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NUTRITIONAL VALUE DETERMINATION OF THERMALLY PROCESSED POTATO MAIN COURSE IN RETORT PACKAGING

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Consumers are increasingly demanding choices of ready-made foods with excellent organoleptic and health-related properties. There are two main trends in Europe; firstly, consumers are increasingly choosing foods that are comfortable for use, secondly, the number of people who are overweight is increasing, with more consumers paying close attention to the ingredients and nutritional value of products in order to balance the amount of the food they consume per day.
The aim of the research was to develop new potato main courses and to determine their nutritional value. The research was carried out at the Faculty of Food Technology of the Latvia University of Agriculture, Institute of Food Safety, Animal Health and Environment "BIOR" and Laboratory of Mineral Nutrition at the Institute of Biology of the University of Latvia.
Four different potato main course types with amaranth, quinoa, bulgur and chicken were prepared for the study; plain potatoes were used as the control sample. The content of protein, carbohydrates, lipids, fibre and minerals (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Mo, B) was determined in all potato main course samples.
The addition of amaranth, quinoa and bulgur significantly increased the content of dietary fibre, protein, carbohydrates and lipids ($p<0.05$), whereas the addition of chicken fillet significantly increased protein and lipid content, but reduced the content of carbohydrates and dietary fibre. The content of various minerals, which are an indispensable part of the diet as they are necessary for the body's life processes and normal development, was significantly increased by the addition of chicken to the potato main course. The highest dietary fibre content was detected in potato main course with amaranth (3.0 g per 100 g product), drawing up to 9.0 g dietary fibre per one serving (300 g). Following the Regulation (EC) No 1924/2006, potatoes with amaranth can be defined as the "source of fibre".

Keywords: nutritional value, potato main course, retorts packaging.

INTRODUCTION

Convenience, together with price, sensory appeal and health-related concerns, is believed to be a major determinant of food choices (Costa, 2007, Geeroms, 2008). In Europe, the tendency to eat out or to buy ready-made, easy-to-eat foods has grown over recent years (Olsen, 2012). Ready-made, easy-to-eat dishes are defined as fully or partially prepared dishes that are adapted for industrial production and distribution. The use of ready-made, easy-to-eat food is not only related to time-saving but also energy-saving, culinary skills and dislike/anxiety about cooking (Celnik, 2012; Olsen, 2012; Geeromsa, 2008; Kanzler, 2015). Most of the easy-to-eat food consumers work long hours and pay little attention to meal planning and cooking, instead trying to find an alternative to increase their free time (Olsen, 2012; Regueiro 2015; Kanzler, 2015). In recent years, there has been an increase in the number of households with one to two people, which boosts market potential for this type of products (Hanssen, 2015). From the consumer point of view, today the product is assessed by the taste, price, healthiness and, of course, its convenient consumption (Celnika, 2012). Consequently, ready-made foods have become one of the main components of nutrition in today's society, therefore having a significant impact on the health of consumers (Regéeo 2015; Stratako 2015). However, regardless of the increase in ready-made food consumption, often ready-made meals are associated with poor taste, low nutritional value and unhealthy food (high fat, high salt) (Kanzler, 2015; Olsen, 2012). Approximately 63% of the food products available on the European market contain meat (40% chicken, 30% pork and 30% beef), 16% contain meat products such as sausages or bacon, 16% contain fish (salmon, catfish) and only 6% are vegetarian dishes. The most commonly used starchy ingredients are rice (41%), potatoes (22%), noodles (22%) and dumplings (16%) (Kanzler, 2015). Ready-meals are designed for “main meals” (lunch or dinner), typically in four ranges: (1) 'healthy', (2) 'economy' or 'value', (3) 'normal' and (4) ‘special’ "finest". There are no agreed nutritional criteria within or between these ranges (Celnik, 2012).

More and more, the focus is on the composition/ingredients of the products and their nutritional value (Patras, 2009). Scientifically based health claims and clear nutrition labelling are essential elements for consumers when choosing foods (Rufell, 2016). Ready-made meals on the market often contain less calories than one meal, but they have a higher salt, total fat and saturated fat content (Remnant, 2015). The content of minerals and trace elements in ready-made meals is particularly important as the consumed fat amount is considered too high and carbohydrate amount is too low (Kanzler, 2015). UK Food Standards Agency (FSA) guidance suggests that daily energy consumption should be split over four eating occasions or meals each day: breakfast – 20% of daily energy intake, lunch – 30%, evening meal – 30% and food between meals (snacks) – 20%. Using the same rationale as RDAs for daily nutrient intakes, "main meals" should each contain 30% of recommended daily energy and nutrient intake for women (2000 kcal), i.e., around 600–700 kcal; men need about 20% more (Celnik, 2012). Introducing simple nutritional standards for entire meals could be effective and less contentious than trying to categorise individual foods as “healthy” or otherwise (Celnik, 2012).

Ready to eat traditionally cooked dishes cannot be stored for a long time. One of the most effective ways of preparation of such products is heat treatment in packaging. This method of food treatment guarantees a long-term storage at room temperature, providing the quality and microbiological safety (Catauro, 2012). Very important is the product compatibility with packaging material, so the correct choice of packaging is one of the ways to maintain maximum product quality, while maintaining the nutritional value of the product (Rodriguez, 2003; Olsson, 2004). The retort pouch minimizes the thermal damage to nutrient, sensory, and other food quality characteristics due to quicker heating based on the thinner package profile when compared to metal cans (Awuah, 2007).

The aim of the research was to develop new thermally processes potato main courses in retort packaging and to determine their nutritional value.

MATERIALS AND METHODS

The research was carried out at the Faculty of Food Technology of the Latvia University of Agriculture, Institute of Food Safety, Animal Health and Environment "BIOR" and Laboratory of Mineral Nutrition at the Institute of Biology of the University of Latvia. A total of four different types of potato main course samples and control sample (potatoes) were prepared for this study: potatoes with amaranth *(Amaranthus* L.) (66% potato, 33% amaranth, 1% spices and salt), potatoes with quinoa (*Chenopodium quinoa* Wild.) (66% potato, 33% quinoa, 1% spices and salt), potatoes with bulgur (*Triticum durum* Desf.) (66% potato, 33% bulgur, 1% spices and salt) and potatoes with chicken fillet (49.5% chicken fillet, potato 49.5%, 1% spices and salt). Each sample was packed in two different packaging materials: two-layer PA/PE (polyamide/polyethylene) laminated film pouch with 80 µm thickness and PET/ALU/PA/PP (polyethyleneterephthalate/ aluminium/polyamide/polypropylene) film pouch with aluminium layer, 110 µm thickness. Cut potatoes were mixed with chicken fillet, or amaranth, quinoa, or bulgur, then 1% spices and salt was added to each sample. After mixing, products (300±10 g) were filled in 200x250 mm sized laminated pouches. After filling, pouches of potato main course were hermetically sealed using chamber type vacuum packaging machine *Multivac C350.* Vacuum sealed pouches were thermally treated in a pilot autoclave HST 50/100, ZIRBUS Technology GmbH (Germany). Sterilization was carried out at 120 ± 2 °C for 10 min, the cooling temperature was 20 ± 2 °C. After thermal treatment, sterilized products were stored at 20 ± 2 °C for 12 months.

Such nutritional parameters as protein, carbohydrates, lipids, dietary fibre and energy value, as well as minerals were determined in the products after 12-month storage. Nutritional value was assessed by the methods summarised in Table 1.

Table 1. The methods used for nutritional value analysis of the products.

Parameters	Method of analysis
Protein	LVS EN 12135:2001
Lipids	GOST 8756.21-89 p.2
Carbohydrate	Calculated by difference
Dietary fibre	ISO 5498:1981
Energy value	Regulation (EU) No 1169/2011
Macro (N, P, K, Ca, Mg, S) and micro (Fe, Mn, Zn, Cu, Mo, B) minerals	N – colorimetric with Nessler's reagent in alkaline conditions P – colorimetric with ammonium molybdate K – flame photometry (Jenway PFP7) Ca, Mg, Fe, Mn, Zn, Cu – atomic absorption spectroscopy (Perkin Elmer Aanalyst 700) S - turbidimetry with BaCl2 Mo – colorimetric determination of molybdenum by the reaction with thiocyanate B – colorimetric with quinalizarin in acid conditions

The obtained data were processed using SPSS software package 16.0; differences among results were considered significant if p-value < 0.05. One-way analysis of variance (ANOVA) and Tukey’s test were used to interpret the results.

RESULTS

Four different potato main courses were developed in this study, followed by their nutritional value analysis. Initially, the content of protein, lipids, carbohydrates, dietary fibre were determined and energy value was calculated.

Protein content in potato main course samples – control (potatoes) (F1), potatoes with amaranth (F2), quinoa (F3), bulgur (F4) and chicken fillet (F5) – in PET/ALU/PA/PP pouches was determined after 12-month storage at 20 ± 2 ºC temperature (Fig. 1). The comparison of protein content (per 100 g) in potato main courses showed that the highest protein content was in potatoes with chicken fillet (F5), 13.4 g per 100 g of product, thus the total protein content per serving (300 g) is 40.2 g. Almost half the protein content was found in potatoes with amaranth (F2) – 7.0 g per 100 g product. The protein content of all ready-meals (F2, F3, F4, F5) was significantly different ($p<0.05$) compared to the control sample (F1); the addition of amaranth, quinoa, bulgur and chicken significantly increased the content of protein in potato main courses. According to Regulation (EC) No 1924/2006, potatoes with amaranth (F2), quinoa (F3) and bulgur (F4) can be considered a “source of protein”, as protein provide at least 12% of the energy value of the product, but potatoes with chicken fillet (F5) can be considered “high protein”, as protein provide at least 20 % of the energy value of the food.

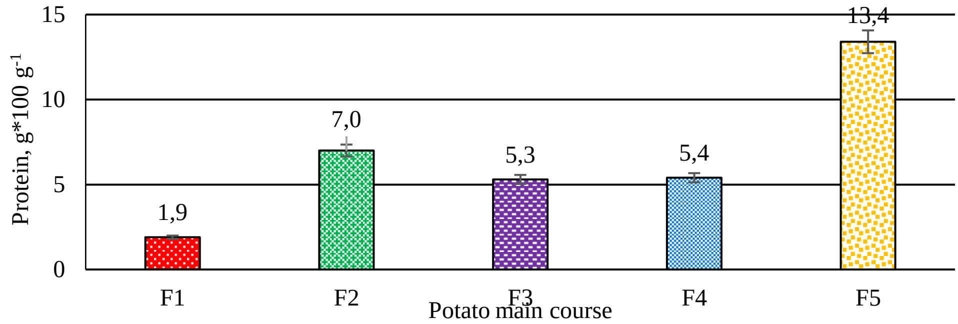

Fig.1. Protein content ($g*100\ g^{-1}$) in potato main courses in PET/ALU/PA/PP packaging

The content of lipids in potato main courses was significantly different among the tested samples ($p<0.05$) (Fig. 2). The highest lipid content was determined in potatoes with quinoa (F3) – 2.3 g per 100 g and potatoes with amaranth (F2) – 2.2 g per 100 g. Potatoes with chicken fillet (F5) had a lower lipid content (1.5 g per 100 g). All potato dishes (F2; F3; F4; F5) had a significantly higher lipid content ($p <0.05$) in comparison to control sample (F1).

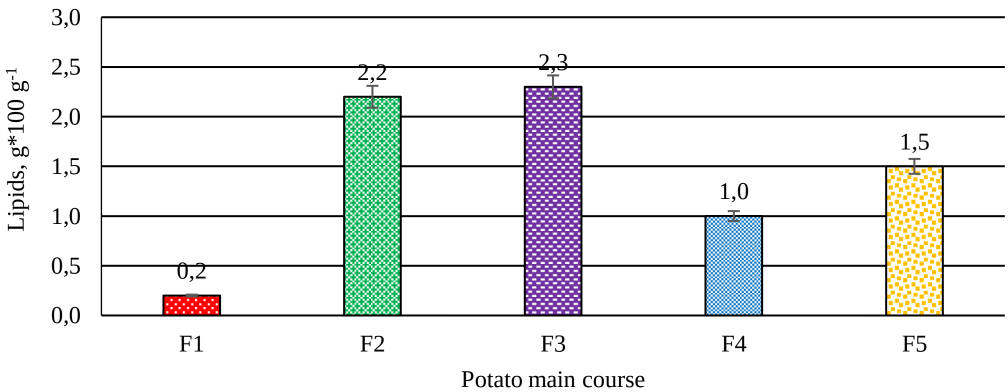

Fig 2. Lipid content ($g*100\ g^{-1}$) in potato main courses in PET/ALU/PA/PP packaging

According to Regulation (EC) No 1924/2006, control sample, which only consists of potatoes, can be referred to as “fat-free” product, since the legislation defines that if the product contains less than 0.5 g fat per 100 g of product, then the above-mentioned claim may be used. Whereas, potatoes with amaranth (F2), quinoa (F3), bulgur (F4) and chicken fillet (F5) contain less than 3 g fat per 100 g product and are eligible for “low-fat” nutrient claim.

Carbohydrate content in potato main course samples – control (potatoes) (F1), potatoes with amaranth (F2), quinoa (F3), bulgur (F4) and chicken fillet (F5) – in PET/ALU/PA/PP pouches was calculated by difference after 12-month storage at 20 ± 2 ºC temperature (Fig. 3).

The highest content of carbohydrates was found in potatoes with bulgur (F2) – 34.3 g per 100 g, which accounts for 82% of the total energy value, followed by potatoes with amaranth (F2) – 33.3 g per 100 g, accounting for 74% of the total energy value and potatoes with quinoa (F3) – 32.6 g per 100 g, representing 76% of the total energy value. The lowest content of carbohydrates was found in potatoes with chicken fillet (F5) – only 6.1 g per 100 g. In comparison to control sample – potatoes (F1), there were significant differences ($p <0.05$) in carbohydrate content of potato main courses (F2; F3; F4; F5).

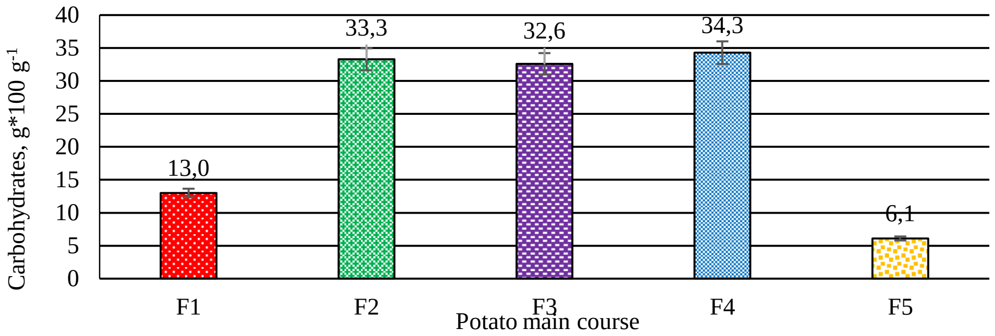

Fig.3. Carbohydrate content (g*100 g $^{-1}$) in potato main courses in PET/ALU/PA/PP packaging

Dietary fibre content in potato main course samples – control (potatoes) (F1), potatoes with amaranth (F2), with quinoa (F3), with bulgur (F4) and chicken fillet (F5) – in PET/ALU/PA/PP pouches was determined after 12-month storage at 20 ± 2 ºC temperature (Fig. 4).

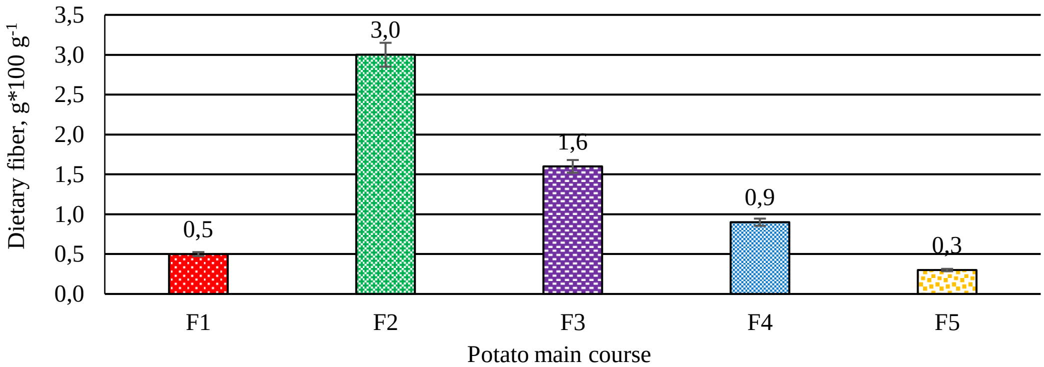

Fig.4. Dietary fibre content (g*100 g $^{-1}$) in potato main courses in PET/ALU/PA/PP packaging

Summarizing the results of dietary fibre obtained in the study, the highest content of fibre was determined in potatoes with amaranth (F2) – 3.0 g per 100 g of product, thus the total fibre content of the portion (300 g) reaches 9.0 g. Conforming to Regulation (EC) No 1924/2006, potatoes with amaranth are a “source of fibre”, as this product contains at least 3 g of fibre per 100 g of product. Half the dietary fibre content was found in potatoes with quinoa (F3) – 1.6 g per 100 g. Potatoes with chicken fillet (F5) showed the lowest fibre content – 0.4 g per 100 g. There were significant differences between the samples F2, F3 and F4, while sample F5 did not differ significantly from the control sample ($p>0.05$) in terms of dietary fibre.

Energy value of potato main course samples – control (potatoes) (F1), potatoes with amaranth (F2), with quinoa (F3), with bulgur (F4) and chicken fillet (F5) – in PET/ALU/PA/PP pouches was calculated after 12-month storage at 20 ± 2 ºC temperature (Fig. 5). The highest energy value was found for potatoes with amaranth – 767 kJ per 100 g, which is 505 kJ higher than that of the control sample (F1); the total energy value of potatoes with amaranth is 2301 kJ or 550 kcal per serving (300 g). Potatoes with quinoa (F3) showed equally high energy value – 467 kJ higher compared to control (F1) per 100 g, and a total of 2187 kJ or 523 kcal per portion (300 g). Energy value of potatoes with bulgur (F4) was 450 kJ higher than in control sample (F1) per 100 g, with the total portion (300 g) energy of 2136 kJ (511 kcal). The energy value of potatoes with chicken fillet (F5) was significantly lower compared to samples F2, F3 and F4, reaching only 387 kJ per 100 g of product, which is 92 kcal.

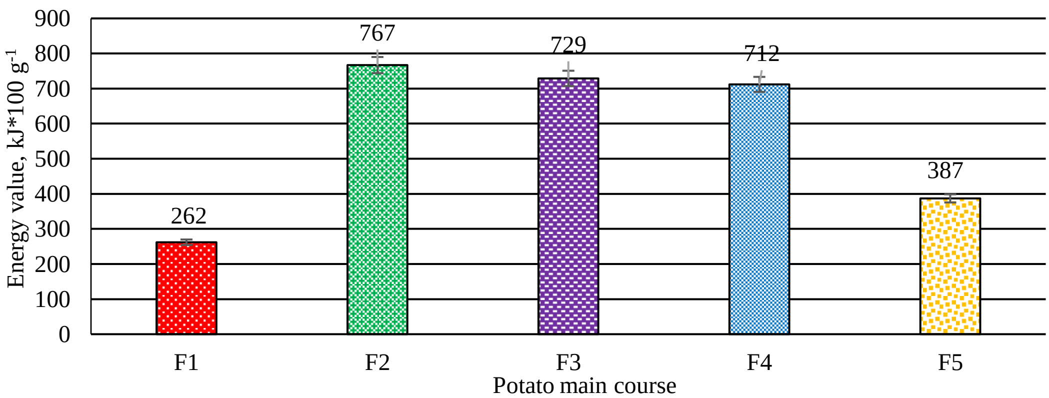

Fig. 5 Energy value (kJ*100 g $^{-1}$) of potato main courses in PET/ALU/PA/PP packaging

The assessment of energy value of potato main courses indicates that the new products cover around ¼ of the recommended daily caloric needs, as defined by the ordinance No 174 issued by the Ministry of Health of the Republic of Latvia, which sets the recommended energy and nutrient intakes for residents of Latvia. The recommended daily energy intake for men is 2400 kcal and for women it is 2000 kcal. The new potato main courses do not contain excessively high fat content and the total energy value does not exceed 30% of the recommended intake of energy, which is needed for lunch or dinner.

The content of macronutrients and micronutrients was determined in potato main course samples – control (potatoes) (P1), potatoes with amaranth (P2), quinoa (P3), bulgur (P4) and chicken fillet (P5) in PA/PE packaging and control (potatoes) (F1), potatoes with amaranth (F2), quinoa (F3), bulgur (F4) and chicken fillet (F5) in PET/ALU/PA/PP pouches was calculated after 12-month storage at 20 ± 2 ºC temperature (Table 2, 3).

Potato main courses contain six different minerals – macro-elements nitrogen, phosphorus, potassium, calcium, magnesium and sulphur, and trace elements – iron, manganese, zinc, copper. The highest level of phosphorus was found in potatoes with amaranth and chicken fillet (P2; F2; P5; F5), which, according to ordinance No 174 issued by the Ministry of Health of the Republic of Latvia, provides the recommended daily phosphorus intake (Ordinance No 174 on recommended allowance of energy and nutrition for Latvian citizens issued by Ministry of Health of the Republic of Latvia, 2008). Potassium was most abundant in the control sample (potatoes) (P1; F1) and potatoes with chicken fillet (P5; F5), however, the recommended potassium daily intake of 4000 mg can only be provided by control sample – potatoes without added ingredients (P1; F1). In turn, the highest magnesium amount was found in potatoes with amaranth (P2; F2), which also ensures the required daily intake of magnesium – 350 mg (Ordinance No 174 on recommended allowance of energy and nutrition for Latvian citizens issued by Ministry of Health of the Republic of Latvia, 2008).

Table 2. Content of macronutrients in potato main courses

	P1 %	F1 %	P2 %	F2 %	P3 %	F3 %	P4 %	F4 %	P5 %	F5 %
N	1.47	1.67	2.29	2.33	1.80	1.80	1.85	1.83	6.40	6.40
P	0.19	0.21	0.44	0.43	0.14	0.16	0.36	0.33	0.43	0.45
K	1.72	1.70	0.92	0.92	0.76	0.79	1.01	0.98	1.17	1.20
Ca	0.018	0.017	0.16	0.14	0.004	0.002	0.084	0.080	0.049	0.05
Mg	0.14	0.13	0.24	0.24	0.08	0.10	0.18	0.17	0.14	0.13
S	0.12	0.14	0.17	0.15	0.16	0.20	0.26	0.25	0.30	0.27

The assessment of trace elements (micronutrients) established that sample P2; F2 – potatoes with amaranth had the highest iron content. The lowest iron content was found in the control sample (P1; F1) and potatoes with quinoa (P3; F3). According to the Ordinance No 174 on recommended allowance of energy and nutrition for Latvian citizens, the recommended daily iron intake for men is 10 mg, but for women 18 mg. Therefore, it is possible to conclude that potatoes with amaranth (P2; F2) and bulgur (P4; F4) provide the recommended daily iron intake for both men and women.

Table 3. Content of micronutrients in potato main courses

	P1 $mg*kg^{-1}$	F1 $mg*kg^{-1}$	P2 $mg*kg^{-1}$	F2 $mg*kg^{-1}$	P3 $mg*kg^{-1}$	F3 $mg*kg^{-1}$	P4 $mg*kg^{-1}$	F4 $mg*kg^{-1}$	P5 $mg*kg^{-1}$	F5 $mg*kg^{-1}$
Fe	25±0.80	26±0.72	79±1.02	80±1.58	26±0.76	26±0.62	66±2.03	64±1.68	38±1.21	37±1.16
Mn	9±0.29	8.60±0.35	34.80±1.49	36±1.40	11±0.40	12.20±0.46	24±0.99	23±0.91	8±0.33	8.60±0.38
Zn	13±0.37	12±0.47	34±0.91	33.30±1.33	4.60±0.43	15.20±0.46	22±0.53	22±0.78	18±0.61	16.90±0.51
Cu	2.80±0.07	2.80±0.11	4.80±0.14	4.20±0.16	3.11±0.12	3.60±0.12	4.20±0.15	3.60±0.10	2.50±0.077	3±0.09
Mo	0.23±0.01	0.25±0.01	0.65±0.02	0.73±0.02	0.45±0.02	0.42±0.02	0.20±0.01	0.20±0.01	0.30±0.01	0.25±0.01
B	5±0.21	4.50±0.18	7.50±0.20	7.00±0.24	2±0.08	1.50±0.05	7.50±0.31	6.50±0.29	2±0.08	2.80±0.10

With regards to manganese content in potato main courses, the highest amount was found in potatoes with amaranth (P2; F2), whereas the lowest – in potatoes with chicken fillet (P5; F5). The recommended daily intake of manganese for women and men is 3 mg per day (Ordinance No 174 on recommended allowance of energy and nutrition for Latvian citizens issued by Ministry of Health of the Republic of Latvia, 2008). The consumption of one serving (300 g) of potatoes with amaranth, quinoa or bulgur provides the recommended daily manganese intake.

The highest content of copper was found in potatoes with amaranth (P2; F2), but the lowest copper content – in potatoes with chicken fillet (P5; F5). The recommended daily copper intake for both genders is 3 mg. None of the potato main courses (one serving of 300 g) was able to provide the recommended daily copper intake.

Summarizing the results of the study, it can be concluded that the addition of amaranth, quinoa, bulgur and chicken fillet to a plain potato main course can significantly improve the nutritional value of the product. The new products are "source of protein" and "low-fat", providing ¼ of the recommended daily calorie intake and ensuring the body with valuable minerals (iron, potassium, copper, etc.); potato main courses do not meet the predefined characteristics of ready-made foods, which are usually high in fat and low in nutritional value.

CONCLUSIONS

1. The addition of amaranth, quinoa and bulgur to potatoes significantly increased the content of dietary fibre ($p<0.05$), whereas the addition of amaranth, quinoa, bulgur, chicken fillet significantly increased the content of protein ($p<0.05$)

and amaranth, quinoa, bulgur can be defined as "source of protein", but chicken fillet can be defined as "high protein" product based on Regulation (EC) No Regulation 1924/2006.
2. Potato main course with amaranth had the highest fibre content – 3 g per 100 g of product, hence this dish is also "source of fibre".
3. All potato-based main courses are "low-fat" foods based on the low fat content.
4. Potato main courses – potatoes with amaranth, quinoa and bulgur provide the required daily manganese intake, while potatoes with amaranth and bulgur provide the recommended daily iron intake.
5. Potatoes with amaranth are the most valuable potato main course based on the nutritional composition.

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