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Enhancing Gerodietic Nutrition: Innovative Technology for Developing Health-Promoting Feed

Author's Affiliation:
Plekhanov Russian
University of Economics -
Russian Federation

Manana Tkeshelashvili*, Galina Bobozhonova

Abstract

***Corresponding Author:**
Manana Tkeshelashvili
Email:
man.em.tkeshelashvili@mail.ru

Background: The growing elderly population calls for specialized dietary options to address the unique nutritional needs of aging individuals. Current food production methods often overlook the dietary requirements of older adults. Expanding the range of gerodietic food products can significantly contribute to improving the health and well-being of the elderly.

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Methods: This study focuses on the development of gerodietic cookies, a pastry product enriched with key additives—phytolin, collagen hydrolysate, and trehalose. Organoleptic and physicochemical parameters of the cookies were evaluated using standard techniques. The formulated cookies aim to support collagen-containing tissues' health, reduce the risk of type 2 diabetes, and lower the product's glycemic index while maintaining an appealing taste and texture.

Results: The synergistic effects of phytolin, collagen hydrolysate, and trehalose in the gerodietic cookies contribute to their potential health benefits. The study determined the optimal composition of these additives, ensuring their effectiveness and overall product quality. The enriched cookies displayed favorable characteristics, including uniform porosity, pleasant aroma, and taste, meeting the established standards for alkalinity, moisture content, and wetness.

Conclusion: Developing gerodietic cookies with scientifically justified formulations offers a promising approach to address the dietary needs of the elderly population. These cookies have the potential to support collagen-rich tissues, mitigate the risk of type 2 diabetes, and provide a tasty and nutritious addition to the diet of older adults. This research contributes to the growing field of gerodietic nutrition, offering innovative solutions to promote healthy aging through dietary choices.



Introduction

The demographic situation in the modern world is distinguished by an intensive growth of the elderly population [1]. The trend of population aging – an increase in the share of older generations in the total population and the share of the oldest ages in the oldest population – has swept virtually every country in the world. As suggested by demographic forecasts, this trend will persist in the coming decades [2, 3]. Nutrition is a well-recognized factor in premature aging [4, 5]. In older people, good nutrition is a particularly important factor in managing the risks of many diseases [6]. According to studies, proper nutrition can reduce the incidence of such diseases as diabetes, arthritis, heart disease, neuropsychiatric disorders and eye diseases [7-9]. Gerontologists' recommendations for foods for the elderly are focused on reducing calories by cutting fat content, reducing sugar intake, and enriching foods with vitamins, microelements, dietary fiber, probiotics, and prebiotics [10-12]. Russian researchers have developed recipes and product technologies for this category of people for dairy [13], meat [14], and grain [15] based products, using various components that have a positive effect on the body. The diet of older adults should include any products, and the diet should be varied. Research indicates [16] that one of the most demanded groups of food products among the elderly population is pastry products, with a greater preference for cookies, gingerbread, and waffles. Given this, the development of products for the elderly, including pastry products, that contribute to a harmonious supplementation of their diets is a promising and topical direction in the development of the food industry.

The purpose of the present study is to develop a pastry (cookies) adapted for gerodietic nutrition and using a combination of several enriching ingredients as additives: phytolin, collagen hydrolysate, and trehalose.

Methods

The object of the study was cookies enriched with an extract of ground sugar cane with isolated polyphenols (phytolin), collagen hydrolysate, and trehalose (its recipe models). In summary, a "cookie" in this context is a pastry product, and "gerodietic cookies" are cookies that are specially created to cater to the dietary needs of older adults.

The main raw materials used were all-purpose wheat flour, enriching additives, vegetable oil and/or a mixture of vegetable oils, a humectant, a leavening agent, flavoring, and drinking water; as dry milk products, milk powder and/or milk protein concentrate (MPC) and/or whey protein concentrate (WPC) can be

used; sweetening ingredients can be maltitol and/or isomalt and/or trehalose and/or stevia and/or sucrose; foaming agents – Hyfoama and/or egg protein.

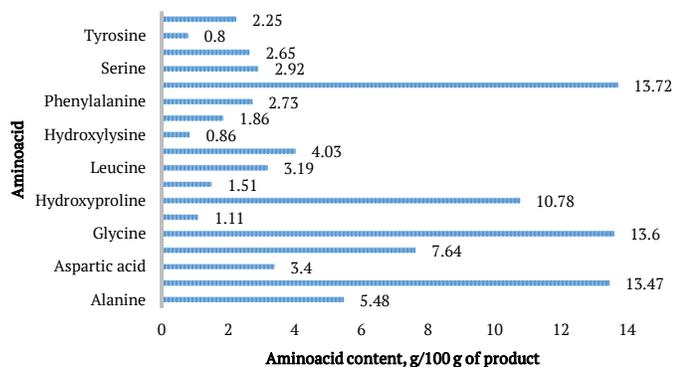
The phytolin biologically active food supplement produced by The Product Makers Pty LTD. (Australia) is a dark brown viscous liquid with a bittersweet taste, 100% natural extract of sugar cane. Its recommended dose for adults is 10 ml per day, and under these recommendations, Phytolin can serve as a source of flavones and catechins (Table 1) [17].

Metabolite	Content
Flavonoids	1.47 mg/g
(Flavones and their glycosides)	19.84 mg/13.5 g (10 ml)
Catechins, incl.	3.9 mg/g
	52.65 mg/13.5 g (10 ml)
Epigallocatechin	0.4 mg/g
Catechin	0.6 mg/g
Epicatechin	1.6 mg/g
Epigallocatechin gallate	0.2 mg/g
Gallocatechin gallate	0.1 mg/g
Epicatechin gallate	1.0 mg/g

Source: Compiled by authors

Table 1: Flavonoid and catechin content in Phytolin dietary supplements.

Hydrolyzed fish collagen (Lapi Gelatine Spa) is a natural ingredient containing over 94% protein (in dry weight) and 18 amino acids, seven of which are essential (Fig. 1). The nutritional value of hydrolyzed fish collagen is presented in Table 2.



Source: Compiled by authors

Figure 1: Amino acid profile of hydrolyzed fish collagen

Nutrients	Amount (per 100 g)
Protein	>85 g
Carbohydrates	<1 g
Dietary fiber	<1 g
Fats	<0.1 g
Sodium chloride	0.713 g
Water	<8.00 g
Ash	<2.00 g
Energy value	365 kcal
	1,528 kJ

Source: Compiled by authors

Table 2: Nutritional value of hydrolyzed fish collagen

Trehalose is a naturally occurring, non-reducing disaccharide derived from starch by an enzymatic process. Trehalose (Tongliao Meihua Biological Sci-

Tech Co., Ltd., China) is a white powder with a main substance content of 99.05%.

Organoleptic quality parameters in accordance with the requirements of GOST 24901-2014 were determined by controlling the sample of products. Alkalinity was assessed by titration of product filtrate with a sulfuric acid solution in the presence of bromothymol blue until the appearance of yellow color according to GOST 5898-87. Humidity was evaluated by drying the weighted product at 130°C and calculating weight loss in relation to the pre-drying mass of the analyzed sample according to GOST 5900-20144, and soak-ability – in relation to the product after soaking the mass of the dry product according to GOST 10114-80.

Results

All components of the cookies are selected in accordance with the results of scientific research and reinforce their combined effect on the human body to achieve maximum favorable results in reducing the risk of developing type 2 diabetes and the protection of bone tissue, as well as reducing the glycemic index of the product. The effect of gerodietic cookies is due to the synergistic effects of their components on the body.

Calculation and testing of formulations of cookies for gerodietic nutrition in laboratory conditions were carried out and the optimal number of components in the formulations of products was determined. Characteristics of the formulations of the developed cookies are presented in Table 3. When developing the recipes, the ingredient composition of the cookies was purposefully modeled with 100% sugar replaced by natural sweeteners trehalose, maltitol, and isomalt (formulations 1-4), which helps lower the glycemic index of this product. Since these sweeteners are characterized by not very intense sweetness, stevia (with an average sweetness factor of 300 and no caloric value) has been introduced into the recipe to enhance the sweet taste of the cookies.

The developed gerodietic cookies contain easily digestible collagen hydrolysate in an amount of 2.5-8.0%. The high content of this component is an advantage of the designed product because the consumption of 100 g of the product provides 25-80% of the recommended daily collagen intake. When the content of collagen hydrolysate in cookies is lower than the specified interval, its effectiveness decreases, and when it is higher, the consumer properties of cookies deteriorate. The use of collagen in the form of its hydrolysate eliminates possible problems associated

with the duration and possible discomfort of digestion of natural collagen in the stomach.

Raw material		Formulation				
		1	2	3	4	5
		Content, %				
Wheat flour, AP		29	30	31	32	33
Enriching additives	trehalose	7	8	7	6	5.0
	phytolin	5	4	3	2	1.4
	collagen hydrolysate	8	6	4	5	2.5
Sweetening components	maltitol and stevia	10	-	-	-	-
	isomalt and stevia	-	12	-	-	-
	trehalose and stevia	-	-	12.5	13	-
	sucrose	-	-	-	-	15
Vegetable oil or vegetable oil mixture		20	18	21	22	21
Dry dairy products	milk powder	7	-	-	-	-
	MPC	-	5.5	-	-	-
	milk powder, MPC, and WPC mix	-	-	7	6	-
	WPC	-	-	-	-	5
Humectant additives		6	7	4.5	3	5
Foaming agents	Hyfoama	2	-	-	-	-
	egg protein	-	-	-	4.5	5
	Hyfoama and egg protein	-	3	3.5	-	-
Baking powder		0.5	0.5	0.5	0.6	0.6
Vanillin		0.3	0.3	0.2	0.2	0.1
Water		the rest				
Total		100	100	100	100	100

Source: Compiled by authors

Table 3: Recipe for the developed cookies.

It also significantly increases its digestibility and accelerates the synthesis of the body's own collagen. The gerodietic cookies contain trehalose in an amount not less than 5% of the product. If the content of trehalose is less than the specified interval, its effectiveness drops. The cookies also contain processed extract of ground sugar cane with isolated polyphenols (phytolin) in an amount of 1.4-5% of the product. The lower content of this product leads to a decrease in efficiency, and higher content deteriorates the consumer properties of the cookies. The developed recipes for gerodietic cookies allow for keeping the existing machinery and equipment schemes and enable the production of products without radical changes in the technological process. The technological scheme for the preparation of cookies (according to formulation 1) uses as a battering agent (hydrolyzed vegetable protein) Hyphoma, 2 kg, its dissolution in water at 17-30°C, followed by mixing in trehalose, 7 kg, and a mixture of maltitol and stevia, 10 kg. The mixture is whipped with a mixer and the prescribed amount of flavoring, 0.3 kg, is added to the resulting mass. Separately, 29 kg of wheat flour, 0.5 kg of leavening agent, and 7 kg of milk powder are mixed and sifted, then the dough is kneaded on water, adding 5 kg of phytolin and the mixture obtained at the first stage, 10

kg of vegetable oil, 8 kg of collagen hydrolysate, and 6 kg of humectant. The dough is kneaded until homogeneous. The dough is at room temperature. The humidity of the dough is 24-28%. The prepared dough is then shaped. The shaped dough pieces are placed on a baking tray covered with parchment paper. The cookies are baked in a batch oven for 10-12 minutes at a temperature of about 160°C. The finished cookies are cooled and packaged. Cooking schemes for formulations 2-5 are the same as for formulation 1.

To determine the effect of the selected enriching additives on the quality of the finished product, model samples of cookies were produced and tested by organoleptic and physicochemical parameters. The samples of cookies have good uniform porosity, brittle when bitten, with a pleasant smell; taste – harmonious, with a palatable light touch of phytolin; color – brown, homogeneous, uniform. The alkalinity, moisture content, and wetness of cookie samples meet the standard norms.

Discussion

Phytolin as a source of flavonoids

Phytolin is a proprietary product made from a processed extract of ground sugarcane with isolated polyphenols and serves as a source of flavonoids. Flavonoids are plant phenolic compounds whose structural basis consists of two benzyl rings (A and B) connected by a heterocyclic pyran or pyrone (C ring). By their chemical structure flavonoids are distinguished into flavanols, anthocyanidins, flavones, flavanones, and chalcones. These natural substances and their analogs are essential for the body, meaning that they must be continuously ingested with food or as drugs and dietary supplements [18].

It is generally believed that the greatest role in the multifarious effects of flavonoids on the human body is held by their antioxidant properties. Numerous *in vitro* studies suggest that flavonoids can be classified as non-enzymatic antioxidants capable of directly or indirectly dampening or preventing cellular damage by free radicals, thus preventing the premature aging of the body [19]. Studies on the various positive effects of flavonoid consumption on the human body give evidence of a possible reduction in the risk of developing insulin resistance [20]. Insulin resistance is related to the occurrence of obesity, metabolic syndrome, and diabetes mellitus, which adds to the interest in the effects of flavonoid-rich foods. Successful results have been obtained in reducing cardiovascular morbidity with flavonoid extracts and foods rich in them [21]. Among plant substances of phenolic nature, catechins are of great importance.

Catechins (flavan-3-ols) are a fairly extensive group of plant organic compounds: the number of known flavan-3-ols exceeds 1,000. In plants, catechins occur in isomeric forms corresponding to (+)-catechin and (-)-epicatechin. Antioxidant properties of flavan-3-ols are 50 times greater than those of vitamin E and 20 times greater compared to vitamin C. In addition, catechins have anti-inflammatory, antimicrobial, antispasmodic, and neuroprotective effects [22].

Furthermore, flavonoids are of great importance in food processing, since flavonoid oxidation products are responsible for the specific flavor, color, and aroma of processed products. Phenolic compounds are effective inhibitors of lipid peroxidation (their properties are preserved even at high temperatures, such as in cooking) [23].

Collagen hydrolysate as a dietary supplement

Collagen is the main structural protein of the intercellular matrix. A collagen molecule consists of three polypeptide chains, each having approximately 1,000 amino acid residues, among which glycine dominates (33%). Collagen makes up 25-33% of the total amount of protein in the body. Different types of collagen are prevalent in different tissues. 95% of all collagen in the human body is collagen types 1, 2, and 3, which form very strong fibrils. They are the main structural components of organs and tissues that experience constant or periodic mechanical stress (bones, skin, tendons, cartilage, intervertebral disks, and blood vessels) [24].

Normally, collagen is constantly synthesized by connective tissue cells and broken down (enzymatically), but with age (especially in old age) collagen metabolism decreases markedly [24]. Thus changes in the content of collagen proteins break the structure of cartilage tissue, which can cause such diseases as arthritis and arthrosis of joints and destruction of the intervertebral disks [25]. One of the means to ensure the natural synthesis of collagen in the body is the supplementation of collagen in food. The human body does not absorb whole protein collagen from food well because of the large size of its molecules. However, the hydrolyzed form of collagen is well tolerated and is not associated with gastrointestinal side effects [26]. According to published studies, orally administered collagen accumulates in the articular cartilage and provides a significant increase in the synthesis of extracellular matrix macromolecules [27]. Studies [26, 28] have shown the effectiveness of collagen hydrolysate in reducing pain and improving joint function in patients with osteoarthritis. A positive effect on the processes of cartilage remodeling in osteoarthritis is possible with

the administration of collagen in a daily dose of 10 g [26].

Research has also assessed the prospects for using hydrolyzed collagen in the technology of a whey-based beverage. The addition of hydrolyzed collagen has been found to increase the bioavailability, nutritional value, and antioxidant activity of the beverage. Hydrolyzed collagen acted as an antimicrobial agent since no pathogenic microorganisms were observed in the treated beverages [29]. The technology of a specialized probiotic protein dessert enriched with collagen and calcium has been developed. The product can be used as the main or additional source of collagen and calcium for the treatment or prevention of osteoporosis and related diseases [30].

Trehalose and its effect on the body

Trehalose is a disaccharide in which two units of glucose are linked by an α -1,1-glycosidic bond. Trehalose is abundant in nature and is found in a wide variety of organisms, from bacteria to invertebrates. The largest amounts of trehalose are concentrated in the spores of mycelial fungi and yeast. Large-scale industrial production of this disaccharide is carried out by biotechnological methods based on enzymatic transformations of starch [31].

Trehalose has been recognized as a safe food ingredient following approval of this disaccharide by the U.S. Food and Drug Administration. In Japan, the toxicity of trehalose to humans has been investigated. The disaccharide has been proven safe for commercial mass consumption as an ingredient in consumer products [32]. Based on research findings, it has been concluded that a daily intake of 3.3-10 g of trehalose increases glucose tolerance and slows the progression of insulin resistance. In addition, results indicate that trehalose can potentially inhibit the development of the metabolic syndrome and related diseases, particularly type 2 diabetes mellitus [33]. Trehalose protects proteins and cell membranes from inactivation or denaturation caused by various stress conditions and amplifies autophagy, protecting organisms' cells from various stressors. It also acts as a modifier of abnormal protein accumulation in human neurodegenerative diseases [32].

Scientists have suggested that trehalose may reduce the risk of cardiovascular disease. Oral administration of trehalose has been found to improve vascular resistance by increasing the bioavailability of nitric oxide and the sensitivity of smooth muscle cells to it [34]. It was demonstrated that trehalose administration can inhibit osteoclast differentiation, which is crucial for bone strengthening and the prevention of osteoporosis [32]. In the food industry trehalose is mainly used as a sugar substitute. In pastry products

trehalose prevents starch retrogradation much more effectively than other sugars, thus increasing the stability of products and delaying staling [35]. The conducted research resulted in the development of gerodietic cookies whose composition contributes to a healthy state of collagen-containing body tissues, reduces the risk of type 2 diabetes mellitus, and lowers the glycemic index of the product. Product formulation was scientifically justified and selected to obtain a product with high organoleptic indicators. The technology of the production of gerodietic cookies adapted to the actual conditions of enterprises for the production of flour confectionery products was developed. Furthermore, the formulation of these cookies is strategically designed to target specific health objectives, such as reducing the risk of type 2 diabetes and supporting collagen-containing tissues' health. If subsequent research and testing validate these health benefits, gerodietic cookies could become an essential component of dietary recommendations for managing age-related health conditions, marking a notable advancement in geriatric care. From an industry standpoint, the development of gerodietic cookies represents an opportunity to diversify food product portfolios. This specialized niche caters to a distinct demographic with unique dietary needs, potentially opening up new markets and revenue streams for food manufacturers.

Moreover, this study serves as a pivotal foundation for future research and innovation in the realm of gerodietic foods. Subsequent investigations may explore variations in formulations, assess the long-term effects of consumption, and delve deeper into the specific health advantages these products offer older adults. As awareness of the significance of healthy aging continues to grow, the demand for gerodietic cookies may surge. Their potential integration into dietary plans by healthcare professionals could further bolster their adoption and impact on the well-being of older individuals. In summary, this study holds promising prospects spanning improved nutrition for the elderly, market expansion, scientific exploration, and enhanced collaboration with healthcare experts in pursuit of healthier aging.

Author Contributions

All authors contributed equally to this study. The conceptualization of this study was a collaborative effort involving all authors. Furthermore, all authors contributed to the discussion section, providing insights into the potential health benefits and prospects of gerodietic cookies. They jointly supervised the project, secured funding, and provided critical guidance throughout the research process. All authors

reviewed and approved the final manuscript, ensuring its accuracy and scientific integrity.

Conflict of Interest

The authors declare that there is no conflict of interest.

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