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CRISPBREADS WITH CARROT AND PUMPKIN PROCESSING BY-PRODUCTS

Daiga Konrade[#], Dace Kļava, Ilze Grāmatiņa, Solvita Kampuse, and Tatjana Kince

Faculty of Food Technology, Latvia University of Life Sciences and Technologies, 22 Rīgas Str., Jelgava, LV-3001, LATVIA

[#] Corresponding author, daigakonrade@gmail.com

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The results of carrot and pumpkin processing are by-products like bark and peel. Therefore, food processing waste has the potential to be converted into useful products and utilised as a source of functional compounds for consumers. Carrot and pumpkin by-products contain carotenoids, precursors of vitamin A, and dietary fibre. The consumption of these is linked to decreased incidence of cardiovascular disease, diverticulosis, and colon cancer. The aim of the study was to investigate means to increase nutritional compound content in extruded crispbread with carrot and pumpkin processing by-products. Samples were prepared from wheat flour 70%, rice flour 24%, and wheat bran 4% as control with addition of 5%, 10%, 15%, 20 % dried and grinded carrot and pumpkin by-products. Products were extruded in GÖTTFERT 1 screw Extrusiometer L series. The temperatures for extrusion zones were set at 78/83/98 °C. Total carotenoid content of the new products was determined by spectrophotometry. Total dietary fibre content was determined with Enzymatic-Gravimetric Method, AOAC 985.29. The total carotenoid content increased significantly with addition of pumpkin and carrot by-products in crispbread samples. The increase of dietary fibre content was from 9.3 mg·100 g^{-1} in wheat crispbread to 15.89–16.08 mg·100 g^{-1} in products with added carrot and pumpkin by-products.

Key words: *carotenoids, crispbread, dietary fibre, extrusion.*

INTRODUCTION

People nowadays tend to consume foodstuffs that contain compounds promoting health and preventing several diseases. These products are not necessarily the slow food as we would like to think, but they are products for quick cooking like pasta, cereal snacks, breakfast flakes, crispbreads, and some instant drinks as well. During vegetable processing like juicing or making purees, the remaining by-products are still rich in various biologically active compounds like dietary fibre and carotenoids. For example, after juicing, 10–30% of the product remains as by-products (peel, marc). Food processing waste has the potential to be converted into useful products and utilised as supplements as a source of functional compounds for consumers.

Functional foods play an important role in research and in the innovative food industry.

Many foodstuffs have functional properties that can prevent occurrence of a certain disease or delay its progression, such as diabetes, obesity, gastrointestinal diseases, cancer, allergies, and cardiovascular diseases (Arias-Aranda *et al*., 2010; Cho and Clark, 2010). There are few studies on how the human body functions are affected by a nutrient, vitamin, or trace element deficiency.

In Europe, functional foods sales have increased significantly, although demand for functional foods within European Union varies considerably from country to country, mainly due to food traditions and cultural heritage (Annunziata and Vecchio, 2011).

Fibre is an important component of diet and nutrition. Dietary fibre is the edible parts of plants, or similar carbohydrates, that are resistant to digestion and absorption in the small intestine (Dreher, 2001). Its consumption is also linked to decreased incidence of cardiovascular disease, diverticulosis, and colon cancer. Dietary fibre (DF) is a good sorbent for heavy metals (Nawirska and Kwasniewska, 2005).

Dietary fibre decreases the risk for type 2 diabetes, cardiovascular disease and colon cancer by reducing the digestion and absorption of macronutrients and decreasing the contact time of carcinogens within the intestinal lumen (Kaczmarczyk *et al*., 2012). Supplementation with dietary fibre can result in fitness-promoting foods, low in energy cholesterol and lipids. According to current recommendations, the average daily requirement of dietary fibre is 21–25 g per day for women and 30–38 g per day for men (Elleuch *et al.* 2011).

Table 1

IMPORTANT NUTRITIONAL PARAMETERS OF SELECTED PRODUCTS FOR CRISPBREAD

	Energy, kcal	Fat, g·100 g^{-1}	Protein, g·100 g^{-1}	Carbohydrates, g·100 g^{-1}	Dietary fibre (DF), %
Carrot	26	0.2	1	4,9	2,4
Pumpkin	25	0.1	1.1	4.6	2.4
Wheat flour	339	1.9	13.7	72.6	12.2
Rice	357	2.8	6.7	81.3	2.8
Wheat bran	216	4.3	15.5	64.5	4.2

Anonymous (2016). Nutrient Database for Standard Reference Release, 2016. Available from:
https://www.efsa.europa.eu/en/data/food-composition

Dietary fibre has also important health benefits in childhood in preventing and treating obesity, and in lowering blood cholesterol.

Studies have shown that flour obtained from pumpkin fruits could be recommended as a component suitable for food production, due to its high content of dietary fibre (Černiauskiene *et al.,* 2014; Table 1).

A diet rich in foods containing β-carotene may reduce the risk of developing certain types of cancer, offers protection against heart disease and helps prevent skin diseases and vision disorders (Anonymous, 2008).

Studies of carrot and pumpkin by-products have shown that biologically active substances such as carotenoids are responsible not only for the colour of product but also as antioxidants in human body. There is considerable evidence that carotene, being a highly active singlet oxygen quencher, may play an important role in the prophylaxis of free radical-mediated diseases (Killeit, 1994). Vitamin A and related carotenoids are not stable in the presence of oxygen and heat; thus, they are particularly vulnerable during extrusion. Beta-carotene is an antioxidant that is a vitamin A precursor. Beta-carotene is added to foods to make them more orange in colour, but it is unstable when heated (Camire *et al*, 1990). Crispbreads coloured with natural vegetables may appeal to consumers interested in healthy food. Crispbreads can be processed by a variety of different methods and techniques, using different raw materials with different properties (Brennan *et al*., 2013). One of the means of producing crispbreads is extrusion with HTST (high temperature, short time) method. A major ingredient in extruded food formulation is starch.

It is only relatively recently (since the 1970s) that there has been an appreciable use of extrusion technology in the food industry (Harper, 1991). Extrusion cooking has been studied extensively to produce a variety of specialty foods, including pasta products and RTE (ready-to-eat) breakfast cereals, baby foods, snack foods, texturised vegetable protein, pet foods, dried soups and dry beverage mixes. Nowadays extruded products are well known among consumers (Brennan *et al*., 2008).

Cereals, in turn, are the customary, traditional snack ingredient due to their high starch content (Brennan *et al.,* 2009).

Extrusion cooking combines several unit operations such as mixing, kneading, cooking, shearing, shaping, drying, and expanding. This is a process of high temperature in a short time that brings several changes in the feed material such as physical expansion, change in density, texture etc. in addition to chemical changes such as gelatinisation of starch, denaturation of protein, modification of lipid, and inactivation of enzymes (Brennan *et al*., 2011, Dilip *et al*., 2013, Riaz, 2000).

Extrusion technology has many advantages, including its versatility, high productivity, low cost, and the ability to produce unique product shapes and high product quality (Robin, 2001). Extrusion-cooking is a versatile and feasible alternative for manufacturing snack foods as crispbreads, and has been used to promote the nutritional and functional properties.

Vegetable by-products should be dried to obtain products with less moisture content and to obtain soft grinded powder. After these processes a part of carotenes, phenols and total antioxidant activity are lost.

The aim of the study was to determine the total content of carotenes and DF of extruded cereal samples with addition of dried and grinded pumpkin and carrot by-products.

MATERIALS AND METHODS

The study was carried out at the scientific laboratories of the Faculty of Food Technology at Latvia University of Agriculture, in cooperation with Ltd Baltās Naktis Mario — the producer of different crispbreads in Latvia.

The basic ingredients used were: carrot (*Daucus carota* L.*)* and pumpkin (*Cucurbita pepo* L.) by-products remaining after juice extraction, wheat flour, rice flour, wheat bran, water, salt, and sugar. Wheat flour 405 type was obtained from JSC "Dobeles dzirnavnieks" and wheat bran from JSC "Valdo". Rice from JSC "Valdo" was ground to flour.

Carrot and pumpkin juice production by-products were dried in a microwave–vacuum dryer "MUSON-1" according to the programme of the equipment and preferred moisture 8% of final dried by-product.

Dried vegetable by-products were ground to a powder by a grinder FOSS KNIFITECTM 1095 for 30 seconds for each grind. Then the powder was sieved through a 2-mm sieve.

Total carotene of carrot and pumpkin processed by-product powder was determined by the spectrophotometric method CSNBK with a 6705UV/VIS YENWAY spectrophotometer (UK) at wavelength 440 nm, after extraction with petroleum ether (boiling temperature range 80–110 ^{o}C). Measurements were carried out in two replications for each sample.

Table 2

INGREDIENT PROPORTIONS (%) FOR CRISPBREAD SAMPLES

	Wheat crispbread	Carrot powder	Pumpkin powder
Control sample	100	-	-
Sample 1.1	95	5	
Sample 1.2	90	10	
Sample 1.3	85	15	
Sample 1.4	80	20	
Sample 2.1	95		5
Sample 2.2	90		10
Sample 2.3	85		15
Sample 2.4	80		20

The moisture content of selected material was determined by standard method with a Memmert Modell-100-800 according to standard LVS EN ISO712:2010 A.

Crispbread samples were prepared from wheat flour 70%, rice flour 24%, wheat bran 4%, salt 1%, sugar 1%, and water 13%.

For experiments, various mixtures with addition of carrot and pumpkin by-product powder were used to produce crispbread soft ingredients (Table 2). The extrusion process was performed using a laboratory single-screw extruder GÖTTFERT 1 screw Extrusiometer L series (Germany). An extrusion screw (compression ratio 2:1) at a speed of 60–80 rpm and a rectangular die (aperture: 20 mm wide, 1.0 mm high, 100 mm long) were used. Temperatures for the extrusion process were: 78 °C / 83 °C / 98 °C.

Obtained extrudates were dried at 130 ^{o}C for 20 minutes in a conventional oven to obtain a soft and crispy product.

Colour changes of product samples in the colour system CIE L*a*b* were determined by means of Colour Tec–PCMTM equipment. Results were expressed as tri-stimulus values: L* lightness, a* greenness/redness, b* blueness and yellowness. Measures for each sample were done in six replications.

The content of total dietary fibre was determined according to the AOAC–AACC method No. 985.29 by a FOSS Analytical Fibertec E 1023 system.

Calculation of nutritional value was done according the EU Regulation for Food Nutritional value 31.1, XIV (Anonymous, 2013).

The analysis of experimental data was done in accordance with mathematical statistical methods. The figures and tables were created using MS Excel 2007 software.

RESULTS

Total content of carotenes in dried by-product was 12.08 ± 0.58 mg·100 g^{-1} in carrots and 32.11 ± 5.70 mg·100 g^{-1} in pumpkin by-product. Carotene content in samples increased

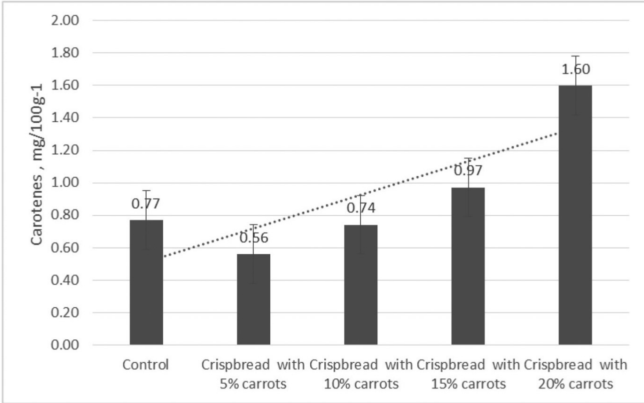

Fig. 1. Total content of carotenes in crispbreads with carrot by-product powder.

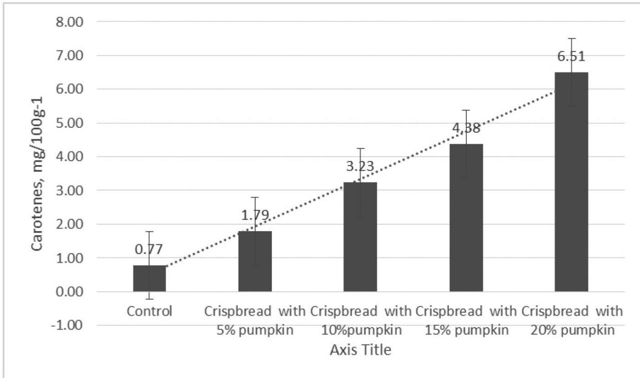

Fig. 2. Total content of carotenes in crispbreads with pumpkin by-product powder.

proportionally from 0.77 ± 0.01 mg·100 g^{-1} in wheat crispbread to 1.60 ± 0.01 mg·100 g^{-1} in the sample with 20% carrot powder, and to 6.51 ± 0.02 mg·100 g^{-1} with addition of pumpkin powder (Figs. 1, 2).

Addition of 5% and 10% of carrot by-products decreased the total carotene content.

Colour of food product is one of the desired factors in acceptance of new food products for consumers. Colour changes of product samples in the colour system CIE L*a*b* are represented in Table 3. Sample 4 was more yellow, while sample 3 was more reddish. There was no close

Table 3

COLOUR CHANGES OF PRODUCT SAMPLES IN THE COLOUR SYSTEM CIE L*a*b*

	L*	a*	b*
Control sample	55.77 ± 0.66	1.92 ± 0.15	23.97 ± 0.75
Sample 1.1	55.45 ± 0.79	1.69 ± 0.12	22.93 ± 0.89
Sample 1.2	56.09 ± 0.57	2.15 ± 0.14	23.38 ± 0.93
Sample 1.3	53.84 ± 0.78	2.36 ± 0.12	22.55 ± 0.59
Sample 1.4	55.04 ± 0.87	1.84 ± 0.11	23.38 ± 0.54
Sample 2.1	55.45 ± 0.56	2.01 ± 0.13	23.71 ± 0.66
Sample 2.2	55.09 ± 0.61	2.33 ± 0.15	24.54 ± 0.29
Sample 2.3	57.77 ± 0.80	2.59 ± 0.10	25.58 ± 0.38
Sample 2.4	59.48 ± 0.58	2.85 ± 0.12	26.52 ± 0.54

correlation between carotene content and colour in the samples, though the 3rd sample and increased a* value (red colour), and sample 4 had higher b* value (green colour). The correlation coefficient s between carotene content and colour were: r = 0.260, R^2 = 0.068 for L*, r = 0.354, R^2 = 0.127 for a* and r = 0.654, R^2 = 0.428 for b*.

The addition of vegetable by-products influenced the total DF content in samples. DF content was 9.39% in the control sample; the addition of 5% carrot and pumpkin by-product powder to wheat-rice crispbread sample decreased the total DF content in carrot crispbread to 8.42% and pumpkin crispbread to 9.02%. Addition of 20% of carrot by-product powder increased total DF content to 15.89% and addition of 20% of pumpkin by-product powder increased total DF content to 16.08%. Therefore, the total DF in selected samples increased.

Figure 3 shows total content of DF in crispbreads with carrot by-product powder.

Figure 4 shows total content of DF in crispbreads with pumpkin by-product powder.

The nutritional value of crispbreads was calculated to compare the changes after adding vegetable by-products. All recipes were based on using more than 70% grain products. Our purpose was to obtain higher nutritional value of extruded products by addition of vegetable by-products consisting of more carotene and DF.

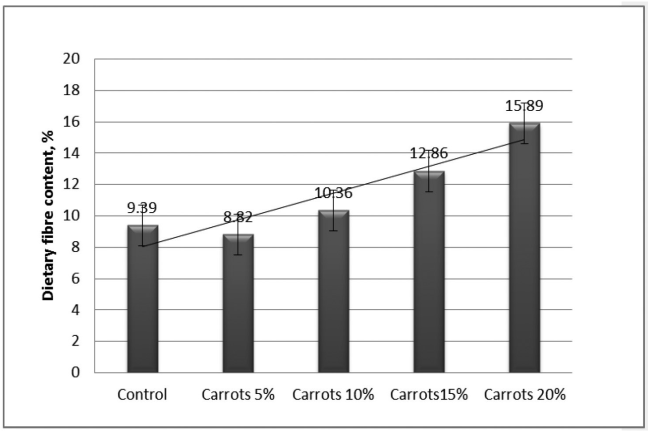

Fig. 3. Total content of DF in crispbreads with carrot by-product powder.

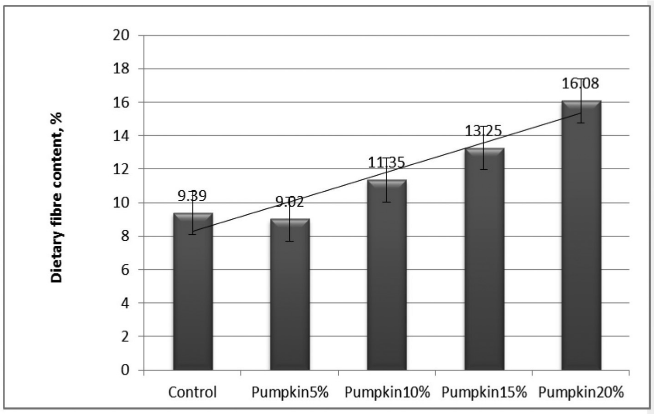

Fig. 4. Total content of DF in crispbreads with pumpkin by-product powder.

Table 4

PRODUCT NUTRITIONAL VALUE

	Energy, kcal	Carbohydrates, $g{\cdot}100\ g^{-1}$	Protein, $g{\cdot}100\ g^{-1}$	Fat, $g{\cdot}100\ g^{-1}$	DF, $g{\cdot}100\ g^{-1}$
Control	361 ± 2	73.8 ± 0.3	11.6 ± 0.2	2.1 ± 0.2	0.8 ± 0.1
Sample1.1	344 ± 1	70.4 ± 0.4	11.0 ± 0.2	2.0 ± 0.1	0.6 ± 0.1
Sample1.2	328 ± 2	66.9 ± 0.3	10.5 ± 0.3	1.9 ± 0.1	0.7 ± 0.1
Sample1.3	311 ± 1	63.5 ± 0.5	10.0 ± 0.2	1.8 ± 0.2	1.0 ± 0.1
Sample 1.4	296 ± 3	60.0 ± 0.4	9.4 ± 0.4	1.7 ± 0.1	1.6 ± 0.1
Sample 2.1	346 ± 2	70.2 ± 0.2	11.0 ± 0.5	2.0 ± 0.2	1.8 ± 0.1
Sample 2.2	332 ± 3	66.9 ± 0.4	10.5 ± 0.2	1.9 ± 0.1	3.2 ± 0.1
Sample2.3	318 ± 4	63.4 ± 0.5	10.0 ± 0.2	1.8 ± 0.1	4.4 ± 0.3
Sample 2.4	305 ± 1	60.0 ± 0.3	9.4 ± 0.5	1.7 ± 0.1	6.5 ± 0.2

Calculated nutrition value is summarised in Table 4. There were no significant changes of product energetic value as the addition of vegetable by-product was increased to 20 %. The control sample 1 had the highest energy value. The energy value was lower in other samples. This is because wheat bran contains more fibre than vegetable by-product powder.

DISCUSSION

Previous studies of carotene content in fresh vegetables found contents of 76.0 $mg{\cdot}100\ g^{-1}$ in carrots and 98.87 $mg{\cdot}100\ g^{-1}$ in fresh pumpkin by-products.

We determined total carotene content, but there are few forms of other carotenes susceptible to heat treatment. Lutein, zeaxanthin, α-Carotene, 9-Cis-β-carotene and 13-Cis-β-carotene are in the range of total carotenes. Lutein originated from pumpkin is probably more susceptible to high temperatures. The sensitivity of carotenoids greatly depends on their source (Obradović *et al.*, 2015). α-Carotene is a pigment normally found in different kinds of pumpkins (Seo *et al.*, 2005) and therefore carotene content may be expected to increase with pumpkin addition to raw samples. Degradation of β-carotene (as a model substance or from other sources than pumpkin) during extrusion cooking was also shown in other studies (Waramboi *et al.*, 2013 and Emin *et al.*, 2012). Oxygen concentration has greater effect on the stability of β-carotene than the heating temperature. When β-carotene was heated and exposed to air, polymerisation took place in addition to degradation (Qiu *et al.*, 2009). Degradation of β-carotene from pumpkin puree during thermal treatment above 60 °C is found to follow first-order reaction kinetics and Arrenius relationship for temperature dependence (Dutta *et al.*, 2006). There is no information on effect of extrusion influence on this pigment. 13-*cis*-β-carotene can show similar retention as α-carotene (Obradović *et al.*, 2015). The extrudates obtained at different extrusion temperatures between 110 °C and 140 °C showed that the samples extruded at 120 °C, 130 °C and 140 °C resulted in higher degradation of functional components like β-carotene (Aamir Hussain Dar, 2012). Carrots consist mainly of β-carotene, which can explain the decrease of total carotene content after extrusion in crispbread with 5% and 10% of carrot by-product powder and the higher content of total carotenes in crispbreads with addition of dried pumpkin by-product.

Colour changes of product samples in the colour system CIE L*a*b* are shown in Table 3. Colour is one of the desired factors for crispbread (Delgado *et al*., 2015; Lado *et al*., 2015). Therefore, increase of the amount of vegetable by-product powder as raw material for new products should be associated with colour change to more yellow or red, as carotenes are responsible for this desired colour. The appropriate addition of vegetable by-products powder to cereal flour will improve the colour of extruded rice and wheat. Further studies are needed to determine relationship between addition of carotenes and the colour of obtained products.

TDF for samples with added by-products increased to 15.89 $g \cdot 100\ g^{-1}$ in crispbreads with carrot by-product powder and to 16.08 $g \cdot 100\ g^{-1}$ in samples with pumpkin by-product powder.

CONCLUSIONS

Nutritionally balanced foods are necessary for maintaining good health. Foods prepared from pumpkin and carrot processed by-products powder could have nutritional advantage in terms of carotenoids and dietary fibre content. The present study showed that vegetable by-products can be added up to 20% to promote the nutritional requirement. The obtained results show that carotenoids can improve the colour of crispbread and still are in significant amounts in the final product. The addition of pumpkin by-product powder can increase the total amount of carotenes as the source of them is more thermostable.

Dietary fibre increased in all samples with addition of by-product powder and according to functional food definition, this can be called a product with high content of dietary fibre (EU REG Nr. 1924/2006).

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BURKĀNU UN ĶIRBJU PĀRSTRĀDES BLAKUSPRODUKTU IZMANTOŠANA SAUSMAIZĪŠU RAŽOŠANĀ

Burkānu un ķirbju pārstrādes procesā rodas blakusprodukti, piemēram, mizas un izspaidi, kurus var pārstrādāt un izmantot kā funkcionālas pārtikas sastāvdaļas. Arī blakusproduktos saglabājas daudz bioloģiski aktīvu vielu — karotīni un diētiskās šķiedrvielas, kuru pielietojums uzturā var aizkavēt vai novērst dažādas slimības: sirds un asinsvadu saslimšanas, zarnu vēzi, aptaukošanos. Pētījuma mērķis bija izpētīt, kā blakusproduktu izmantošana ekstrudētu sausmaizīšu ražošanā paaugstina to funkcionālās īpašības. Paraugi tika sagatavoti, ņemot par pamatu 24% rīsu miltus, 70% kviešu miltus un 4% kviešu klijas; eksperimenta laikā kontroles receptūrai pievienoja burkānu un ķirbju pārstrādes blakusproduktu pulveri 5%, 10%, 15%, 20% daudzumā attiecībā pret sausmaizīšu receptūrā izmantotajiem graudaugiem. Maisījumi tika ekstrudēti ar vienskrūves laboratorijas ekstrudieri GÖTTFERT 1, L sērija. Pēc ekstrūzijas tika noteikts kopējo karotīnu daudzums ar spektrofotometrijas metodi CSNBK ar iekārtu 6705UV/VIS YENWAY(UK). Kopējās diētiskās šķiedrvielas tika noteiktas saskaņā ar AOAC 985.29 standartmetodi. Iegūtie rezultāti parādīja kopējā karotīnu daudzuma palielināšanos sausmaizītēs, kam tika pievienotas ķirbju un burkānu spiedpaliekas. Kopējais karotīnu daudzums pieauga no 0,77 mg·100 g^{-1} kontroles paraugā līdz 1,67 mg·100 g^{-1} paraugā ar 20% burkānu spiedpaliekām un 6,51 mg·100 g^{-1} paraugā ar 20% ķirbju spiedpaliekām. Diētisko šķiedrvielu daudzums palielinājās no 9,3 mg·100 g^{-1} kontroles sausmaizītē līdz 15,89–16,08 mg·100 g^{-1} paraugos ar ķirbju un burkānu spiedpaliekām. Karotīni ir ne tikai vitamīna A prekursori, bet lielā mērā nosaka arī gatavā pārtikas produkta krāsu.