AMARANTH PRODUCTS IN THE GLUTEN-FREE DIET AND THEIR IMPACT ON PATIENTS' PHYSICAL DEVELOPMENT

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ABSTRACT

Introduction*: The article is devoted to the problem of gluten intolerance. In recent years, amaranth products have been considered an alternative source of gluten-free products due to low content of prolamins.*

Objective*: To evaluate physical growth in children following gluten-free diet after introduction of new amaranth products into their diet, and to study the influence of amaranth products on the adherence to gluten-free diet. Materials and methods. The study included 37 children, aged 1-17, with gluten intolerance, who followed gluten-free diet six months and more. Their physical development was assessed according to WHO criteria, and their parents reported adherence to gluten-free diet using a specially designed questionnaire. The patients were examined before and after amaranth product introduction into their diets.*

Results*: The research demonstrated that 73% of patients (n=27) strictly followed gluten-free diet. 18.9% of children violated the diet rarely, 8.1% frequently violated the diet for a long time. Pathologically low height was diagnosed in 21.5% of children; 5.4% were tall, 59.5% of children were of medium height, 8.1% of children were shorter than medium, 5.4% were higher than medium. Lower body mass was diagnosed in 37.8% of patients, excess body mass was observed in 8.1%; 54.1% of patients had regular (normal?) body mass value. 100% of families included in the study became interested in the option to expand the diet of a child with gluten-free products made from amaranth. Regular amaranth product consumption resulted in the increased number of children following strict gluten-free diet (up to 83.8%) and improved physical growth parameters.*

Conclusion*: Amaranth products consumption facilitated adherence to gluten-free diet, improved nutrition quality, reduced psycho-emotional overstrain in children due to the opportunity to vary their diet by new gluten-free amaranth products.*

Keywords*: gluten intolerance, gluten-free diet, amaranth products, physical growth, children.*

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Introduction

Gluten is a protein found in many cereals including wheat, barley, oat etc. Sensitivity to gluten causes inflammation in the body starting with the intestine. Gluten intolerance (GI) often manifest in three major conditions. One of them is linked to the atopic form of allergy to wheat; this condition is indicated by general and specific immunoglobulins class E (IgE) in blood. Apart from an atopic reaction to cereal proteins there is another condition associated with GI and linked to the production of IgG antibodies. This is food hypersensitivity. The most well-known form of GI is celiacia. According to WHO definition celiacia is an autoimmune disorder that is characterized by the damage of mucus membrane of the small intestine - T-cell mediated enteropathy. It is a chronic immune-mediated form of enteropathy developing in the genetically predisposed people(1). Sensitivity to wheat, rye, barley, oats varies from 18% to 50% in children with atopic dermatitis and bronchial

asthma[2]. Another form of gluten sensitivity (GS) is non-celiac non-allergic gluten intolerance, which has been identified in the recent decade[3-6]. Gluten-free diet appears to be an ultimate option for treating both celiacia and GS[3-5]. It allows jugulating basic symptoms of the disease and decreasing risk of complications. However, researchers have revealed a range of challenges associated with the diet. These involve psychological problems due to permanent nutritional restrictions, a possibility of macro- and micronutrient deficiency, gluten-free products are not always available[4-5].

In recent years, amaranth products have been considered an alternative source of gluten-free products due to low content of prolamins (approximately 2%, comparing to 35% in wheat, 30% in rye) and higher nutritional value. An analysis of amaranth flour in comparison to other types of flour has demonstrated a range of benefits of the former. Firstly, amaranth flour contains a higher amount of protein with better amino acid composition. Secondly, it is characterized by a larger amount of lipids presented by polyunsaturated fatty acids, squalene, tocopherol and other biologically active components. Thirdly, amaranth flour has less digestible carbohydrates, including starches, but a larger amount of fiber. Moreover, amaranth flour contains a considerably larger amount of calcium, iron, phosphorus, potassium, magnesium and other nutrients compared to other types of flour. Finally, amaranth flour contains little amount of prolamins which makes it indicated for consumption to people with celiacia and other forms of gluten intolerance[12-14].

Physical development (height and body mass) is reported to be an important characteristic of child health at any age. Parameters of physical development may be compromised by an acute or chronic disorder and are dependent on nutrition, social and ecological factors[15]. Thus, we argue that amaranth products in a gluten-free diet may have a positive impact on children and adolescents with gluten intolerance. To prove this hypothesis, we evaluated the parameters of physical development in children following a gluten-free diet with new amaranth products; we studied the influence of amaranth products on the degree of gluten-free diet adherence.

Materials and methods

The inclusion criteria were

• the occurrence of pathology related to GI;

• gluten-free diet compliance for 6 months and longer.

The study included 37 children, aged 1-17 (a median line is 9 years, 25 quartiles is 5 years, 75 quartiles is 12 years), who followed a gluten-free diet for 6 months and more (a median line is 8 years, 25 quartiles is 3 years, 75 quartiles is 11 years). It should be noted that patients could be divided into two groups based on the degree of diet non-adherence. 25 patients were diagnosed with celiacia and 12 patients were diagnosed with GS. Patient cohort included 19 male patients and 18 female patients. Due to high age variability all patients were divided into three age groups: Group 1 included 15 patients of 1- 6 years old; Group 2 included 16 patients of 7-12 years old; Group 3 included 6 patients of 13-17 years old.

Parameters of physical development (height, body mass) were evaluated in all patients according to the regional percentile tables relevant for children, aged 1-19[17]. The study also included patients' parents, who reported about the quality and challenges of the gluten-free diet adherence of their children using a specially designed questionnaire. After all the patients had been examined, their diet was supplemented by amaranth products and the children regularly consumed them for 9-12 months. Amaranth flour came in different forms, e.g. as porridge 2-4 times a week, daily snacks (crisps, cakes, biscuits, waffles, pancakes, blini), other meals. To monitor the consumption of amaranth products parents kept food diaries. Children's examinations and parents' surveys were performed in the beginning and at the end of taking the optimized gluten-free diet.

All stages of the study conformed to legislation of the Russian Federation, international ethic norms and codes of research organizations. This study was approved by the Ethic Committee, Federal State Budget Educational Institution of Higher Education "Voronezh N.N. Burdenko State Medical University", Ministry of Healthcare of the Russian Federation. Parents gave a written informed consent for their children participation in the study.

Statistical data analysis was performed with an software "STATISTICA–-version10" (StatSoftInc.), BIOSTAT 2009 Professional and plugins "Data analysis" by Microsoft Excel 2010. Prior to the study the authors confirmed sample representativeness. Methods of descriptive statistics were applied (relative values expressed in percents, determination of a median line and an interquartile range -

25-75%). Regression modelling was used to determine relations between parameters. Spearman's non-parametric coefficient was used to assess data that were not followed Gauss' law, Mann-Whitney and Wilcoxon tests were used to assess the degree to which investigated groups differed from each other. The critical value of statistical significance was 0.05.

Results

In the cohort of study 73% of children (n=27) were strictly following the gluten-free diet, the rest 27% (n=10) periodically broke it down not ceasing completely. It should be noted that patients could be divided into two groups based on the degree of diet non-adherence. The first group included patients whose diet violations were insignificant and rare. The diet violation episodes were not accompanied by clinical symptoms and increased level of specific antibodies in 18.9% (n=7) of patients. The second group were patients with poor adherence to the diet therapy, diet violation episodes were frequent and, most probably, lengthy, which resulted in clinical symptoms and in a rise of specific antibodies in 8.1% (n=3) of patients.

100% of families included in the study became welcomed in the option to expand the diet with gluten-free products made from amaranth. More than half of all children - 62.2% (n=23) developed liking for amaranth porridge. 37.8% (n=14) of children had various complaints related to insufficient lightness and specific taste of the product. These problems were quickly solved by 27% (n=10) of parents, who added another type of flour (buckwheat, rice, corn) or flavor additives (cinnamon, vanillin, berries, honey, jam etc.). 10.8% of families could only partially overcome children's unwillingness. They reported a rare consumption of porridges from amaranth flour mixed with other types of flour. However, their children more actively consumed confectionary.

It is important to note that half of those children (5.4%, n=2) were under 3 years of age. The introduction of new products at this age is usually complicated due to a child's refusal to taste new unfamiliar products. Consumption of confectionary made from amaranth flour (crisps, cakes, biscuits, waffles, pancakes, bliny) caused no negative reaction in children. It should be mentioned that parents tend to choose products which conformed to eating habits of children. 89.2% of families (n=33) reported about positive response of children strictly following gluten-free diet to the diet expansion. Thus, all children participating in the study consumed amaranth products regularly. This was supported by the data from patients' dietary diaries.

A a questionnaire on exit survey of parents after active amaranth product consumption by their children as a part of their gluten-free diets demonstrated that 70.3% (n=26) of families would like to proceed with home-made products from amaranth flour in their everyday diets; 59.5% (n=22) and 56.7% (n=21) respectively were planning to consume porridges and confectionaries made from ready mixtures for bakery (based on amaranth flour); 54% (n=20) of families would prefer ready-made products: amaranth cakes, waffles, crisps, biscuits and others. The increased adherence to gluten-free diet appeared to be an important result of constant long-term consumption of amaranth products. Thus, the number of children strictly following gluten-free diet increased by 10.8% and reached 83.8% (n=31); the rest 16.2% (n=6) reported frequent episodes of diet violation, however, no one reported ceasing the diet completely.

Assessment of the patient's parameter	Position of the patient's parameter in the WHO percentile table	Height		Body mass	
		Before amaranth products consumption	After amaranth product consumption	Before amaranth products consumption	After amaranth product consumption
Low	<3	21,6	8,1	18,9	18,9
Below medium (decreased)	3-15	8,1	13,5	18,9	10,8
Medium	15 - 85	59,5	67,6	54,1	64,9
Above medium (increased)	85 - 97	5,4	5,4	2,7	2,7
High	>97	5,4	5,4	5,4	0

Table 1: Parameters of height and body mass in children with gluten intolerance after introduction of amaranth products in their diet therapy (%).

Table 1 demonstrates the results of the initial assessment of children's physical development. The assessment revealed the interdependence between the height of children and their age: in 59.5% (n=22) of children this parameter was within the interval 15 to 85 percentiles, in 21.6% (n=8) of children this parameter was <3 percentiles, in 8.1% (n=3) of children the height parameter was within the interval 3-15, and in 5.4% (n=2) – 85-97 percentiles; 2 children (5.4%) were tall (>97 percentiles).

The assessment of children's body mass in connection with their height demonstrated that this finding fell within the interval 15-85 percentiles in one in two babies (51.4%, n=20) was lower than 3 percentiles in 18.9% of children (n=7), was within the interval 3-15 percentiles in 18.9 % of patients (n=7), was within the interval 85-87 percentiles in 2.7% of children (n=1) and more than 97 percentiles in 5.4% of patients (n=2).

The assessment of dependence between the growth parameter of children and their age after consumption of amaranth products demonstrated that this parameter was within the interval 15-85 percentiles in most children (67.6%, n=25), it was <3 percentiles in 8.1% of children (n=3), this value was within the interval 3-15 percentile in 13.5% of children (n=5), it was 85-97 percentiles in 5.4% of children (n=2), and this value was >97 percentiles in 2 children (5.4%). Thus, the number of children with pathologically low height reduced in 2.7 times and the number of children with medium height increased by 8.1% due to the gluten-free diet in combination with amaranth product consumption. Statistical analysis showed that these values are significant and valid on Wilcoxon criterion (p=0.011) and are not valid on Mann-Whitney criterion (p=0.792).

However, it should be noted that positive changes of physical growth parameters in patients after amaranth products consumption are also supported by the tendency to a more regular distribution of the parameter – the average growth parameter has increased with the reduction of the average squared deviation (M+σ): from 128,7cm ±24,5cm to 133,2 cm ±24cm (Figure 1).

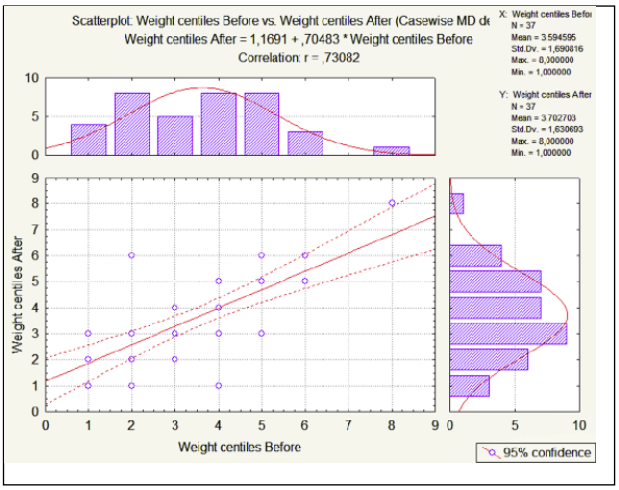

Figure 1: Regressive analysis on growth centiles.

Due to the fact that normalization of height parameters took place regularly in all age groups, i.e. a possibility of the growth spurt at a certain age is excluded, we may conclude that the tendency to growth normalization is exactly related to the more efficient gluten-free diet of children.

The analysis of body mass parameters dependently on the height demonstrated (Table 1) that this parameter was within the interval 10-90 percentiles in most children - 64.9% (n=24), the body mass parameter was low (<3 percentiles) in 18.9% (n=7), it was within the interval 3-10 in 10.8% (n=4), it was within the interval 90-97 percentiles in 5.4% (n=2); no children with body mass parameter >97 percentiles were registered. Thus, amaranth product consumption resulted in the reduced number of children with the body mass deficiency by 8.1% and the increased number of patients with the regular body mass from 51.4% to 64.9% (U-test, p=0,002) (Figure 2).

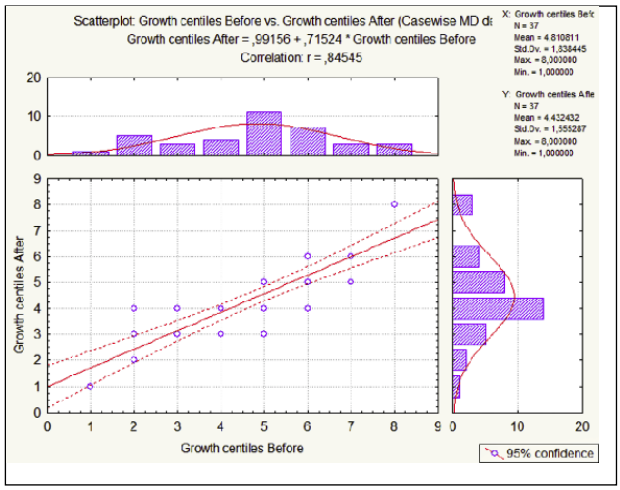

Figure 2: Regressive analysis on body mass-centiles.

This research study specifies dynamics of gluten-free diet adherence and physical growth parameters under regular amaranth product consumption in children and adolescents - residents of the European part of the Russian Federation.

Discussion. The results have demonstrated that regular consumption of amaranth products for 9-12 months by children with gluten intolerance has resulted in enhanced adherence to the diet and in the patients' physical growth improvement. The number of children following strict gluten-free diet has increased from 73% to 83.8%. Gluten-free diet can have a positive impact on patients' quality of life[20-23]; that is why, this change can be explained by the fact that diet expansion by amaranth products provided solution of major problems arising

when following gluten-free diet, such as psychological problems related to the ban on certain products, especially sweet and flour-based food, and the inaccessibility and high cost of specialized products[24]. Halmos et al.[25] also highlighted that little awareness about gluten-free diet and psychological problems were independent risk factors for nonadherence to gluten-free diet by patients with celiacia[25]. Strict adherence to gluten-free diet decreases risk of gastroenterological complications, results in the recovery of the mucus membrane of the small intestine, normalizes digestion that, in turns, provides high level of nutritive status[26-29].

Amaranth product consumption as a component enriching gluten-free diet is determined by biological characteristics of amaranth. Optimal amino acid composition of protein, high level of microelements, fiber, lack of gluten allow not only varying a diet but also provide nutritive status recovery[12-14]. Due to amaranth product consumption the number of children with pathologically low height has decreased, the number of children with medium height has increased. The number of children with the body mass findings lower than average values has decreased and the number of patients with the regular body mass has increased.

Therefore, these tendencies have demonstrated the increased interest of patients and their parents towards stricter adherence to gluten-free diet, improved nutrition quality due to amaranth product consumption, reduced psycho-emotional overstrain resulted from the opportunity to vary children's diet by new gluten-free amaranth products.

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