

## DRIED VEGETABLES SNACKS – REVIEW OF THE PROCESS TECHNOLOGIES AND CONSUMPTION PREFERENCES AMONG STUDENTS

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**Abstract.** Vegetables are a basic element of each diet and their relatively low consumption in Poland is a stimulus to look for new attractive forms of the products. This paper presents an outline of production technologies of dried vegetable snacks and results of a questionnaire on vegetable consumption and social acceptance of new products in the area as described in this paper. The new processing technologies of vegetable snacks are based on a drying method that generates products attractive in terms of physical and chemical properties. A questionnaire survey shows that interest among respondents to buy snacks made of root vegetables is highest with respect to carrot-based products. The respondents highly assessed visual properties of the new product, primarily the colour and shape.

**Keywords:** vegetables, snacks, consumptions, preferences

### INTRODUCTION

Vegetables – due to their nutritive values and properties of their phytonutrients should constitute a significant element of each rational diet. The importance of fruits and vegetables in adequate nutrition is confirmed with the fact that they are recommended for daily consumptions in the form of a minimum of 5 portions (not including potatoes). As confirmed with much scientific research, the active compounds in vegetables (including vitamins and polyphenols) are related to multidirectional health supporting actions (Kajaba et al., 2007). For example, beta-carotene

found in carrots (*Apiaceae*) displays the activity of vitamin A. Additionally, carrot roots contain *inter alia*: B group vitamins, E vitamin, carbohydrates and fibre (Kunachowicz et al., 2005). Further, *Brassicaceae* have high nutritive value, high anti-oxidation activity and health supporting effects (Sikora and Bodziarczyk, 2012). Non-nutritive components of edible vegetables are involved in multiple metabolic processes strengthening the body's immune system. Antioxidants in vegetables are able to neutralise free radicals (Steinmetz and Potter, 1996).

The reduced consumption of fruits and vegetables and continued low consumption of fish in Poland is worrying from the viewpoint of balanced consumption (Piwowar, 2016). The reduced vegetable consumption is accompanied with structural changes towards more processed products (this applies also to vegetables) (Piwowar, 2008). Among the subjects under review, it is not only the quantity, but also the type of vegetables in the context of their overall anti-oxidation potential (Prędką and Gronowska-Senger, 2009). Vegetables may be consumed in various forms while scientific and technical progress in food processing makes various forms of food products more available. New solutions in the sphere of drying plant products may provide for varied consumption forms of vegetables. Thermal processes which are the most important methods to preserve food, in the case of vegetables, may ensure high quality of the generated crispy snacks and attractive sensory values.

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This paper presents an outline of the drying technologies of dried vegetable snacks and the results of empirical studies concerning consumption of vegetables among students, including their preferences with respect to product innovation (vegetable snacks). The Polish Central Statistical Office data shows that the characteristic features of vegetable consumption models of Polish households include varied levels of consumption and assortment structure in various social-economic types of households. Consumption analyses of selected food products in Poland in public statistics are very general and the results of surveys on vegetable consumption do not take into account e.g. the age of people in households which is a major determinant of consumers' attitudes to food products.

## RESEARCH METHODOLOGY

The core objective of this paper is to analyse the frequency and the forms of vegetable consumption by students and their acceptance level for new products in respect to the outline. The measurement of consumers' preferences was related to vegetables generally and root vegetables, and covered both positive and negative opinions. The survey was carried out in June 2015 with a direct questionnaire, containing 14 questions in two thematic categories (6 questions about intake of vegetables generally and 8 questions in the section on root vegetables consumption, preferences, and acceptance of new products). The questionnaire was completed by 107 students of the Wrocław University of Economics, most of them in second-cycle studies (62%). The visual values of considered vegetable products were also assessed in the research (a colour photo was placed in the questionnaire). The survey sample was dominated by women (74.8%). People aged 19–25 (96% of the surveyed group) dominated among the respondents. Most of the respondents lived in towns and cities, including 34% in cities with more than 500 thousand inhabitants. Every fifth respondent lived in rural areas.

## OUTLINE OF THE MANUFACTURING TECHNOLOGY OF DRIED VEGETABLE SNACKS

Dried vegetables are commonly consumed in most countries of the world. It is estimated that in China the annual production is worth USD 800 M of which almost

60–70% is exported (Liu, 2003). The value of the European market of dried vegetables grew from USD 260 M at the beginning of the 1990s (Tuley, 1996) to almost one billion USD now (Huang and Zhang, 2012). The European Union countries are the major importers with the largest suppliers being China, USA, Hungary and Poland (Stepka, 2004).

Snacks are most often produced of potatoes, carrots, pumpkins (in the form of slices), tomatoes, and beans (dried in whole). Sometimes vegetables are processed as paste with some spices and salt added and afterwards reprocessed and dried (Zhang et al., 2011). With the addition of cereal flour or fruit pure, dried products are generated with new taste, aroma and colour (Huang et al., 2011).

Considering the growing structure of vegetables in Poland, carrots (*Daucus carota* L.) are of major importance for potential production of dried snacks. The high nutritive value of carrots and the variety of culinary applications have caused that carrots for years have been among the most valued vegetables in the world. Carrot roots may be orange, yellow, red, and purple which is visual evidence of the varied profile of phytonutrients. Orange carrots have a high concentration of beta and alpha carotene. Yellow carrots contain much lutein and red carrot – lycopene (Dias, 2012).

Now, the main trends in carrot processing are focused on minimum root processing – peeling, developing a shape ("baby carrots" or "cut- and-peel carrots") and proper processing, including canning, freezing, marinating, juice extraction, cutting in various ways and snack production (Joy and Lada, 2006).

Among the manufacturing methods of vegetable snacks made of carrot, the most frequent are: hot-air drying (1), vacuum drying (2), freeze drying (3), drying in a microwave field (4) (Zhang et al., 2006), extrusion (5) and combined (or hybrid) methods (6). Appropriate processes are selected subject to the texture of the material, its chemical component, and the nature of the drying process. Each method is different not only with the way of energy consumption of the dried material, but primarily with the physical, chemical, and sensory quality of the final product. Hot air drying is the oldest and most popular manufacturing method of vegetable snacks. The advantages of the process include low costs and easy performance. However, moisture removal by applying high temperatures with a long drying time results in a major reduction of nutritive and sensory values

and changes the colour and aroma. As a result of the drying process, there are changes to the plant tissue – often permanent – like deformation of the shape, shrinkage, sticking or browning which also adversely affects the quality of the final product (Kamińska and Ciesielczyk, 2011; Kowalski and Szadzińska, 2003).

Low temperatures in the drying process are obtained by applying a vacuum. Gentle thermal processing results in a higher quality final product as compared to those obtained with the convection drying method under normal pressure (Fernando and Thangavel, 1987). High costs of the drying process under reduced pressure are appropriate for processing expensive material that is sensitive to temperatures, e.g. fruits with high sugar content or some expensive vegetables. As a stand-alone process, drying under reduced pressure is not recommended for vegetable processing (Huang and Zhang, 2012).

The best colour, shape, aroma, texture, and preservation of active compounds are obtained as a result of freeze drying (sublimation drying) as the dried material is subjected to more gentle thermal processing and limited contact with oxygen. Many freeze dried products – boiled and seasoning – may be consumed as a snack, e.g. courgettes, potatoes or carrots (Huang and Zhang, 2012). Despite this, freeze drying is in many ways an expensive process. The investment in equipment requires approximately 3-fold higher cost than in the case of other types of dryers. Moreover, the cost of energy are 2–3-fold higher compared to other methods, and the drying time is long (up to 24 hours) (Witrowa-Rajchert, 2009).

One of the most promising techniques to improve the performance of the drying process and quality of the final product is to apply microwaves. This method of generating heat energy in place of convection may materially shorten the drying time and reduce demand for energy in the process as compared to the traditional drying technique with hot air (Stanisławski, 2005). The operation cost of equipment is lower, because the absorption of microwaves occurs only in the heated product. There is no need to heat the entire reactor. Because of the small size, microwave installation does not require additional production infrastructure. Compared to conventional drying methods, microwave food processing reduces labour cost (automation, elimination of some interoperable activities) (Przetaczek-Rożnowska and Szuba, 2014). Microwave heating provides heat to the entire volume of the material being dehydrated and thus

the shape of the particles is retained and the drying time is substantially reduced (Kamińska and Ciesielczyk, 2011). However, the microwave field may damage the structure of the material and cause undesirable changes to the texture. That is why the micro wave field is used combined with other manufacturing methods of vegetable snacks.

Extrusion is another method of producing snacks. It is applied to products obtained from vegetable or cereal flours with the addition of vegetable puree. The process consists in transferring chopped moist material through nozzles of an appropriate size to a drying chamber at a high temperature. Snacks manufactured with this method have low bulk density, are crispy and tasty (Dehghan-Shoar et al., 2010). Extrusion technology is one of the HTST processes. Its advantage is the low cost of production, the continuity of the process, small production area, low specific energy consumption and automation (Fichtali et al., 1995).

Removal of individual limitations of the methods and reinforcement of their advantages can be obtained by appropriate designing of the process. Products generated with various methods will differ in aroma intensity, texture and taste. The best combined manufacturing method is drying in a micro wave field. The application of microwaves to the air drying process materially shortens the process and thus the contact of the material with the oxygen in the air. This affects the behaviour of nutritive components as well as the product texture, colour, and taste.

Evaporation of moisture from the material by reducing pressure with simultaneous delivery of micro wave energy is called puffing. Such reduced pressure results in reduced boiling temperature of the water in the dried material. Additionally, the material is supplied with heat energy with the operation of the micro wave field. Intensive production of water vapour and operation of vacuum expands the volume of the material. The process generates material with a crispy and stable texture (Yan et al., 2010). Due to the short processing time and low temperature of the material during drying, the dried mass obtained with this method is characterised with a higher quality than obtained with other techniques (Szarycz et al., 2002). As a result of appropriately selected process parameters – the power of micro waves and the range of the applied pressure – depending on the structure of the dried material – the product is suited to consumers' needs.

## CONSUMPTION OF VEGETABLES BY STUDENTS AND THEIR RELATED PREFERENCES – RESULTS OF EMPIRICAL STUDY

The knowledge of the respondents in the sphere of effects of vegetable consumption can be termed as very good. 94% of the respondents agreed with the statement that “high consumption of vegetables reduces the risk of obesity, cancer, and cardiovascular diseases”. However, there was concern about the respondents’ knowledge on recommended consumption of fruits and vegetables. 24% of the respondents claimed that the “recommended daily consumption of fruits and vegetables was about 100 g (1 portion)”, while 25% of the respondents had no opinion on the subject.

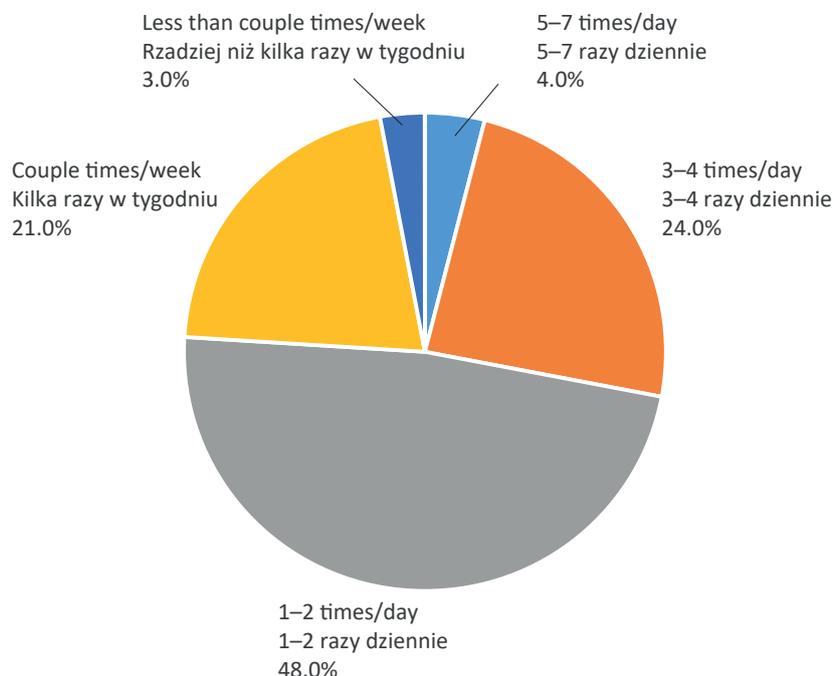
Almost all of the respondents like vegetables. To the question “Do you like eating vegetables”, over 55% of the students responded “absolutely yes” and another 39% of the respondents replied “rather yes”. The

frequency of vegetable consumption in the interviewed group is presented in Fig. 1.

Declarations among the respondents relating to the frequency of vegetable consumption were materially different with respect to various plant species (Table 1).

The results of the analyses indicate varied consumption of vegetables among the interviewed group of students. As the study shows, 43% of the respondents eat tomatoes once–twice a day and 20% of the interviewed students eat cucumbers once–twice a day. The consumption of beans, beetroots, and celery was infrequent in the studied group while a major part of the respondents do not eat those vegetables at all (in particular celeriac). The respondents identified the following reason of low celery consumption: taste and aroma. The respondents like the natural taste of vegetables and they like the colours (in particular of carrots and beetroots) (Table 2).

The respondents further stated that the preparation of celery and beetroots for consumption is too time consuming for them.



**Fig. 1.** Frequency of vegetable consumption by respondents  
Source: own elaboration on the basis of questionnaire studies (N = 107).

**Rys. 1.** Częstość spożycia warzyw przez respondentów  
Źródło: opracowanie własne na podstawie badań ankietowych (N = 107).

**Table 1.** Frequency of vegetable consumption by respondents

**Tabela 1.** Częstość spożycia wybranych gatunków warzyw przez respondentów

Specification Wyszczególnienie	5–7 times/day 5–7 razy dziennie	3–4 times/day 3–4 razy dziennie	1–2 times/day 1–2 razy dziennie	Couple times/ week Kilka razy w tygodniu	Couple times/ month Kilka razy w miesiącu	Less than couple times/ month Rzadziej niż kilka razy w miesiącu	Never Wcale
	[%]						
Potato – Ziemniaki	0	1	7	48	34	7	4
Cucumber – Ogórek	0	0	20	52	24	3	1
Tomato – Pomidor	1	5	43	38	9	1	3
Cauliflower – Kalafior	0	0	1	9	47	37	6
Broccoli – Brokuły	0	0	5	19	40	31	6
Carrot – Marchew	0	2	8	43	37	7	2
Bean – Fasola	0	0	2	8	29	47	15
Capsicum – Papryka	0	0	11	29	37	17	6
Beetroot – Buraki	0	0	1	9	37	44	8
Celeriac – Seler	0	0	1	8	25	32	34

Source: own elaboration on the basis of questionnaire studies (N = 107).

Źródło: opracowanie własne na podstawie badań ankietowych (N = 107).

**Table 2.** Respondents' opinions on selected features of root vegetables

**Tabela 2.** Opinia respondentów na temat wybranych cech warzyw korzeniowych

Specification Wyszczególnienie	I like the taste Lubię ich smak	I don't like the tast Nie smakują mi	I like the colour Odpowiada mi ich barwa	I don't like the colour Nie odpo- wiada mi ich barwa	I like the texture in the meals Odpowiada mi ich konsystencja w potrawach	I don't like the texture in the meals Nie odpo- wiada mi ich konsystencja w potrawach	I like the flavor Lubię ich zapach	I don't like the flavor Nie lubię ich zapachu
	[%]							
Carrot Marchew	36	2	21	1	21	1	17	0
Parsley Pietruszka	18	20	13	4	15	5	19	7
Celeriac Seler	11	24	9	7	12	5	10	14
Beetroot Burak cukrowy	24	8	20	3	15	2	12	5

Source: own elaboration on the basis of questionnaire studies (N = 107).

Źródło: opracowanie własne na podstawie badań ankietowych (N = 107).

**Table 3.** Form of selected vegetables consumed by respondents split by the autumn-winter and spring-summer season

**Tabela 3.** Postać spożywanych przez respondentów wybranych warzyw w podziale na okresy jesienno-zimowy i wiosenno-letni

Specification Wyszczególnienie	Autumn-winter season Okres jesienno-zimowy			Spring-summer season Okres wiosenno-letni		
	Raw Surowa	Processed Przetworzona	Never Wcale	Raw Surowa	Processed Przetworzona	Never Wcale
	[%]					
Potato – Ziemniaki	–	97	3	–	96	4
Cucumber – Ogórki	57	42	1	85	14	1
Tomato – Pomidory	74	23	3	86	11	3
Cauliflower – Kalafior	13	76	1	21	72	7
Broccoli – Brokuły	11	79	10	18	74	8
Carrot – Marchew	55	42	3	70	29	1
Bean – Fasola	4	74	22	9	73	18
Capsicum – Papryka	68	23	9	80	14	6
Beetroot – Buraki	6	82	13	8	79	13
Celeriac – Seler	10	50	40	13	47	40

Source: own elaboration on the basis of questionnaire studies (N = 107).

Źródło: opracowanie własne na podstawie badań ankietowych (N = 107).

It is interesting to note the form of vegetables consumed by respondents split by the autumn-winter and spring-summer season (Table 3).

From among the vegetables listed in table 3, four (cucumbers, tomatoes, carrots, and peppers) are consumed in raw form most often. However, major differences were noted in replies in view of the time of consumption.

Respondents like consuming root vegetables in the processed form (in particular carrots and beetroots). Results of the surveys related to the respondents' willingness to purchase vegetable snacks are presented in Table 4.

As the surveys show, the respondents' willingness to buy chips of root vegetables was highest with respect to carrot products (54% of the respondents) and of beetroots (28% of the respondents).

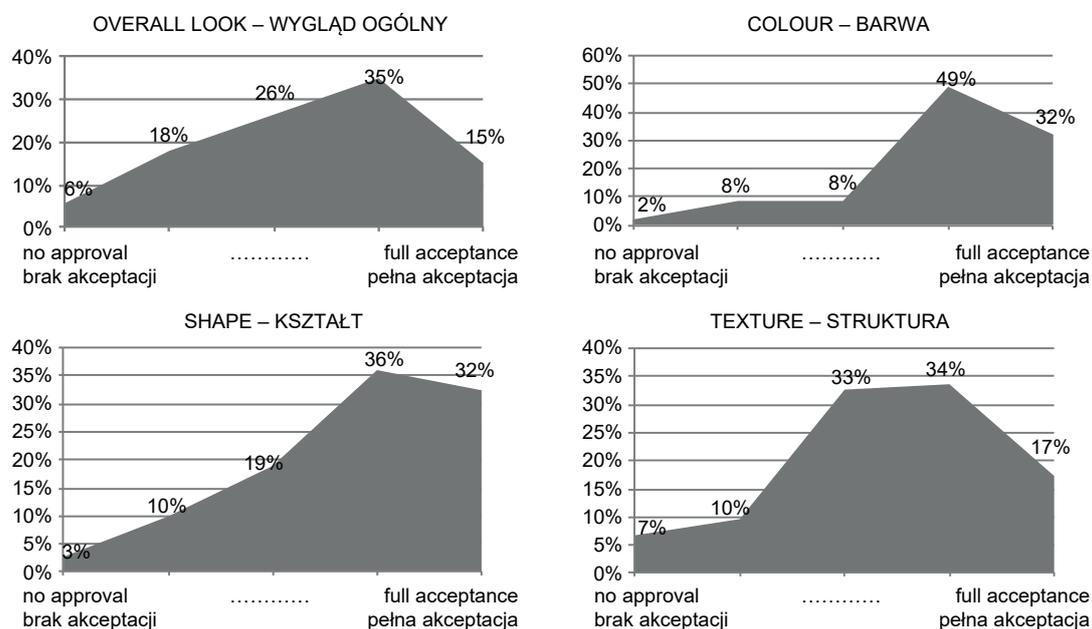
**Table 4.** Respondents' willingness to buy dried products of root vegetables with spices (vegetable chips) (%)

**Tabela 4.** Skłonność respondentów do zakupu suszonych produktów z warzyw korzeniowych z dodatkiem przypraw („chipsy” warzywne) (%)

Specification Wyszczególnienie	Yes – Tak	No – Nie	I don't know – Nie mam zdania
	[%]		
Carrot – Marchew	54	38	8
Parsley – Pietruszka	12	74	13
Beetroot – Seler	12	74	13
Celeriac – Burak ćwikłowy	28	64	8

Source: own elaboration on the basis of questionnaire studies (N = 107).

Źródło: opracowanie własne na podstawie badań ankietowych (N = 107).

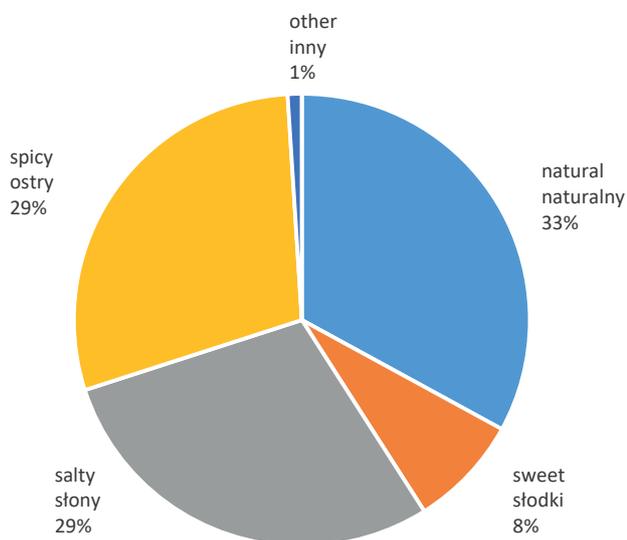


**Fig. 2.** Visual advantages of the assessed product

Source: own elaboration on the basis of questionnaire studies (N = 107).

**Rys. 2.** Walory wizualne ocenianego produktu

Źródło: opracowanie własne na podstawie badań ankietowych (N = 107).



**Fig. 3.** Preferred tastes of vegetable chips in the respondents' opinion

Source: own elaboration on the basis of questionnaire studies (N = 107).

**Rys. 3.** Preferowany w opinii respondentów smak przekąsek warzywnych

Źródło: opracowanie własne na podstawie badań ankietowych (N = 107).

As mentioned in methodology section with a grade scale of 1 to 5, the respondents expressed their opinions on the product (Fig. 2).

The respondents highly assessed visual properties of the new product, primarily the colour and shape. Preferred tastes of vegetable snacks are presented in Fig. 3.

The results of the surveys showed differentiated tastes of the respondents in their consumption of vegetable snacks. Most of the respondents were interested in natural tastes (33% of the respondents) followed by spicy and salty tastes (29% of the respondents each).

## SUMMARY

It is worrying that the consumption of vegetables has been decreasing in Poland while the use of vegetables (in raw or processed form) for meals is a major element of correct nutrition. Thus, it is necessary to look for new attractive forms of those products. Technological innovations in food drying support the manufacturing of attractive sensory vegetable products that can be consumed directly. As a result of the application of modern drying technologies and manufacturing techniques,

drying does not result in a major deterioration of the quality of final products as related to fresh material. Additionally, various additives can be used in manufacturing processes (e.g. herbs, spices) that improve organoleptic and healthy aspects of the snacks.

Consumers' behaviour has been constantly changing and therefore it is necessary to analyse the levels and changes of consumption in various circumstances. The numerous recommendations, confirmed with much research, requires special focus on vegetable consumption. As the surveys show, consumption of 400–500 g per day of vegetables and fruits reduces the risk of many diseases, including cancer and bile stones. Students are a special focus group among nutrition specialists.

The analysis of consumers' behaviour presented in this paper identified the most commonly consumed vegetables, the frequency of consumption, and an opinion was obtained on their sensory values. As the questionnaire surveys show, the willingness of the respondents to purchase snacks made of dried root vegetables is the highest with respect to carrot products. The respondents highly assessed visual advantages of dried vegetable snacks, in particular their colour and shape. It is recommended to continue monitoring the nutrition model among students with respect to vegetables, in particular dried products. As a result of popularisation of new technologies, in the near future there will be an increased supply of those products on the market.

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## SUSZONE PRZEKĄSKI WARZYWNE – ZARYS TECHNOLOGII WYTWARZANIA I POZIOM AKCEPTACJI WŚRÓD STUDENTÓW

**Streszczenie.** Warzywa to podstawowy element diety, a ich relatywnie niskie spożycie w Polsce skłania do poszukiwania nowych, atrakcyjnych form produktów. W niniejszej pracy przedstawiono zarys technologii produkcji suszonych przekąsek z warzyw oraz wyniki badań ankietowych dotyczących spożycia warzyw i akceptacji społecznej dla nowych produktów w zakresie przedmiotowym opisywanym w niniejszej pracy. Nowe technologie produkcji tzw. snacków warzywnych, oparte na metodzie suszenia, pozwalają uzyskać atrakcyjne pod względem właściwości fizyko-chemicznych produkty. Z przeprowadzonych metodą ankietową badań wynika, że skłonność respondentów do zakupu przekąsek z warzyw korzeniowych była największa w przypadku produktów marchwiowych. Respondenci wysoko ocenili walory wizualne nowego produktu, w tym głównie barwę i kształt.

**Słowa kluczowe:** warzywa, przekąski, spożycie, preferencje

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