

## Chemical Composition of Natural Raw Materials in Producing Innovative Food Products

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### ABSTRACT

The Far Eastern Economic Region is a unique area with specific plant species composition growing there, which can be used in food technologies. These species include the Jerusalem artichoke, Chinese magnolia vine, hawthorn berry and cowberry. This article considers how natural raw materials from the Far Eastern Region of Russia can be used to produce innovative nutritionally balanced food products. Safety and quality parameters of raw materials and finished products were assessed using such methods as the organoleptic assessment, methods for determining chemical composition of food items, biological methods for determining nutritional value of products, and calculation method for linking food quality to its parameters. Research resulted in the profiles of functional ingredients of plant origin that were further included into formulations of melted cheese products, dry mixtures intended for the production of flour confectionery products, and ground meat systems.

**Keywords:** diet, innovative food products, raw materials from the Far Eastern Region (EER), chemical composition, product line expansion

### INTRODUCTION

The full plate diet is one of the most important factors that make up human life, reducing the risk of nutritional deficiencies, improving the quality of life and longevity. Russians, like any other citizens of other countries, receive micro- and macronutrients in insufficient quantities – their diet lacks around 30% of required amount of those [1,2]. Enriching staple foodstuffs (flour, bakery and pasta, vegetable oils, flavorings) is a regulated-by-law must for many developed (the USA, Canada) and developing countries (in Asia, Latin America, Africa) [3-5]. In the EU-member countries, food products are being actively fortified [6-9], but the top functional food producers are Germany, Great Britain, France and Netherlands [10-12].

Many researchers point to that the EER is one of those regions that has potential for delivering raw materials, including those for the production of food items, rich in minerals, vitamins, organic acids and micronutrients. The region is source of biologically active substances. Which are good for any kind of processing. Besides, many researchers acknowledge that the use of those substances reduces the product costs [13,14].

The use of herbal raw material growing in the EER allows producing innovative functional food items.

Theoretical and practical fundamentals for creating combined dairy/meat products, dry mixtures for flour products with some new properties, and therapeutic products are laid and described by domestic and foreign scientists [15-21].

Raw materials for combined products are selected intentionally so they may fulfill human demand for necessary nutritional elements.

**The purpose of this research** is to investigate the potential for multiply utilization of raw materials from the Far Eastern Region (EER) in producing innovative food products.

The goal was achieved through a multi-method research on formulating dairy and meat products, and dry mixtures for cupcakes, pancakes and gingerbread, using nonconventional vegetable materials defined as triticale flour, soy flour, Jerusalem artichoke powder (*Helianthus Tuberosus L.*), Chinese magnolia vine powder (*Schisandrachinensis(Turcz.) Baill.*), hawthorn berry drink (*Crataegus dahurica Koehne et Schneid*) and cowberry powder (*Vaccinium vitis-idaea L.*).

Health-promoting food formulations with potential vegetable-based enrichers are of great theoretical and practical interest, and open a door for expanding the product line, improving quality, nutritional and biological value of finished products.

## MATERIALS AND METHODS

Safety and quality parameters of raw materials and innovative formulations were assessed in accordance with the current reference documentation of the Russian Federation.

### Survey

In research practice, survey is the most common way of data collection. A questionnaire survey is the most important source of information about the health status of the population and reasons behind the emergence of various diseases. The questions that were asked were about the link between ordinary, or fortified, diet and human health. The survey involved 1.000 residents of the Blagoveshchensk city (Amur Region, Russian Federation) aged 18 to 55 years.

### Materials and Functional Ingredients Collection

#### *Cowberry (Vaccinium vitis-idaea L)*

Common cowberries were finger-teared by locals in the northern part of the Amur region, where they typically grow, in late August/early September 2017. When gathered, berries were inspected, sorted through, washed and mechanically squeezed to juice. IR spectroscopy was used to berries in order to determine the content of vitamins, bioflavonoids, carbohydrates and organic acids in them. The procedure was performed as instructed in the manual.

#### *Hawthorn Berry (Crataegus dahurica Koehne et Schneid)*

Hawthorn berries were cut down in clusters in August 2017. Gatherings were sorted through and washed under stream of pure water. Their ripeness was determined by color – good berries should be bright red. The berries then were done with 5 parts water to 1 part herb (5:1) and brewed to a decoction. Their chemical composition was defined using the same method that was applied to cowberries.

#### *Chinese magnolia vine (Schisandrachinensis (Turcz.) Baill.)*

The fruits were collected in September 2017. The batch was washed and sorted through to pull out bruised berries. The prepared raw material was dried at 35° C until 15% of water left in it. The dried fruits were ground with a knife mill (150 microns, 7000 rpm) (Retsch, Grindomix GM 200, Germany), and the resulted powder was stored at 6-10° C in a dark place until further use. The chemical composition of magnolia vine powder was defined using the same method that was applied to cowberries.

#### *Flower Pollen*

The EER houses more than 250 species of wild-growing woody, shrubby and grassy honey and pollen plants, 90 species of which account for high-priority honey and pollen plants, which together make up a food reserve in beekeeping. The chemical composition of pollen depends on the plant species, timing and site of collection. Biochemical analysis was performed on pollen from the bee yard attached to the Far Eastern State Agrarian University. The pollen was collected at the end of August in the beginning of September. The content of amino acids in collected pollen was determined by infrared scanning using the analyzer No. K-4250 (USA). The procedure was guided by the standards developed in the laboratory of the All-Union Scientific-Research Institute of Soybeans. The content of polyunsaturated fatty acids was determined by capillary gas chromatography using the gas chromatograph (Hitachi) filled with sorbent SW10 210. Fatty acid concentrations were determined using the ratio of the peak area on the chromatogram.

### **Jerusalem Artichoke (*Helianthus Tuberosus L.*)**

The tubers were collected in autumn. Thoroughly washed tubers were cut into thin slices and dried in an oven at a temperature equal to or less than 70° C. Dried slices were ground with a knife mill (150 microns, 7000 rpm) (Retsch, Grindomix GM 200, Germany). If drying conditions are met, this method maximizes the amount of essential enzymes, vitamins and bioactive substances preserved in the food item (up to 90%). The chemical composition of Jerusalem artichoke powder was defined using the same method that was applied to cowberries.

### **Cheese Product Sampling and Analysis**

Cheese samples were taken with a cheese trier by immersing it to a depth of  $\frac{3}{4}$  of the total product length. The resulted 4.5 cm long piece was then examined. The overall average weight should be equal to or less than 50 grams. A 30-35 g portion of the average sample was weighed and ground to a fine powder with a mortar or a sampler pulverizer. The powder was taken through a sieve with holes 0.5 mm in diameter. The remaining coarse particles were ground again until no particles left.

Total chemical composition was determined by standard methods:

- fat weight was measured using a butyrometer. The idea was to separate fat from proteins by adding sulfuric acid (relative density 1.5-1.55 g/cm<sup>3</sup>) upon heating. The following isoamyl alcohol (density 0.811-0.813 g/cm<sup>3</sup>) and centrifugation facilitated the separation;
- water and dry solids weights were measured by drying the test sample in a drying oven to a constant weight at 100-105°C;
- protein weight was measured using the Kjeldahl method. The idea was to mineralize samples, and quantify nitrogen contained in resulted ammonia. The amino-acid content of proteins was determined using an infrared scanner NIR-4250.

### **Dry Flour Mixture Sampling and Analysis**

Total chemical composition was determined by standard methods:

- fat weight was measured using a butyrometer;
- water and dry solids weights were measured by drying the test sample;
- protein weight was measured using the Kjeldahl method.

IR spectroscopy was used to mixtures to determine the content of vitamins, carbs, and minerals in them. The procedure was performed as instructed in the manual.

### **Ground Meat Sampling and Analysis**

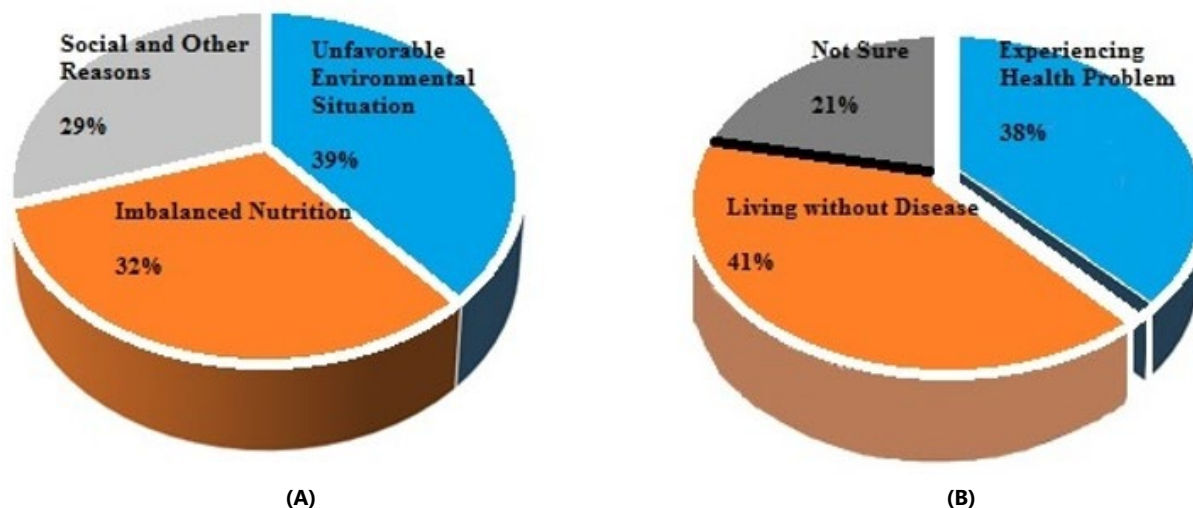
The organoleptic assessment of food products was performed using the method of paired comparisons and score scales. Scoring method is a method for assessing the quality of food items based on several qualitative indicators, in which their scores, expressed in points, are summarized. Scoring is for differentiated analysis, performed by highly qualified tasters. The scores, expressed as points, were put on a conventional scale in an increasing order. Each score corresponds to a certain quality measure.

Energy efficiency of raw materials and finished products was calculated using the Rubner coefficient. Product viscosity during production was determined using a Rheograph (Toyosiki, Japan) equipped with a steel U-shaped sample cell. Adhesiveness parameter was determined using the Fudoh Rheometer (Rheotech Co., LTD, Japan) as instructed by the manufacturer, with a 20 mm diameter flat steel plunger. The water binding capacity was measured with the press method.

## **RESULTS**

Healthy and safe diet issues are on the front banner now. An issue of great interest is to compare one's health parameters with the choice of appropriate functional food products.

Basic information was collected with a survey questionnaire. We asked Blagoveshchensk residents (Amur Region) at age 18-55. Self-assessed health statuses and reasons behind various diseases are distributed as follows from the [Figure 1](#).



**Figure 1.** Survey Results

The survey revealed that 41% of respondents consider themselves relatively healthy people, 38% said they had various kinds of diseases, and 21% of respondents found it difficult to answer, and they doubt whether they have a disease or not.

Speaking of disease causes, 39% of respondents pointed to an unfavorable environmental situation contributing to the increase in the incidence rate, 32% - to imbalanced nutrition, lack of vitamins and minerals, and 29% - to social and other reasons.

The research shown that people are highly interested in their personal health, aware of the relationship between health and nutrition, and so are interested in purchasing balanced food products, rich in essential substances.

We laid scientific grounds for using products of processing wild berry raw materials (cowberry juice, hawthorn berry drink, Chinese magnolia vine powder); Jerusalem artichoke powder; triticale flour, defatted soy flour; pollen and enzyme TGases (transglutaminase) in producing innovative food products.

Data on chemical and amino acid compositions, qualitative indicators and biological values were used to explain formulations of melted cheese products, dry mixtures intended for the production of flour confectionery products, and ground meat systems for different categories of population.

After research, we filed two applications to the Federal Institute of Industrial Property of the Russian Federation for the "Melted Cheese Formulation" Patent No.2017107982/10 (013981) (filing date: 10.03.2017) and the "Cupcake Dough Method" Patent No. 2017126001/13 (044780) (filing date: 19.07.2017).

Wild plants as a source of pectin substances, vitamins, carbohydrates, organic acids and minerals are an excellent reserve of raw materials for melted cheese production. Wild plants are commonly used as health-promoting food. In some sense, its utilization will add to a healthy therapeutic diet. Melted cheese formulation contains 40.0-20.0% of curd cheese, 35.0-17.5% of light cheese, 24.0-12.0 of nonfat dry cow milk; 6.0-3.0% of cream; 8.0-4.0% of butter; 2.0-1.0% of Fonakon salt-melter; 6.0-3.0% of lyophilized concentrated starter culture, and 4.0-2.0% of filler (flower pollen). Instead of drinking water, one can take cranberry or hawthorn berry juice. Their chemical composition per 100 g of fruit is as follows: vitamin C - 139.75 mg and 72.3 mg, respectively; bioflavonoids - 0.52 g and 1.56 g; fiber - 2.54 g and 4.4 g; pectin - 0.92 g and 2.5 g; mono- and disaccharides - 7.55 g and 7.57 g; organic acids - 2.41 g and 0.95 g.

Flower pollen is a complex structure, which chemical composition is diverse, variable and depends on the plant species, harvest timing and site. For biochemical analysis, pollen was collected at the end of August in the beginning of September in the beeyard attached to the Far Eastern State Agrarian University. The focus was laid on the lipid composition, and the ratio of saturated and unsaturated fatty acids. Flower pollen contains 9 kinds of fatty acids, but oleic (50.3%), palmitic (22.5%) and linoleic (12.2%) acids dominate. What's interesting is that the ratio of total unsaturated fatty acids to the total of saturated ones approximately equals to 2, and that is typical for plant sources of lipids.

We chose the fruit from wild cowberry and hawthorn, and flower pollen as functional ingredients because they are high in biologically active substances. They provide large enough amount of environmentally friendly raw materials, native to the EER.

The chemical composition of formulated melted cheese allows us to judge its functionality. With cowberry juice as a functional ingredient, 100 grams of melted cheese contain 8.1 grams of protein, 12.8 grams of fat, 0.1 grams of

**Table 1.** Chemical Composition of and Nutrition Info on Flour Mixture Formulations

Nutrients	Content in 100 g		
	Mix with Chinese Magnolia Vine Powder	Mix with Jerusalem Artichoke Powder	Mix with Flower Pollen
<b>Nutrition Summary, g</b>			
Protein	7.0	8.80	8.32
Fat	18.04	17.52	17.73
Carbs	58.76	60.60	61.60
Kilocalories	425.40	476.40	482.37
<b>Vitamins, mg</b>			
Vitamin A	0.88	0.19	0.11
Vitamin PP	0.48	0.61	0.60
Vitamin B <sub>2</sub>	0.10	0.20	0.14
Vitamin B <sub>1</sub>	0.01	0.27	0.20
Vitamin B <sub>9</sub>	-	0.01	-
Vitamin C	-	0.06	-
Vitamin E	-	0.02	-
<b>Minerals, mg/g</b>			
Potassium	18.84	20.13	18.56
Sodium	15.91	16.21	16.07
Calcium	3.95	4.0	4.09
Magnesium	2.77	2.72	2.61
Fluorine	6.48	6.41	6.75
Iron	0.22	0.31	0.21
Zinc	0.01	2.91	-
Aluminum	-	8.12	-

carbohydrates, and 2.39 grams of ash. It has 109.4 kcal. As for vitamins, there are B1 (0.02 mg), B2 (0.1 mg), P (0.485 mg), and C (0.139 mg). It contains minerals like Na (436.92 mg), Ca (308.4 mg), and Mg (14.816 mg); and fatty acids like arachine acid (0.071% of total product weight), lauric acid (0.025%), myristic acid (0.025%), palmitic acid (0.675%), oleic acid (1.508%), stearic acid (0.160%), and linoleic acid (0.366%).

Flour confectionery took the path of formulating dry flour mixtures for cupcakes, pancakes and gingerbread.

As a base, mixture formulations use wheat flour, non-fat soy flour and triticale flour made of Ukro Grade triticale grains grown all across the Amur Region. By chemical composition, triticale flour contains 47.01% of protein, 1.22% of fat, and 38.37% of carbohydrates. It has 330 kcal. By contrast, soy flour 13.18% of protein, little fat (1.81%), and a lot of carbohydrates - (73.14%) along with fatty acids ( $\omega_3$  - 0.1%; and  $\omega_6$  - 0.88%), so it has more calories (338 kcal). Triticale flour has a good amino acid composition in mean values: valine (0.54%), methionine (0.18%), threonine (0.39%), lysine (0.41%), isoleucine (0.46%), tryptophan (0.14%), phenylalanine (0.72%).

According to research data, combined flour mixture (ratio: wheat flour -75%, triticale flour - 15%, non-fat soy flour - 10%) is a best choice. Products made of this mixture turned out to be softer, with a pleasant taste and aroma, and good porosity as well. We introduced a variety of functional ingredients into the mix - it was either Jerusalem artichoke powder (10%), or flower pollen (2%), or Chinese magnolia vine powder (10%).

Jerusalem artichoke is used as an immunostimulating product, to boost the vitality of mind- and physically working people, who in an unfavorable environment. Jerusalem artichoke nutrition info on 100 g of material: protein - 2.1 g; total fat - 0.1 g; carbohydrates - 12.8 g; macroelements (potassium - 200 mg, calcium - 20 mg, magnesium - 12 mg, sodium - 3 mg, phosphorus - 78 mg, and sulfur - 15 mg); microelements (iron, zinc, iodine, copper, fluorine, molybdenum - around 10.1 mg each); vitamins A, C, E, and PP; B-group vitamins,  $\beta$ -carotene; amino acids and organic acids (malic, citric, fumaric, malonic, amber).

Chinese magnolia vine has other special substance (lignans), which show a wide range of biological activity. It is also known as adaptogen for the stimulating effect that it has on the central nervous system. Adaptogens are amazing natural substances. With regular use, they can boost the immune system, so it could beat the most severe illnesses. This is why this plant is in one health-promoting team with ginseng, aralia, and eleutherococcus. Chemical composition of powder prepared from 100 g of fruit is as follows: vitamin C - 447.1 mg; bioflavonoids - 1.8 g; fiber - 2.76 g; pectin - 2.7 g; mono- and disaccharides - 11.4 g; organic acids - 12.72 g.

Chemical composition of and nutrition info on flour mixture formulations are in [Table 1](#).

Flour mixture formulations for confectionery manufacture with a functional ingredient are well balanced, so the baking is of high quality. Instant mixes contain a minimum amount of moisture. One pack is small in volume

and weights little, while low humidity and lack of active enzyme systems allow storing it for much longer with the original quality maintenance.

In combo meat manufacture, functional ingredients come from vegetable raw materials, which are a source of such indispensable components as fiber, vitamins, macro- and microelements, unique carbohydrates, phytoncides and other biologically active substances.

Vegetable protein is used as meat extender, which can not only balance the chemical composition, but also significantly reduce the product price. The most common is soy protein made of either soybeans or soy flour. Although soybeans are high in protein (40.5%), they are also high in fat (19.5%) and calories (381 kcal). At this point, we suggest using triticale flour.

Ground meat is a semi-finished product used in a variety of chopped products (patties, sausages, ravioli, etc). If modifying ground meat, keeping certain target in mind, one can play with its nutrition. This case calls for items that human body cannot synthesize on its own.

Modern meat industry trends imply that some structure-forming items must be introduced into meat and meat products to improve the texture, water binding and water holding capacities. By definition, enzyme TGase fits into the category.

Ground meat formulation we used was from quail meat with triticale flour (10 -30%) and TGase (1-3%).

Our research revealed that quail meat can be considered low fat, if it contains about 4-6% of fat. By definition, these formulations are dietary. The water holding capacity decreases with the increase in fat. This is evident from the moisture-protein ratio – if moisture is too little and protein too high, then the amount of fat will rise. A formulation containing 15% of triticale flour and 2% of TGase is a top one by fat (75%). Research on moisture binding capacity revealed that reference formulation shows significantly lower moisture binding capacity than other.

The organoleptic studies revealed that if using 15% of triticale flour in ground meat, final taste will not be worse, but only get better, so will the juiciness and aroma parameters. Microbiological studies show that our formulations meet the SanPiN 2.3.2.560-96 standards.

Formulating various ground meat systems with veggie raw materials for manufacturing low-calorie foods is of practical interest. The need for such products is felt by people with excess weight, who suffer from various endocrine disorders, and golden age people. Recommendations given by dieticians and public health authorities are primarily to decrease caloric intake from fat, cholesterol, sugar, and salt, so they imply a switch to food rich in vegetable proteins, vitamins, microelements, and fiber.

## DISCUSSION

Following the requirements of modern market, manufacturers strive to produce quality products that would be good for one's health and technologically cheap at the same time. A long line of ingredients and extensive knowledge of food technology allow brining modern innovative food products into the world.

The idea of research and formulations made by scientists from the Technology Department (Far Eastern State Agrarian University) is that manufacturers should use some sources of nutrients and modify vegetable raw materials native to EER with agro- and biotechnologies in order to formulate food with varied nutritional value [21,22].

Technology improvement is primarily about using nonconventional raw materials. This calls for only natural ingredients that show biological activity, but not for additives directly from the lab [20,23-27].

Eun Young Kim and Hye Ran Jeong, who studied the wild-growing Chinese magnolia vine, indicate a high content of stimulating components, like Schizandrin, that have a positive effect on digestion and metabolism processes, and on the central nervous system [28,29].

A significant amount of herbal adaptogens has been found in the common cowberry fruit [30,31], and this supports our research results. Cowberry juice enriches the product with catechines, anthocyanins, leukocyanins, vitamins B, C, and E, making it antioxidant and bactericidal.

The Jerusalem artichoke is a culture of a multifunctional purpose [32]. It is widely used in food production as an additive not only to pastries, but also to meat, dairy and other products. Food products fortified with microelements make the immune system of the human body stronger [33,34]. In addition, Jerusalem artichoke is rich in inulin, which promotes calcium absorption and lipid metabolism, improving the health status of a person having a product with this additive in it as a meal, and reducing the risk for many health problems, including cardiovascular ones [35].

Some researchers determined that intense physical activity comes with the activation of lipid peroxidation, which is one of the metabolic factors limiting the performance and causing fatigue. Hence, functional products enriched with pollen, which shows antioxidant activity, can be recommended for physical activity [36,37].

Triticale is one of the alternative sources of raw materials used for bread with a higher content of protein and lysine [38,39]. According to some researchers, fatty acids in triticale are linoleic, oleic and palmitic acids [40,41]. Grain triticale grown in the EER has the full range of amino acids in it.

The EER is a rather rich and still little used source of natural raw materials that can be used to produce specialized and functional foods [14,21,42-45]. Formulated line will allow introducing more local raw materials. Food products with wild raw materials in their bases are low-calorie, with high nutritional value, and enough of essential biologically active substances.

Further research is aimed at using the potential of raw materials from the EER in making formulations and creating technologies for a variety of products in dairy and meat industries, confectionery and bakery.

## CONCLUSIONS

The entire world's concern is the affordable natural sources of nutrients. The Far Eastern Economic Region of Russia has a great potential for providing new sources of raw materials, including those that can be used to produce target foods.

In the light of current consumer's preferences and modern requirements for food, we formulated staple health-promoting foods with a pre-investigation of the chemical composition of introduced raw materials, their biological and nutritional values. Through the practical use, we established a rationale for using products of processing wild berry raw materials (cowberry juice, hawthorn berry drink, Chinese magnolia vine powder); Jerusalem artichoke powder; triticale flour, defatted soy flour; pollen and enzyme TGases (transglutaminase) in producing innovative food products. If combined, animal and vegetable raw materials allow formulating products of required qualities and with functional properties.

Our formulations allow producing nutritionally balanced food products.

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