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ANALYSIS AND ESTIMATION OF THE APPLICATION OF SELECTED SWEETENERS USED IN FOOD BY CONSUMERS. PART 1

ANALIZA I OCENA STOSOWANIA PRZEZ KONSUMENTÓW WYBRANYCH SUBSTANCJI SŁODZĄCYCH W ŻYWNOŚCI. CZĘŚĆ 1

DOI: 10.15611/nit.2016.3.08

JEL Classification: Q19

Summary: Sweeteners such as disaccharides, mannitol, lactitol, sorbitol, xylitol and many others are either purchased by consumers separately or they are added to highly processed food products. These substances can be used in pastry, cakes, beverages and dairy products. The aim of the study was to analyse the application of selected types of sweeteners by Polish consumers. The research was conducted in 2016 and the respondents were interviewed using questionnaires. Almost half (45%) of the respondents drew attention to sweeteners added to food products, especially beverages, sweets, yoghurts, juices, jams, marmalades and confections. Among the different types of food categories with added sweeteners, consumers enumerated primarily pastry products, processed fruit products, dairy and cereal products. The respondents declared that they used sweeteners because of a willingness to reduce the amount of sugar and this was connected with their health and well-being (35%). Moreover, consumers gave the reason for the use of sweeteners as being the less intense sweetness of these substances (13% of respondents) and the desire to lose weight (11% of respondents).

Keywords: sweeteners, consumer preferences.

Streszczenie: Substancje słodzące, m.in. takie jak taumatyna, stewia, mannitol, sorbitol, ksylitol i wiele innych, mogą być nabywane przez konsumentów oddzielnie lub stanowią składnik kupowanych produktów spożywczych. Substancje te są powszechnie dodawane do wyrobów cukierniczych, ciast, napojów oraz produktów mlecznych. Celem pracy była analiza preferencji w zakresie nabywania przez konsumentów wybranych rodzajów substancji słodzących. Badania przeprowadzono w 2016 r. z użyciem kwestionariuszy w wersji papierowej. Uzyskane wyniki wskazują, iż respondenci byli zainteresowani poziomem substancji słodzących dodanych do produktów spożywczych. Prawie połowa respondentów (45%) zwróciła uwagę na ilość słodzików dodawanych do dostępnych na rynku produktów spożywczych. Respondenci wskazali, że używają słodzików ze względu na chęć zmniejszenia ilości cukru, co wiązało się z ich zdrowiem i samopoczuciem (35%). Ponadto ankietowani podkreślali, że użycie słodzików jest związane z mniej intensywnym smakiem słodkim tych substancji (13% respondentów) oraz chęcią zmniejszenia masy ciała (11% respondentów).

Słowa kluczowe: substancje słodzące, preferencje konsumentów.

1. Introduction

Currently, the majority of food products available on the market contain food additives [Rozporządzenie Parlamentu Europejskiego i Rady (WE) nr 1333/2008]. These substances in small quantities are intended to prolong product shelf life, increase consumer acceptance, maintain a constant, repeatable quality, or increase production efficiency, as well as enable the introduction of new products such as functional foods [Cacak-Pietrzak, Ceglińska, Karczewska 2015].

Sweeteners are a large group of food additives. They either occur in highly processed food products or are available for purchase by the consumer separately. Many researchers have reported that sugar has an effect on human health and that it is linked to a rise in non-communicable diseases [Lustig et al. 2012]. Therefore, there is increasingly a tendency to replace it with other sweeteners with similar taste profiles or with mixtures of different sweeteners that are formed in order to enhance the attractive organoleptic quality of the product. A wide range of carbohydrates, natural sweeteners as well as artificial or naturally derived and chemically synthesized sweeteners are available on the market. Sweeteners can be grouped according to different criteria, such as intensity of sweet taste, origin, consistency, technological function or energy value [Miśkiewicz et al. 2012; Świąder, Waszkiewicz-Robak, Świdorski 2011].

Sweeteners can be divided into three main groups: natural carbohydrates, i.e. mono- and disaccharides (glucose, fructose, sucrose, maltose, mannose, lactose, sugar syrups); semi-synthetic sweeteners, so-called fillers of low sweetness (polyols alcohols / polyols / alditols – less sweet than sucrose), e.g. mannitol, lactitol, sorbitol, xylitol, erythritol, maltitol and isomalt, and sweeteners (natural sweeteners) such as Luo Han Guo, Yacon Glycerol, glycerol, steviol glycosides and intensively sweetening, flavor enhancing additives, e.g. sweet proteins (thaumatin, miraculin, monellin), and synthetic sweeteners (aspartame, acesulfame K, saccharin, neohesperidose, cyclamates, alitame, sucralose, neotame, aspartame and acesulfame salt) [Biesiada, Nawirska-Olszańska 2013; Grupińska et al. 2015; Miśkiewicz et al. 2012; Nowicka, Wojdyło 2014; Sadowska, Rygielska 2014].

Moreover, sweeteners are one of the most popular food additives. These substances are used, among others, as additives in the production of pastry and cakes [Rozporządzenie Komisji (UE) nr 1129/2011; Kita 2011; Matuska 2012], beverages [Brouns, Potzel 2014; Gajda-Wyrębek et al. 2012; Kolanowski 2013; Sadowska, Rygielska 2014] and dairy products [Brodziak, Król 2014; Sadowska, Rygielska 2014]. More than half of all sweeteners worldwide are used in beverage production. They are also used to produce sweeteners for coffee and tea, chewing gums, mayonnaises, jams, marmalades, ice creams, desserts, and vegetable processed products. Moreover, they are added to foods for special nutritional purposes such as dietary supplements, e.g. for athletes – high protein foods, diabetics or slimming supplements. Progress in studies on the safety of the use of sweeteners in food and

increased consumer awareness of the health effects of sugar are contributing to the increasing number of food products containing sugar substitutes [Świąder et al. 2007].

In recent years, sucrose substitutes have been increasingly sought, especially in the form of naturally occurring substances. Thanks to the significant number of research projects, alternative compounds for use in sucrose replacement have been discovered. Most of these are characterized by a low glycaemic index and a lower energy value. In addition, they present varying degrees of sweetness and some of these far exceed the sweetness of sucrose. The marketing of these substances is beneficial for people affected by diet-related diseases and helps in their prevention. This allows for an increase in and diversification of the range of available food products and sweeteners. Further research should be focused on obtaining sugar substitutes from new raw materials, and the analysis of their safety and effects on the human body and health [Nowicka, Wojdyło 2014].

Much of the research carried out on the activity of sugar replacement compounds provides ambiguous data [Biesiada, Nawirska-Olszańska 2013; Harricharan et al. 2015; Philippe et al. 2014; Świąder, Waszkiewicz-Robak, Świdorski 2011; Wierzejska 2015]. Also, information on the labels of food products containing these substances can be confusing for the average consumer.

Hence the aim of the paper was to analyse the application of selected types of sweeteners by consumers from Poland.

2. Materials and methods

This research was conducted in September 2016. The aim of the survey was to understand the habits, customs, and opinions of consumers concerning the sweeteners used in processed food production. Printed questionnaires were distributed among the employees of a range of companies from different sectors of the economy, as well as teachers and pupils of primary and secondary schools in Wrocław, Ostrów Wielkopolski, and Wałbrzych. The respondents were characterized by various places of residence, levels of education, gender and income.

The questionnaire consisted of 22 questions, including 13 questions related to the use of and motives for purchasing sweeteners and sweetened products. These data are described in this article (PART 1). Subsequent questions were related to consumer knowledge and opinion about sweeteners. These results are described in the second paper (part 2).

The first four questions were introductory. The survey included closed-ended and open-ended questions related to key issues such as consumer awareness of the occurrence of sweeteners in foods, an analysis of the ingredients of processed food products, knowledge about selected sweetening agents and an evaluation of their consumption in everyday diet.

The closed-ended questions 5-7 were multiple-choice. The respondents had ready prepared answers, and their task was to provide consistent information describing their eating habits.

The questions referred to specific consumer preferences in the consumption of different food products containing sweeteners, and food to which consumers themselves add sweeteners. Also, we asked about favourite types of sweeteners. Question 8 referred to the frequency of use of sweeteners. Questions 9 and 10 (multiple-choice) referred to the origin of sweeteners used by consumers and the way in which they are used.

In questions 11 and 13 (multiple-choice), we asked why respondents use sweeteners and what attracts them to use and purchase these sweeteners. In Question 12, consumers were also able to assess the availability of sweeteners on the market. A three-step scale (high, medium and low) was used.

It should be emphasized that the questionnaires were structured so as to enable completion by even those people who did not use sweeteners in their diet. Depending on the question, respondents could choose the option “do not eat”, “do not use” etc. In addition, most of the multiple-choice questions had the option “other”, which enabled respondents to enter their own individual answers.

3. Results

3.1. Description of questionnaire respondents

186 people took part in the survey: 124 women (67%) and 62 men (33%). The respondents were divided into six age groups. In the youngest group were those people “under 18 years old”. The majority of respondents from this group were children who were dependent on parents. The next age group, 18-24, was chosen to show the position of people who had already reached adulthood, and were able to make independent decisions. This group mainly consisted of students. The subsequent two age ranges were formed on the basis of 9 and 15-year spreads like 25-34 and 35-44. Then, there was the 45-60 group, and the last age group consisted of persons over 60 years old (Figure 1).

More than 30% of respondents were 45-60 years old (31%). The number of people in the next three most common groups, 18-24, 25-34, 35-44, was similar (in the range 16-18%). The lowest number of respondents were in the groups 60+ (12%) and minors (6%).

55% of the respondents declared as their place of residence a city of over 500 thousand inhabitants, 12% of the respondents lived in cities of from 100 thousand to 500 thousand citizens, while 23% lived in a city of up to 100 thousand residents. The smallest group of respondents lived in a rural area (11%).

Over 38% of respondents declared an income of over 1000 PLN. A similar percentage of respondents had an income either less than 1000 PLN or in the range

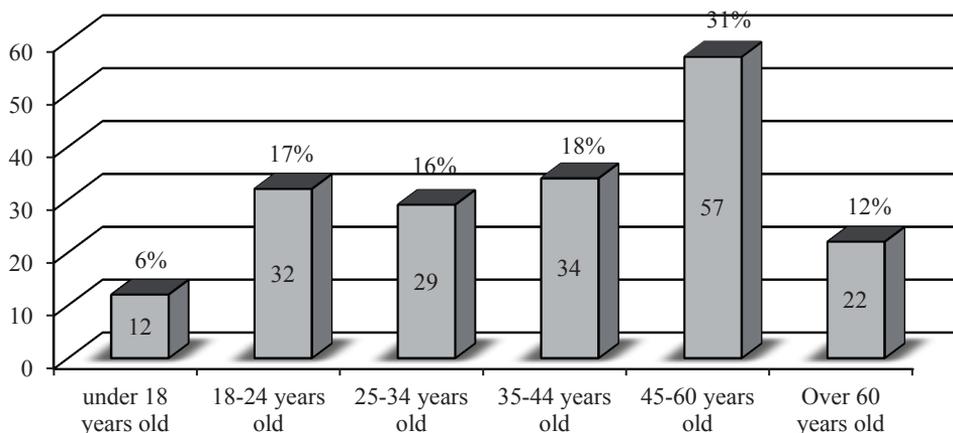


Fig. 1. Age characteristics of respondents

Rys. 1. Struktura wiekowa respondentów

Source: own data.

Źródło: badanie własne.

2000-3000 PLN (24% and 21%, respectively). 11% of respondents had an income above 3000 PLN, while only 6% declared earnings of more than 4000 PLN. The majority of respondents declared they had either Master's (48%) or Bachelor's degrees (37%). The lowest percentage of respondents had completed either vocational training (8%) or only basic education level (primary school) (7%).

The survey participants declared the type of higher education institution they had attended. In this class, top-level technical universities were not indicated for 36% of respondents. Many of the respondents were economists (23%). 13% of the respondents had graduated from the University of Wrocław and 9% had completed a diploma at the Academy of Music. The remaining respondents were from pedagogical (7%), agricultural (4%) and medical (2%) universities. The category of "other" (7%) included colleges such as the split discipline college, not previously mentioned in the categories.

3.2. Results and discussion

Over the past 50 years, the consumption of sugar has tripled worldwide and this trend is expected to continue. In recent years, sugar has been added to nearly all processed foods. In many parts of the world, people are consuming an average of more than 500 calories per day from added sugar alone [Lustig et al. 2012].

In the first question we asked about consumers' interest in sweeteners added to food products. Almost half of the respondents drew attention to sweeteners added to food products (45%). Almost the same number – 42% of people – sometimes check

the differences between sweeteners on their own. 13% of respondents are not interested in sweeteners. The greatest interest in sweeteners is in the over 60 years old group (68%). In different age groups of consumers the following results were observed: aged 45-60 years (49%), 35-44 years (53%), 25-34 years (44%). 30% of people from 18 to 24 years of age and only 8% of minors pay attention to the composition of food products (Figure 2).

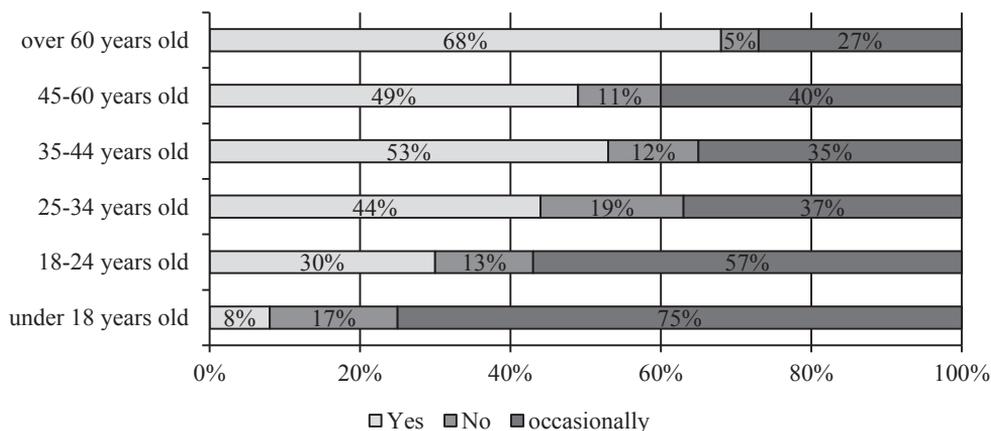


Fig. 2. Consumer interest in sweeteners related to the age of respondents

Rys. 2. Zainteresowanie respondentów substancjami słodzącymi zawartymi w produktach w zależności od wieku

Source: own data.

Źródło: badanie własne.

Most of the respondents were able to list products containing sweeteners (75%). The remaining 25% of the respondents did not answer this question and therefore did not have sufficient knowledge to allow them to give examples of such products.

The list of common sweetener products made up from consumer responses included: sodas, flavors, tea, Pepsi, Fanta, Sprite, Kubaś (41%); sweets such as candy, wafers, biscuits, chocolate (27%); yogurt (22%) and dairy (7%); juices (20%); cakes (16%); jams, marmalades and confectionery (16%); cola (9%), demonstrating repetition of this type of beverage; cookies (8%), fruit and vegetable products (8%) and chewing gum (8%). Only 5% of respondents listed bread and pastry, including cakes, pastries, buns and donuts, 4% of the people cited indicated ice cream, the same percentage as for alcohol, and cereal products (including breakfast cereals). A small number of respondents added canned, pureed or pickled food (3%). Slightly less common were cheese and cheese sauces, ketchup and Nutella (2%). Most consumers referred to salads (1%) and compotes (1%) as products containing sweeteners. The remaining 8% of respondents mentioned products such as jelly,

dried fruit, fruit, crisps, Tic-Tacs, honey, light products, ready-made soups, soups, syrups, medicines, all effervescent medicines, and processed foods.

In question 3 the respondents were asked to list known sweeteners. The results were similar to those concerning their knowledge about products containing sugar or its replacers. Over 76% of the respondents mentioned sweeteners available on the market. On the other hand, 24% did not respond, which confirms the lack of knowledge about different types of sweeteners.

Figure 3 presents the list of sweeteners enumerated by consumers. More than half of the respondents associate sugar as being a sweetener (58%). 34% of the respondents declared the use of honey. Interestingly, aspartame (28%) was stated more frequently by consumers than other sugar replacers (19%). The following sweet compounds were listed: stevia (17%), xylitol (15%), and glucose-fructose syrup (13%). Also, syrup from agave, maple, starch and fruit were mentioned by 12% of respondents. In turn, saccharin was listed by 11%, more often than glucose (9%), cane sugar (8%) or fructose (8%). There were also other substances where sorbitol (5%) and brown sugar (5%) were added. Least frequently cited by respondents was the use of molasses (3%) or acesulfame (3%).

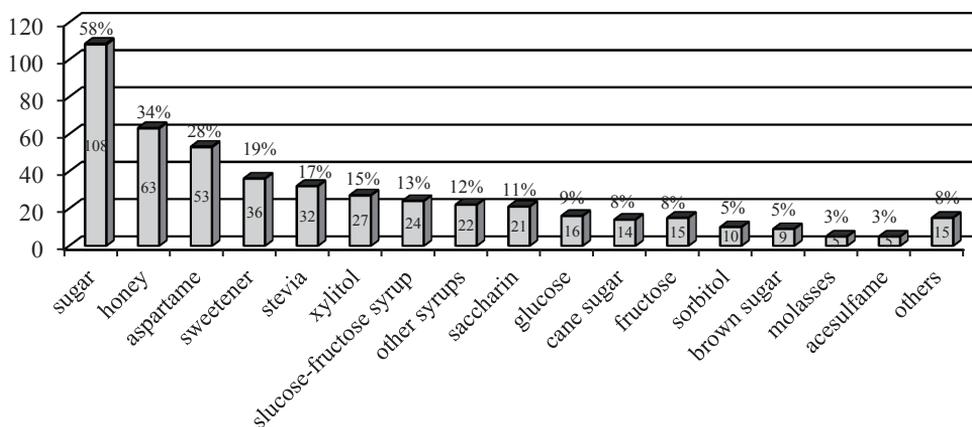


Fig. 3. Popularity of sweeteners according to the consumers

Rys. 3. Substancje słodzące wymienione przez respondentów

Source: own data.

Źródło: badanie własne.

In the next question, we asked whether respondents used sweeteners in their everyday diet. The majority of consumers (96%) used sweeteners. Only 8 people (4% of respondents) admitted that sweeteners were not present in their everyday diet.

In the second part of the survey (5-10) questions about respondents' preferences (eating habits) were included. In question 5, consumers chose those products with

added sweeteners that they most frequently buy and consume. The majority of respondents listed cakes (79%) and fruit products and dairy products (respectively 68% of respondents). Cereal products were chosen by 56% of respondents. These were followed by chewing gum (41% of the respondents), and non-alcoholic and alcoholic beverages (37%). Few people buy food products with added sweeteners (15%) and other food not mentioned in the questionnaires (4%). Only 1% of respondents stated that they did not consume products containing sweeteners.

Low calorie sweeteners are used in a variety of food and drink products, including soft drinks, chewing gum, confectionery, frozen desserts, yoghurts, dessert mixes and puddings. They are also widely used in healthcare, making many medicines more palatable. Low calorie sweeteners are clearly labeled on the packaging of food, healthcare and drink products that contain them [http://www.sweeteners.org/assets/uploads/articles/files/ISA_brochure_April2016.pdf].

Figure 4 shows the preferences of men and women for food product consumption. 81% of women and 77% of men declared that they eat biscuits. Almost as many women as men eat fruit products (67% and 68%, respectively), dairy products (60% and 55%, respectively) and chewing gum (43% and 39%, respectively). Cereal products are more commonly chosen by women (60%) than men (45%), as well as low calorie food (17% and 6%). Men consume more non-alcoholic (53%) and alcoholic beverages (45%) in comparison to women (28% and 34%, respectively).

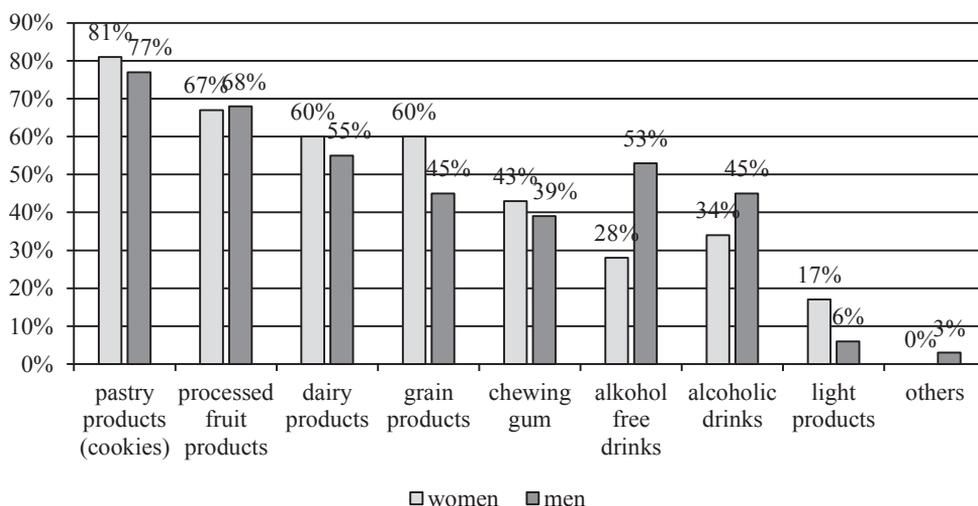


Fig. 4. Consumer preferences for food products with added sweeteners

Rys. 4. Preferencje żywieniowe kobiet i mężczyzn odnośnie do produktów zawierających substancje słodzące

Source: own data.

Źródło: badanie własne.

In the next question, we asked to which food products respondents added sweeteners (Figure 5).

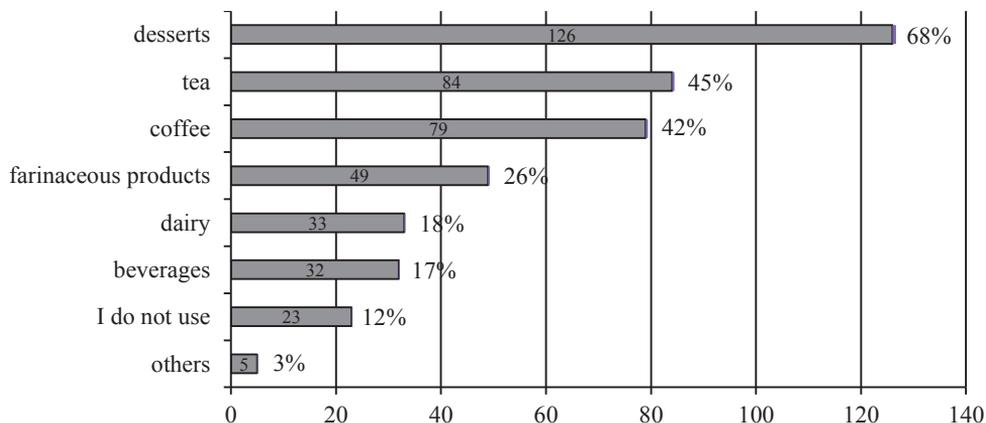


Fig. 5. Types of products to which consumers add sweeteners

Rys. 5. Rodzaje produktów, do których konsumenci dodają substancje słodzące

Source: own data.

Źródło: badanie własne.

Over half of the respondents (68%) add sweeteners to cakes and desserts, while fewer than half of them use these compounds for tea (45%) and coffee (42%) preparation. To farinaceous foods, sugar or its replacers are added by 26% of respondents. A slightly lower percentage of consumers add sweeteners to dairy products (18%) and beverages (17%). Only 23 people (12% of respondents) do not use sweeteners at all, 3% of the respondents listed other product categories. Letich et al. (2016) reported that honey and acesulfame K were not as acceptable as sucrose in black tea.

In question 7, the respondents enumerated which sweeteners they used in their diet (Figure 6). Honey (78%) and white sugar (74%) were the most commonly used substances. Other types of sugar such as cane and brown sugar were quoted by 23% and 15% of the respondents. The respondents' diet also includes syrups (20% of questioned people), such as maple, agave, raspberry, date, fruity, pine and cane syrups. Stevia and xylitol were mentioned by only 5% of respondents. In addition, 3% of consumers included aspartame in their diet. The smallest number of respondents used fructose (1%), inulin (1%) and Herpapol tea (1%). The other respondents (4%) listed: malt extract, sorbitol, erythritol, sugarcane, sweeteners and cyclamate-based huxol.

More than half of the respondents (60%) use sweeteners daily. Over 18% stated a sweetener consumption of 3 times per week. Only 10% of respondents indicated sweetener consumption once per week and 8% less frequent than once a week. On

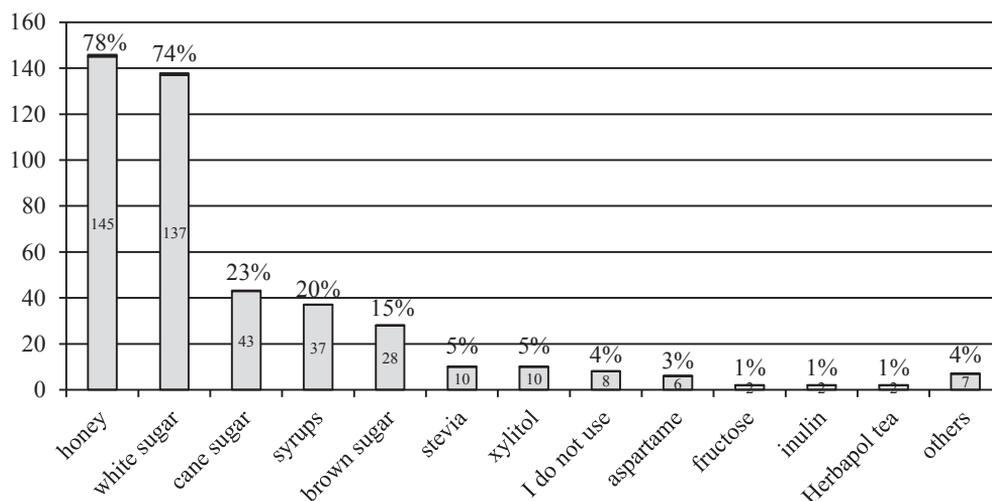


Fig. 6. Sweeteners used by respondents

Rys. 6. Substancje słodzące stosowane przez respondentów

Source: own data.

Źródło: badanie własne.

the other hand, only 4% of those questioned do not use these substances in their diet. In the European Union (EU), the most frequently used low calorie sweeteners are acesulfame-K, aspartame, cyclamate, saccharin, sucralose and steviol glycosides [http://www.sweeteners.org/assets/uploads/articles/files/ISA_brochure_April2016.pdf]. According to Sylvetsky and Rother [2016], consumption of low calorie sweeteners increases with age and is more common among adults between 55 and 74 years of age compared to younger individuals.

Question 9 evaluated the ability of consumers to determine the origin of selected sweeteners (natural, synthetic, and semi-synthetic). The majority of respondents (70%) believed that sweeteners in their diet are natural. Only 8% of respondents stated that they consumed synthetic sweeteners and 5% of respondents considered that they have consumed semisynthetic ones. Moreover, 13% of respondents have no knowledge about the origin of the sweeteners that they use. The other respondents (4%) declared that they do not use sweeteners.

Half of the respondents use sweeteners in crystalline form and a large group of those questioned (42%) use them in liquid form. A small percentage of the respondents (5%) use sweetening agents in tablet form.

The data obtained in question 11 show that the most common reasons for sweetener use is consumer health and well-being (35%), the specific taste of these substances (13%), weight loss (11%), healthy lifestyle (6%), diabetes (4%) or other illness (3%). 1% of those questioned stated that these compounds are present in the

food products that they purchase. Only 3% of respondents reported other reasons for using sweeteners.

According to 63% of the respondents, the availability of sweeteners on the market is high. 34% of the respondents believed that the distribution of sweeteners is sufficient. In contrast, only 3% stated that there is a problem with the availability of these substances on the market.

The next question related to factors influencing consumer purchasing decisions regarding sweeteners. The most important features of sweeteners are taste (58%), safety of use (26%) and price (26%). Slightly fewer respondents (19%) take into account nutritional value when choosing a sweetener. 16% of respondents buy sweeteners because of their importance to wellbeing and 13% of respondents consider the availability of sweeteners. "Other reasons" for buying sweeteners not listed in questionnaires were selected by 4% of respondents (Figure 7).

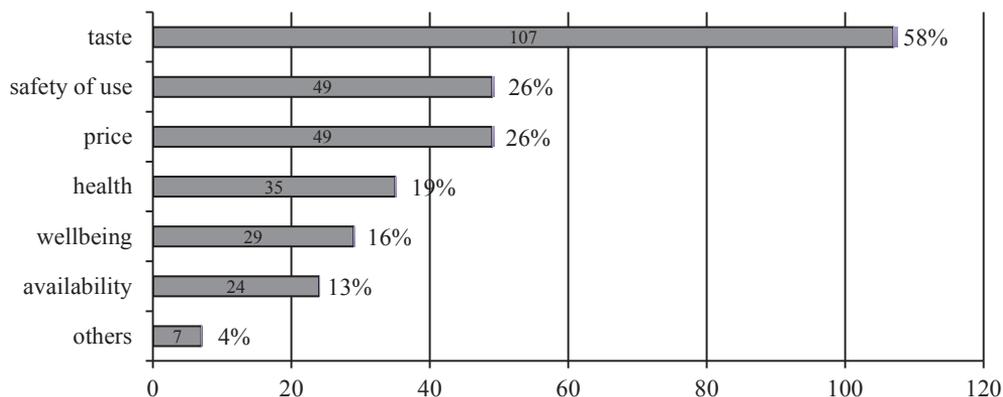


Fig. 7. Factors influencing sweetener purchase by respondents

Rys. 7. Determinanty zakupu substancji słodzących przez respondentów

Source: own data.

Źródło: badanie własne.

At present, the guarantor for the safety of food additives (including sweeteners) is the European Food Safety Authority. Extensive scientific research has demonstrated the safety of all sweeteners permitted for food use in the EU. Their safety is documented by the results of several *in vitro* and *in vivo* animal studies, tests in humans, and in some cases epidemiological studies. Their safety has been evaluated through a risk assessment process covering hazard identification, hazard characterization, exposure assessment and risk characterization [Mortensen 2006].

Taste is also definitely the most important factor influencing consumers' purchasing decision (Figure 8). These data are related to the level of income per person. More than half of the respondents stated taste as the most important factor if

their income was in the range 1000 to 3000 PLN (up to 1000 PLN this was 68%, over 1000 PLN – 55% and over 2000 PLN – 62%). Also, the same answer was cited by 48% of respondents whose income was higher than 3000 PLN.

Product price was the second most important factor motivating the purchase of the selected sweetener, especially for people with an income up to 1000 PLN (36%) and over 2000 zlotys (36%).

However, for consumers with incomes over 4000 PLN per person, the most important feature influencing their choice of sweeteners was safety (45%), while taste was listed second by these respondents (36%). For these consumers, price does not affect their purchasing decisions (0%).

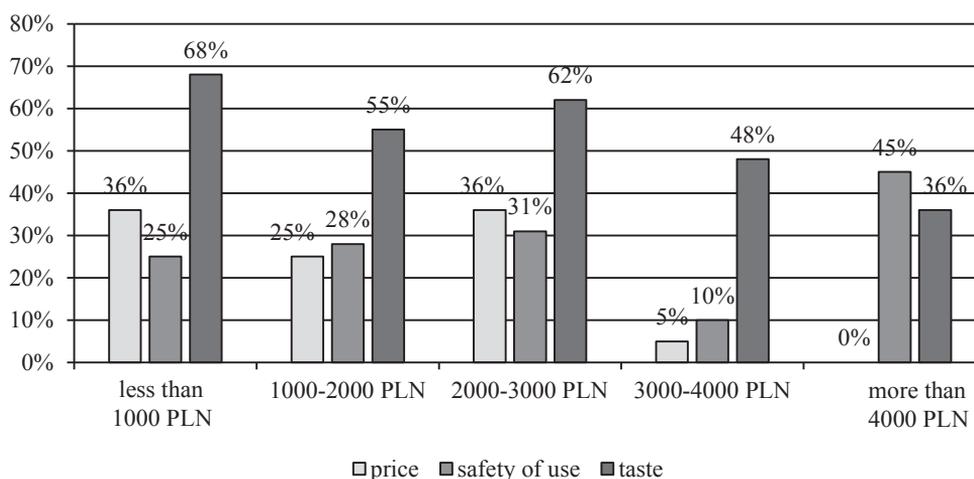


Fig. 8. Factors influencing sweetener purchase by respondents in relation to respondents' income per capita

Rys. 8. Zależności między głównymi motywami zakupu wybieranych przez respondentów substancji słodzących a dochodem przypadającym na 1 osobę w gospodarstwie domowym

Source: own data.

Źródło: badanie własne.

Between 2005 and 2010, the percentage of people citing concerns about the use of food additives increased by about 5% in 21 European countries. It should be emphasized that Poland has identified food additives as the main food risk factor. These compounds were more frequently enumerated by respondents than other food threats, such as pesticide residues in cereals, fruits and vegetables, abnormal freshness or food quality, antibiotic residues after animal treatment, pollution such as mercury in fish meat and dioxin in pork meat. The percentage of non-concerned Polish inhabitants increased by 2% in 2010 in comparison to 2005 (when it was 79%). Table 1 shows the results of studies on European consumers [Walkiewicz 2011].

Table 1. Percentage of consumers concerned about sweeteners added to food according to Special Eurobarometer 354, Food-related risks

Tabela 1. Odsetek badanych osób zaniepokojonych użyciem substancji dodatkowych oraz aromatycznych w żywności według Special Eurobarometer 354, Food-related risks

EU country	% of concerned consumers in 2010	Change in % of concerned consumers in comparison to 2005
Belgium	64	+ 7
Bulgaria	81	-
Czech Republic	68	+ 8
Denmark	67	+ 4
Germany	66	+ 12
Estonia	71	+ 6
Ireland	53	- 2
Greece	85	+ 4
Spain	54	+ 8
France	66	+ 12
Italy	81	+ 5
Cyprus	82	+ 4
Latvia	77	+ 5
Lithuania	87	+ 8
Luxembourg	72	+ 7
Hungary	81	+ 5
Malta	58	- 1
Netherlands	56	+ 16
Austria	61	+ 4
Poland	79	+ 2
Portugal	74	+ 13
Romania	74	-

Source/Źródło: [Special Eurobarometer 354, 2010; Walkiewicz 2011].

The highest increase in the number of uncertain consumers was observed in the Netherlands (56%, +16). A lack of trust in food additives also increased significantly in Portugal (74%, +13) and France (66%, 12%). In Romania and Bulgaria, this parameter was steady. In contrast, the number of consumers not sure of the effect of the use of food additives dropped 2% in Ireland (53%) and 1% in Malta (58%). This trend was observed in only two EU members countries. In all the other EU states, a rise in anxiety has been observed over the past five years.

4. Conclusions

On the Polish market, there are increasing numbers of products which consumers can use to sweeten meals or drinks. Also, these are used on an industrial scale. They are ingredients of many food products. Over 45% of respondents declared that they paid attention to the sweeteners contained in food products, especially in juices and other beverages, sweets, yogurts, cakes, jams, marmalades and confections. Among the different types of sweetened products, consumers most like to choose pastry products, processed fruit products and cereal and dairy products. According to the respondents, sweeteners purchased separately are mostly used as additives in cakes, desserts, tea, coffee and flour based products. Despite the high levels of awareness concerning the hazards associated with the use of sucrose, the majority of the respondents use it every day. The most popular sugar replacers enumerated by consumers are cane and brown sugar. Interestingly, honey was listed as the most commonly used sweetener. However, almost all the respondents who confirmed honey use (78%) also consumed white sugar (74%).

The most important purposes of sweetener use are their positive effect on human health and well-being (35%), their specific taste (13%), or a low-calorie diet (11%). Among the most frequently mentioned factors influencing decisions to purchase sweeteners were the safety of these products and their price (26%). Less important for respondents were health (19%) and well-being (16%).

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