

DOI: <https://doi.org/10.21323/2618-9771-2020-3-4-20-23>Available online at <https://www.fsjour.com/jour>

Original scientific paper

METHODOLOGICAL ASPECTS OF THE USE OF DRY COMPONENTS OF CHICKEN EGGS FOR FEEDING CHILDREN WITH PHENYLKETONURIA

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Currently, one of the most important tasks facing science and production is the creation of functional product technologies for use in different diets of the population in order to preserve and improve health, as well as reduce the risks and consequences of various diseases, including hereditary ones, such as phenylketonuria (PKU). The All-Russian Research Institute of Starch Products develops technologies for the production of low-protein starch-based products/semi-products enriched with functional ingredients and intended for therapeutic nutrition of patients with PKU. As part of the pilot production, the production of these products is organized. Purpose of work:- to justify the possibility of using dry components of chicken eggs (melange, protein, yolk) to enrich low-protein starch products (noodles, vermicel, «spider») intended for feeding children over 3 years old with phenylketonuria;- evaluate organoleptic properties and efficiency of low-protein starch products enriched in hypophenylalanine diet of patients with phenylketonuria older than 3 years.

FUNDING: The article was published as part of the research topic No. 0585–2019–0031–C-01 of the state as-assignment of the V. M. Gorbatov Federal Research Center for Food Systems of RAS and Research «Scientific justification and development of modern methods of dietary therapy for various diseases in children in a multidisciplinary hospital using specialized children's foods» FSAU «National Medical Research Center for Child Health»

1. Introduction

In recent years, studies have been carried out confirming the possibility of using dry ingredients of chicken eggs (protein, yolk, melange) to enrich low-protein starch products [1,2,3]. An important factor determining the feasibility of using enriched starch products in the nutrition of children with phenylketonuria is the low content of protein and, accordingly, phenylalanine. It has been established that the inclusion of new ingredients in small quantities in the composition of dry semi-products allows them to be used in low-protein dietary therapeutic diets of patients with PKU, primarily in the nutrition of children.

Two fundamentally new technological techniques have been developed for introducing dry ingredients of chicken eggs into the starch base: the first is the moisture-thermal treatment of a mixture of corn starch and egg products on a roller dryer, the second is the mechanical mixing of the added ingredients and swellable corn starch.

It was found that the physicochemical properties (swelling, solubility, conditional viscosity) of products obtained using various technological methods are close to each other.

A comparison of the two methods of producing new starch mixtures in combination with dry egg products has shown that it is preferable to use a mechanical mixing method because it is simpler and more economical.

2. Materials and methods

The main ingredients for the production of pasta were: corn starch (GOST 32159–2013) and extrusion corn starch of domestic production «Extramil» (TU9187–001–18020121–2001).

To enrich pasta, dry egg yolk (GOST 30363–2013) and Vectoron Children's Solution (TU9197–033–58693373–06 with changes 1, 2) were used.

According to the results of previous studies [4,5], it has been found that in the development of the formulation of low-protein products, all three components of chicken eggs can be used as a functional additive, but it is preferable to use dry yolk, which is more suitable in quality composition for baby food. Compared to egg melange and protein, the yolk has a higher energy value and the smallest amount of protein, and therefore phenylalanine. In addition, it surpasses melange and protein in terms of organoleptic properties, since it has a pronounced taste and smell characteristic of a chicken egg.

Analysis of the chemical composition of new pasta showed that their protein content per 100 g of dry product is less than 1.0%, fat 3.3–3.6%, ash up to 0.14%, carbohydrates no more than 88.0%, energy value ranges from 1614.1–1617.8 kJ (386.14–387.04 kcal).

The results of the analytical evaluation confirmed that the ingredient composition of these products fully meets the requirements for food products of this class (specialized low-protein products) used in the therapeutic and dietary nutrition of patients with phenylketonuria [6,7,8].

Clinical studies of the safety and effectiveness of these low-protein pasta used for the preparation of low-protein dishes were carried out on the basis of the Advisory and Diagnostic Center of the Federal State Research Institute for Children's Health of the Ministry of Health of the Russian Federation.

Evaluation of the effectiveness of the use of pasta of low-protein starch enriched for dietary therapeutic nutrition for children over 3 years of age: Vermichel, Noodles, Spider was an incomparable, prospective, single-center, uncontrolled study.

Parents (legal representatives) were informed in detail about the goals and tasks of the work, followed by obtaining written informed consent to participate in the study. Children who met the

inclusion criteria and had no contraindications to prescribing the above low-protein products were randomly selected for follow-up.

Inclusion criteria:

- ❑ Children of both sexes between the ages of 3 and 18 years with classical phenylketonuria confirmed at neonatal screening on a hypophenylalanine diet;
- ❑ having written consent of parents/legal representatives to participate in the study.

Exclusion criteria:

- ❑ acute infectious disease.

The study design is shown in Figure 1.

Under supervision there were 10 patients with phenylketonuria, of which 4 boys and 6 girls, aged 3 years 8 months to 11 years 4 months, the average age of patients was 8 years 4 months ± 2 years 8 months.

The study used a clinical method that included the collection of history data, physical examination with an assessment of growth and body weight, the overall health of the child at the beginning and at the end of the study, an assessment of the tolerability and organoleptic qualities of low-protein products according to the 5 points system, which was carried out using telephone and online contacts. All data obtained were recorded in an individual registration card.

Laboratory research methods included a biochemical (fluorimetric) method for determining the level of phenylalanine in blood serum before prescribing the test products and against the background of their intake 1–2 days before the end of the study.

Statistical processing of the obtained data was carried out using the STATISTICA 13.0 package (StatSoftInc., USA). Median (Me) values as well as 5th and 95th percentiles were used to describe the test indicators. The differences between the two dependent groups were assessed using a non-parametric Wilcoxon test. The probability of error (p) was considered statistically significant at values < 0.01

3. Results and discussion

In the course of experimental studies, optimal ratios of starch and dry ingredients of chicken eggs were determined, which is very important for maintaining such a quota of protein, which at the output of the production cycle will be the permissible concentration for a low-protein product. So, to prepare a mixture of starch: dry egg white, the content of the latter should be no more than 5%, for the mixture starch: melange – 10%, and starch: yolk – 15%.

With the addition of egg products and an increase in their quota, the content of amino acids and trace elements in the end product also increases compared to the starting starch, while the amount of phenylalanine varies slightly.

It should be noted that the moisture-thermal treatment of the starch protein mixture can be used to produce an artificial egg substitute as a separate semi-product. The food composition obtained by mechanical mixing of swellable starch and dry egg products can be used as an additive for enriching already existing low-protein products, as well as a necessary ingredient for

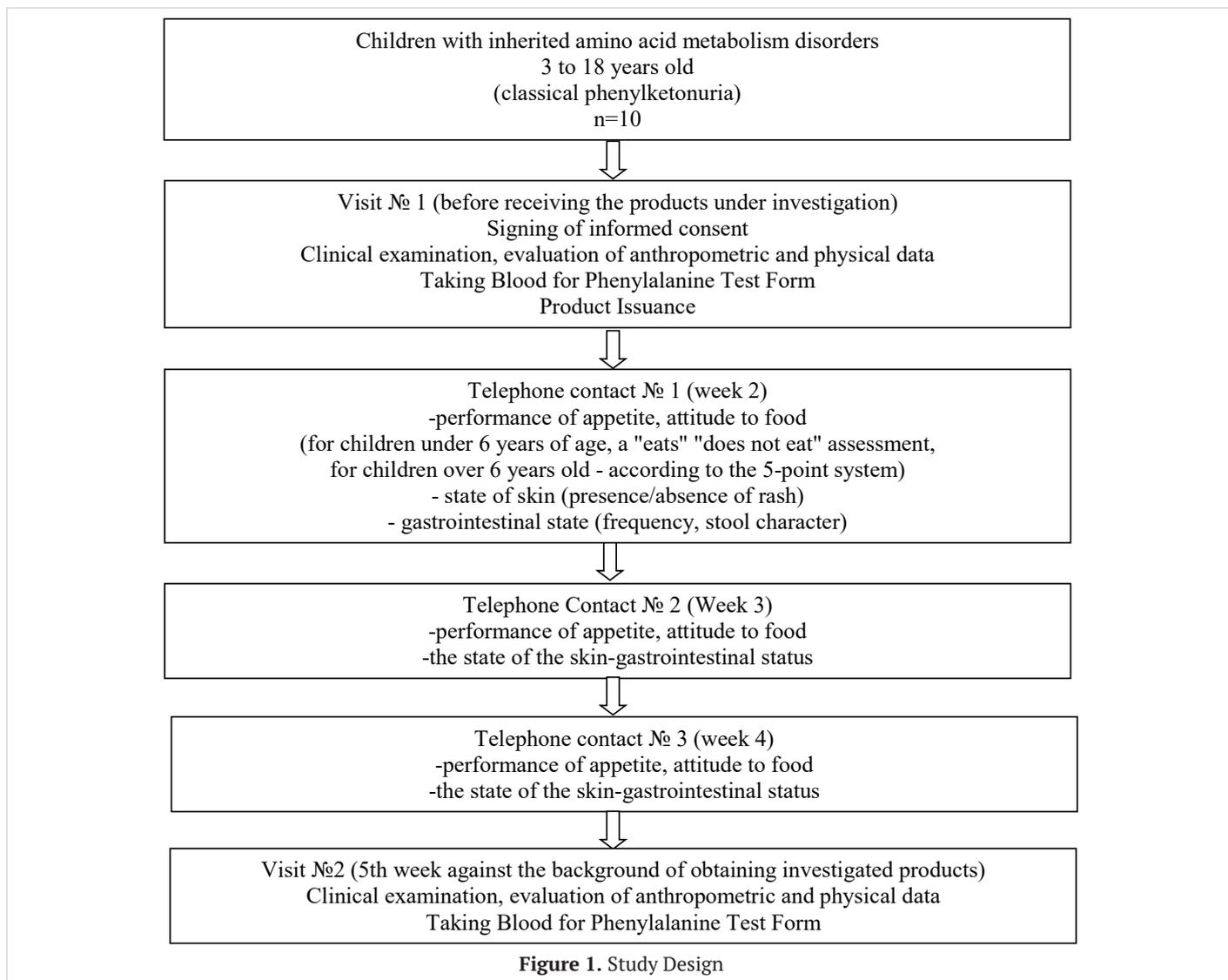


Figure 1. Study Design

baking bread and a filler in various bakery and vegetable dishes (tins, vegetable balls, cutlets, etc.).

In order to increase the nutritional value of low-protein pasta (noodles, vermicel, "spider") widely used in medicinal nutrition of patients with PKU, dry egg products were introduced into their composition.

3.1. Product Assignment Procedure

After the initial examination and assessment of nutritive status (anthropometric indicators), each child was assigned all 3 types of the studied products as part of the low-protein menu throughout the follow-up. The products were given home for 30 days in the form of semi-finished products at the rate of 1 bag (1.0 kg) of each product for use as an independent dish (pasta, vermicel, noodles) or a component for the preparation of other dishes (soup, stew, casserole, etc.).

The investigated products were introduced into the diets of children with phenylketonuria in the form of ready-made dishes instead of previously used similar products of other manufacturers in accordance with clinical recommendations for providing medical care to children with PKU [9] and the fundamental principles of hypophenylalanine diet organization [10,11]. The duration of each product intake was 10 days, in order to avoid uniformity of diet, the products alternated throughout the study.

Organoleptic properties (taste, consistency), as well as the appearance of new low-protein mixtures of starch enriched "Vermichel," "Noodles," "Spider," intended for dietary therapeutic nutrition for children over 3 years old, all children rated "good" and "excellent." Most of them (7 out of 10 children) noted higher palatability compared to previous versions of these products. Three children noted the best appearance, consistency and taste of vermicel, the rest of the children did not single out any separate product. Results of assessment of organoleptic properties of low-protein products are given in Table 1.

Table 1
Assessment of organoleptic properties of dishes from new low-protein mixtures of starch enriched "Vermichel," "Noodles," "Spider"

Parameters	Indicators	Average Score Scores		
		Vermichel	Noodles	Spider
appearance	M±m	4.9±0.18	4.4±0.41	4.8±0.32
	Min	4.0	4.0	4.0
	Max	5.0	5.0	5.0
consistency	M±m	4.5±0.5	4.45±0.45	4.45±0.45
	Min	4.0	4.0	4.0
	Max	5.0	5.0	5.0
taste	M±m	5.0	4.8±0.32	4.9±0.2
	Min	5.0	4.0	4.0
	Max	5.0	5.0	5.0

Physical development indicators before the study began in 8 children corresponded to average age values, one child had

mild malnutrition, and another child had excess body weight. Against the background of the intake of the studied products, body weight indicators tended to increase, but remained within the age norm in 8 children, in a child with overweight during the observation period, the increase was only 100 g, in a child with malnutrition, the body weight increased to the lower limit of the average age indicators.

The main criterion for the effectiveness of the hypophenylalanine diet, which necessarily uses low-protein products, is the concentration of phenylalanine in the blood serum of patients. According to clinical recommendations, the therapeutic range of phenylalanine in the blood is 2–6 mg% for patients of all ages, however, for adolescents with PKU over 12 years old, it is allowed to increase to 10 mg% in the absence of neurological clinical symptoms. At the time of inclusion in the study, two of our patients had elevated levels of phenylalanine in the blood (7.1 mg% and 11.4mg%) due to periodic diet impairment, during the use of new low-protein products, phenylalanine in the blood decreased in these children, remaining only slightly elevated (6.8 mg%) in a teenager of 11.5 years due to increased control over compliance with the diet. In all other children, the serum content of phenylalanine was not increased and remained in the range of 2 to 6 mg%. The dynamics of the serum phenylalanine values before and at the end of the study are shown in Table 2.

Table 2
Dynamics of parameters of body weight, growth and content of phenylalanine in blood serum in children with classical phenylketonuria against the background of taking the analysed products

indicators	Me (DI 5;95%)		p*
	Prior to assignment of investigated products	At using the products under investigation	
Bodyweight (kg)	26.6 (14.8;51)	27.55 (15;51)	0.0001
Height (cm)	130.3 (103.5;162)	130.8 (103.5;167)	0.0001
Phenylalanine in the bloodserum (mg%)	4.45 (2.4;12.5)	2.65 (2.0;8,7)	0.0001

* Wilcoxon criteria

4. Conclusion

Thus, the clinical testing of new pasta low-protein products "Vermichel," "Noodles," "Spider," produced using modern technologies enriched with dry yolk and carotene ("Vetoron" – children's solution) showed high organoleptic qualities and effectiveness in maintaining the stability of the permissible level of phenylalanine in the blood of children with phenylketonuria Use of the above products allows to expand the range of hypophenylalanine diet and increase its nutritional value.

The positive results of the study indicate the possibility of widespread use of new enriched low-protein starch products in the practice of therapeutic nutrition in diseases requiring a low-protein diet.

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The authors declare no conflict of interest.

Received 28.08.2020 Accepted in revised 01.12.2020 Accepted for publication 22.12.2020