Yacón powder			Ice cream with Scorzonera powder			Normative values
	2%	3-4%	6%	2%	3-4%	6%	
Dry substance, mass fraction, %	32.5	33.5	34.0	32.8	33.2	33.6	31-35
Acidity, ^{o}T,	21.5	22	25	22	22.5	25.5	No more than 25
Overrun,%	58	57	57	59	59	59	Not limited

As you can see the ice cream with addition 6 % of Scorzonera or Yacón powder has acidity limit or in excess of the standard.

Based on the results of organoleptic evaluation and the results of physical and chemical research, the best dose to make creamy ice cream functional fortificant are 3-4% powder of Scorzonera or Yacón.

Carbohydrate composition of healthy ice cream (tables 6) with 3-4% powder insertion is presented.

Table 6

Carbohydrate composition of healthy ice cream

Components of mix formula	Carbohydrate composition				
	Disaccharides	Starch	Pectin substances	Cellulose	Inulin
Creamy ice cream	19.8	0	0	0	0
Ice cream with Yacón powder	17.75	0.06	0.21	0.12	1.56
Ice cream with Scorzonera powder	17.54	0.1	0.36	0.16	1.43

Carbohydrate composition of ice cream has improved and enriched by such products as inulin on 1.43-1.56%, cellulose on 0.12-0.16%, pectin on 0.21-0.36%, which confirms prebiotic and health properties of enriched ice cream. Besides the valuable polysaccharide content, ice cream with prebiotics also has a high content of certain vitamins (C, PP) and minerals (Mg, Fe) in comparison with creamy ice-cream.

Conclusions. 1. Researches have shown that as Scorzonera as Yacón contain significant amounts of polysaccharides, in particular inulin that has prebiotic properties.

2. High content of dry substances in the Yacón and Scorzonera powder including mass fraction of inulin on Yacón dry substances (42.3%) and Scorzonera (38.2 %) makes them a valuable raw material for the food industry.

3. Possibility of Yacón and Scorzonera powder using for the enrichment of food products, in particular ice cream of healthy destination was examined.

4. The ratio of ingredients and the optimum process conditions, providing ice cream with high quality prebiotics are obtained.

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Alla Bashta E-mail: all_sher@mail.ru