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Original scientific paper

LOW-PROTEIN PASTA FOR CHILDREN PATIENTS WITH PHENYLKETONURIA

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phenylketonuria, starch, diet food, functional ingredients

ABSTRACT

There are provided data on the work carried out at All-Russian Research Institute for Starch Products to create enriched low-protein pasta based on starch for nutrition the children sick with a phenylketonuria — a hereditary disease (group of fermentopatiya), the bound to violation of amino acids metabolism, mainly phenyl alanine. Optimization of children nutrition is the socially important direction of domestic policy of the Russian Federation since their health directly depends on the good balanced nutrition, especially it is important for the children having diseases of genetic character.

To expand the range of the enriched low-protein food the functional ingredients are picked up, recipes and technology of receiving three types of pasta are developed such as: noodles, vermicelli, «spider line», their nutrition and power values are defined. It is shown that in the received products protein content doesn't exceed permissible value (<1.0%), fat from 3.3 to 3.6%, ashes — to 0.14%, carbohydrates no more than 88.0% that conforms to requirements imposed to reduced-protein products of baby food.

1. Introduction

Now scientific research on creation of the quality food improving health of the population gains the increasing popularity, promoting a healthy lifestyle.

The single (for today) method of treatment of this disease is a dietetics: products with the high content of protein are excluded from a food allowance [1,2,3,4].

The products of the functional nutrition enriched with vitamins, macro — and micro- minerals, improve the food status of the population (prevention and elimination of scarce states) and, thus, help to keep or restore health, normalizing biochemical processes and starting improving functions of an organism [5,6,7,8,9,10].

Now providing sick children with medical products depends in many respects on import. The main suppliers on the domestic market are firms: Nutrition (England), Komida (Germany) and Balviten (Poland). There are delivered both specialized medical products based on mixes of amino acids without phenyl alanine, and prepared from vegetable natural raw materials with low protein content and also low-protein products on the basis of starch. The range of the delivered low-protein products is wide: there are low-protein cookies, fat-free powdered milk, dry mashed potatoes, egg substitute, mix for pastries, low-protein pasta (vegetable, fruit, berry), etc.

Thus, expansion of the range of domestic low-protein goods is a relevant task which solution will promote decrease in import of the functional products and upgrading of life of sick children.

The All-Russian Research Institute of Starch Products conducts researches on creation of low-protein food based on starch for the children sick with a phenylketonuria who include development of technology for receiving a low-protein basis, justification of ingredients structure of products, criteria for evaluation of their quality, clinical effectiveness and safety aimed at range expansion.

The purpose is to choose ingredients, to develop and justify a recipe, to develop technology and organize production of the low-protein, enriched pasta on the basis of starch for the children sick with a phenylketonuria.

2. Materials and methods

For receiving the low-protein enriched pasta products there were used the materials:

- As low-protein basis:
 - corn starch of JSC «Hobotovsky Enterprise Starchproduct» (The Tambov Region), protein content — 0.35%;
 - swelling starch (extrusive) Ekstramil of LLC Zvyaginsky Starch Plant, swelling capacity of 12 cm³/g.
- As functional ingredients:
 - the dry yolk delivered by Roskar Poultry Farm joint-stock company (the Leningrad Region). The product contains: DS — 96.5%, protein — 35.0%, fat — 61.1%, a mass fraction of free fatty acids by oleic acid — no more than 4%, solubility — 84.9% [9, 10].
 - «Vetoron children's solution» is a liquid of dark orange color, with a slight specific smell, easily dissolved in water and contains: beta carotene of 21.6 mg/ml, vitamin E₈ mg/ml, vitamin C9.2 mg/ml. Manufacturer is LLC Biosfera, Yaroslavl Region, Pereslavl-Zalessky.
 - an inulin is a natural polysaccharide which is widely applied in production of various foodstuff [11]. In Russia there is no industrial production of an inulin — it is bought abroad. The inulin of the FRUTAFIT HD brand is used. Manufacturer is Sensus BV, the Netherlands. Indexes of quality: DS — 95.9%, an inulin — 92%, fructose, glucose, sucrose — 8%, an average degree of polymerization — 11, ashes — less than 0.2%.

The demand of use in recipes of an inulin and egg products is confirmed by the conducted researches on their application in food: confectionery, bakery, etc. branches of the food industry [12,13,14,15,16,17]. Use of dry egg products instead of eggs allows to improve on the one hand operational performance, and with another — to reduce the prices of a product and to make it more mass. Addition of extrusion starch allows to create new types of bread and the pasta with useful properties and having excellent consumer qualities — the magnificent tasty bread which is well cut and sluggishly hardening, not boiling soft beautiful and tasty pasta.

The inulin has no contraindications, is useful to digestive, nervous and cardiovascular systems and, besides, it is good technological ingredient in the food industry, is entered into a product

without change of technological process, without prejudice to taste, the texture of a product improves.

Pasta (low-protein starched enriched) are made from mix of corn starch and extrusion corn starch with addition of the enriching ingredients.

Mix of dry ingredients is mixed in the mixer, humidified with the solution containing «Vetoron children's solution» to $W = 30\text{--}35\%$, again carefully mixed and fed in to an auger macaroni press (a spaghetti C-50) where it is exposed to plasticization, a partial gelatinization and formation. Processes of plasticization and formation of pasta are carried out in the camera of a spaghetti at the mixture temperature of $60\text{--}70\text{ }^{\circ}\text{C}$ and under pressure about 15 MPa. Formation of pasta happens during breakdown of the mixture through a matrix to round or slotted openings of a different form that allowed to receive 3 types of pasta: noodles, vermicelli, «spider line». The pasta containing «Vetoron children's solution» has the pleasant yellow color remaining after their cooking.

3. Results and discussion

The ingredients structure of pasta was developed with use of a food theory of combinations (use of individual mathematical models):

$$\sum_i \phi_i = G_m P_m \phi_m + G_\lambda P_\lambda \phi_\lambda + G_c P_c \phi_c \quad (1)$$

(Restriction on phenyl alanine)

$$\sum_i GK = G_m K_m + G_\lambda K_\lambda + G_c K_c \quad (2)$$

(Power value of a dry blend)

The ingredients structure of a dry blend calculated by means of the equations (1) and (2) is given in Table 1.

Table 1

**Ingredients structure of a dry blend
for preparation of low-protein filling sauces**

Name of ingredient	Contents in 100 g of pasta			Caloric content, kcal/kJ (K)
	Quantity, g (G)	Protein, g (P)	Phenylalanine, mg (φ)	
Cornstarch (m)	65.0	0.23	11.5	221/925
Extrusion starch (λ)	30.0	0.1	5.0	102/427
Dry egg yolk (c)	1.0	0.35	17.5	6/25
Inulin	4.0	—	—	0,4/1,6
«Vet or on children's solution»	0.11	—	—	—
Итого (Σ):	100.0	0.68	34.0	330/1381

The prepared pasta products were analyzed with definition of an inulin and phenylalanine content in them before and after cooking (Table 2).

Table 2

The content of an inulin and phenylalanine in pasta

Code of a sample *	Name of an index	The received value	Error	Technique of carrying out researches
466.18 (1)	Inulin	2.52 г/100 г	±10%	P 4.1 1672–03
466.18 (2)	Inulin	2.74 г/100 г	±10%	P 4.1 1672–03
466.18 (3)	Inulin	2.26 г/100 г	±10%	P 4.1 1672–03
466.18 (4)	Inulin	3.87 г/100 г	±10%	P 4.1 1672–03
466.18 (1)	Phenylalanine	117.58 мг/кг	±10%	P 4.1 1672–03
466.18 (2)	Phenylalanine	133.63 мг/кг	±10%	P 4.1 1672–03
466.18 (3)	Phenylalanine	182.03 мг/кг	±10%	P 4.1 1672–03
466.18 (4)	Phenylalanine	225.43 мг/кг	±10%	P 4.1 1672–03

* 466.18 (1) A low-protein starch product «Vermicelli» after cooking;
466.18 (2) A low-protein starch product «Noodles» after cooking;
466.18 (3) A low-protein starch product «Spider line» after cooking;
466.18 (4) A low-protein starch product «Vermicelli», dry.*

According to the data of Table 2, the content of phenyl alanine (FA) for which there is a restriction in low-protein products is: before cooking (sample 4) to — 22.54 mg / 100, after cooking (sample 1–3) — 11.75; 13.36 and 18.2 mg / 100, depending on a type of a product. Decrease in FA by 20–48% in the course of cooking is observed, at the same time the FA content is much below than permissible value.

After cooking of pasta the inulin content decreases by 29–42% depending on a type of a product, i.e. an inulin, being dissolved in water, partially passes when cooking into a liquid phase.

It is apparent that at manufacture of the pasta intended for preparation of second courses it is more preferable to use the long chain inulin, for example, delivered by the Belgian firm «Beneo-Orafti» — «Beneo TM NRH» or «Benco TM NR» which contain an inulin 99.5%, fructose, glucose, sucrose — 0.5%, have an average degree of polymerization > 23.

The inulin of these brands is slightly soluble in water, at the same time «Beneo TM NRH» has high gel-forming ability at elevated temperature (when cooking). On the available data the long chain inulin is capable to connect water in quadruple quantity in relation to its own weight [17].

According to a consumption of ingredients, the content of polyvitamins in 100 g of pasta is:

- vitamin A — 22.93 mkg/%;
- β-Carotinum — 2.2 mg/%;
- reproduction vitamin, TE — 0.91 mg/%;
- B1 vitamin — 0.0035 mg/%;
- hepatoflavin — 0.0047 mg/%;
- RR vitamin — 0.006 mg/%;
- NE (Niacinum equivalent) — 0.008 mg/%;
- redoxon — 0.88 mg/%.

Nutrition and power value of pasta is shown in Table 3.

Table 3

Nutrition and power value of pasta

Name of an index	Unit of measure	ND on a technique	Vermicelli	Noodles	«Spider line»
Humidity	%	GOST 31964	7.6±0.0	7.6±0.1	7.45±0.05
Fat	%	GOST 31964	3.6±0.1	3.5±0.1	3.3±0.2
Protein	%	GOST 31964	0.9±0,1	0.5±0.0	0.65±0.05
Carbohydrates	%	MU 1–40/3805	87.76	88.27	88.46
Ashes	%	GOST 31964	0.14±0.02	0.13±0.03	0.14±0.02
Nutrition value	KJ	MU 1–40/3805	1617.8	1615.9	1614.1
Power value	KJ	MU 1–40/3805	387.04	386.58	386.14

Test data show that, depending on a type of a product, protein content — 0.9; 0.65 and 0.5% don't exceed permissible value for low-protein products (<1.0%); fat — 3.6; 3.3 and 3.5%; ash es — up to 0.14%; carbohydrates — no more than 88.0% that conforms to requirements to low-protein products of baby food. Pasta are used for preparation of first courses (soups) and garnishes for second courses, they can be applied not only for nutrition of sick FKU, but also for the children and adults having a renal failure. The cost of the reduced-protein enriched pasta produced in a pilot plant of the All-Russian Research Institute of Starch Products is 219.0 rub for 1 kg that is much lower of the imported ones (950–1148 rub for 1 kg).

4. Conclusion

The received results allowed:

- to pick up ingredients for creation of the reduced-protein enriched pasta on the basis of starch;

- with use of provisions of the theory of a food theory of combinations (individualmathematical models) to prove and develop ingredients composition and a recipe of pasta;
- to develop the technological mode and standard documentation for production of 3 types of pasta (vermicelli, noodles and a spider line) in a pilot plant of the Institute.

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