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ACCEPTABILITY AND SENSORY EVALUATION OF ENERGY BARS AND PROTEIN BARS ENRICHED WITH EDIBLE INSECT

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ABSTRACT

For consumers, one of the basic criteria of choosing a foodstuff, apart from nutritional values, is their taste and smell. In edible insect as a novel food, these criteria are not quite decisive. The main criterion in the Western countries is the acceptability of the food. This work deals with sensory evaluation of protein and energy bars, enriched with cricket flour from American and Czech producers, and their acceptability for consumers from the Czech Republic. The sensory evaluation was done using the questionnaire survey and a simple electronic nose. The survey has shown that edible insect bars are acceptable as a new type of food for consumers in the Czech Republic. Best rated by consumers were orange and pineapple flavour bars from the Czech manufacturer. Statistically significant difference was not detected between evaluation of the bars from the American and Czech manufacturers. Also, the difference between the bars of different flavours from the Czech producer was evaluated using a simple machine – a portable electronic nose. There was not a statistically significant difference between bars of different flavours from the American manufacturer. The positive contribution of the survey is that more than 80% of consumers are willing to consume food enriched with edible insect. This fact shows a change in public attitude to these foods.

Keywords: edible insect; *Acheta domestica*; sensory analysis; electronic nose; energy bars

INTRODUCTION

Sensory properties are a particularly important criterion for eating edible insect **(Borkovcová et al., 2009; Adámek et al., 2017)**. Food intake and rejection are the result of the involvement of sensory-affective functions that relate to sensory properties. The imaginary ideas of nature and origin of the food have an influence too, and there is also a concern about security that is closely linked to physical and mental harm **(Rozin and Fallon, 1987)**. In western countries, people generally link entomophagy with dirt and poverty, thus they often deny insect eating as unacceptable **(Looy et al., 2014)**. However, in other cultures, insect is commonly eaten and valued for its nutritional properties and taste **(Hanboonsong, 2010)**. According to **Regulation (EU) 2015/2283** of the European Parliament and of the Council of 25 November 2015 on novel foods, in force from January 1st 2018, edible insect became the novel food.

The visual impression is the first of indicator when assessing and choosing a food by a consumer. It depends not only on its own visual effect, but also on the psychological effect on the consumer (taste expectations as a result of past appearances and tasted flavour) **(Köster et al., 2004; Mojet et Köster, 2005)**. As with other meals, pleasant visual stimulus (nice colour) does not ensure good taste – colour serves mainly as an insect species identifier. For most species, however, mainly larvae and pupae are used for culinary treatment, and they are mostly white or colourless. Insect, as well as crustaceans, gains its final (most often attractive red) colour, through the culinary treatment. Black colour of insect may be caused by improper drying or big content of oxidized fat. After proper drying, edible insect gains golden or brown colour and can be easily crushed with fingers **(Borkovcová et al., 2009)**.

Furthermore, the consumer evaluates the shape and consistency that are not easily seen in hidden forms of eating insect. Edible insect is partly made up of an exoskeleton that causes the crispness of the insect when consumed (tactile and auditory effect), which, along with chewing, generates pleasant feelings such as the consumption of pretzels, biscuits or other durable pastry **(Ramos-Elorduy, 1998)**. Larvae after moulting are soft, because their exoskeleton has not yet hardened, thus making them more digestible **(Borkovcová et al., 2009)**. Benefit of exoskeleton is the high content of chitin, which has similar effect as fibre, but it is also an allergen **(Bednářová et al., 2010; Mlček et al., 2014)**.

Insect taste is various. It depends, among other things, on the insect environment and on the feed (fruits, vegetables, pastry, potatoes, rice, grass ...). To enjoy taste of insect in all its richness, insect must be alive and unwashed, but this is dangerous from a health and safety point of view **(Bednářová et al., 2010)**. Therefore, **EFSA (2015)** reccomends heat treatment for security reasons, although it results in the loss of the original aroma.

In the food industry, the scent is one of the most important sensory properties in terms of consumer compliance. The laic consumer evaluates the scent only subjectively, based on his experience and preferences. The nose, as a basic olfactory organ, can be attenuated at the time of ingestion **(Carlsson and Kalinová, 2005)**. Furthermore, pheromones, often present on the exoskeleton, are removed by washing. Edible insect material is therefore de facto without scent, and it absorbs the taste and smell of the added ingredients **(Ramos Elorduy, 1998)**. To enable laic consumer to distinguish the differences between edible insect smell, the intensity of smell would have to be increased by at least 30% **(Carlsson and Kalinová, 2005)**. To better distinguish the individual smells, there is an alternative – several species of olfactometric machines, including electronic noses. As proved, even a simple electronic nose can distinguish insect species and the culinary treatment **(Adámek et al., 2017)**.

The electronic nose is usually equipped with several semiconductor gas sensors, each of which is sensitive to a particular type or group of volatile substances. More accurate devices can use combinations of different methods to measure concentrations of substances in the analysed gas. The electronic nose is used not only as a part of security systems (fire detector – detection of flammable substances hazardous for man), in the environmental segment (air pollution detector), but also in the food industry. While electronic noses cannot fully replace human smell, which is closely related to taste, they can be used to detect a firmly defined condition of a food, which is indicated by a certain odour. This can be used, for example, in monitoring food storage and determining its shelf life. **Gopal et al. (2015)** described in their study the use of electronic nose Peres to evaluate the freshness and shelf life. Also **Peris (2016)** dealt in his study with using the electronic nose in the food industry, to reveal food falsifying and evaluating food authenticity.

Scientific hypothesis

Scientific hypothesis is: Energy bars and protein bars enriched with edible insect are acceptable as novel food for consumers from the Czech Republic.

Aim of the work was to find out, if energy bars and protein bars enriched with edible insect are acceptable as novel food for consumers from the Czech Republic, if there is any consumer preference based on smell or taste, and to compare consumer evaluation with the electronic nose measurement.

MATERIAL AND METHODOLOGY

Material for sensory analysis

Protein and energy bars with cricket flour (*Acheta domestica*) produced in USA and Czech Republic were used. Samples T1 – T4 were made by Czech producer, T5 – T7 were made by American producer.

The ingredients of protein and energy bars were as follows:

T1 Protein bar Peanut Butter & Cinnamon with Cricket Flour: Peanut butter (34%) (Peanuts 100%), Cricket flour (*Acheta Domestica*) (20%), Cannabis Powder, Cocoa Butter, Agave Syrup, Beetroot, Cinnamon (1%)

T2 Protein bar Dark Chocolate & Sesame with Cricket Flour: Sesame (27%), Chocolate (21%) (Cocoa Powder 52%, Cocoa Butter 48%), Cricket Flour (*Acheta Domestica*) (20%), Cannabis Powder, Agave Syrup, Sesame Oil (4%)

T3 Energy bar Pineapple & Coconut with Cricket Flour: Pineapple (30%), Dates, Cashew Nuts, Cricket Flour (*Acheta Domestica*) (10%), Coconut (8.5%), Psyllium, Lemon Peel

T4 Energy bar Dark chocolate & Orange with Cricket Flour: Dates, Cashew Nuts, Chocolate (16%) (Cocoa Mass 69%, Cocoa Powder 31%), Cricket Flour (*Acheta Domestica*) (10%), Psyllium, Orange Peels (2%), Essential Orange Oil (0.9%)

T5 Energy bar Peanut Butter, Cherry and Cacao: Raw Honey, Brown Rice Syrup, Peanut Butter, Almonds , Pumpkin Seeds, Cherry, Cacao Nibs, Sunflower Seeds, Pistachios, Walnuts, Flax Seeds, Rolled Oats, Puffed Brown Rice, Dates, Cricket Flour, Cashews, Blueberry s & Himalayan Sea Salt

T6 Energy bar Cranberry, Blueberry and Pistachio: Brown Rice Syrup, Raw Honey, Pistachios, Almonds, Pumpkin Seeds, Cricket Flour, Cranberry, Blueberry, Cherry, Walnuts, Sunflower Seeds, Chia Seeds, Flax Seeds, Rolled Oats, Puffed Brown Rice, Apricots, Currants, Himalayan Sea Salt

T7 Energy bar Kale, Green Tea, Seaweed and Ginger: Brown Rice Syrup, Crystallized Ginger, Almonds, Pistachios, Pumpkin Seeds, Sunflower Seeds, Cricket Flour, Flax Seeds, Rolled Oats, Puffed Brown Rice, Dates, Apricots, Apple, Cashews, Green Tea Powder, Toasted Kale, Roasted Seaweed & Himalayan Sea Salt.

Nutritional values are shown in Table 1. Data for American bars were taken and recalculated for 100g from: https://www.kickstarter.com/projects/993678727/hopper-energy-bars-made-with-cricket-flour-in-aust.

Survey

Bar samples were subjected to sensory analysis and evaluated on the basis of a questionnaire survey. Respondents were presented with seven types of bars from two companies. Sticks were sliced and presented to the respondents for evaluation.

The survey was attended by 96 lay participants in September 2017. Of the total number of respondents, 18% were women and 82% men of Czech nationality, predominantly aged 20 – 29 years. Respondents only got the information that this was a sensory assessment of energy bars with the addition of cricket flour. Additionally, the bars were numbered 1 to 7 and presented for the evaluation of respondents in the form of a blind test. Respondents were asked to evaluate the smell and taste from 1 (pleasant taste or smell) to 5 (unpleasant taste or smell). The questionnaire also included questions about gender, age, interest in the consumption of insect, and the

Table 1 The nutritional composition of protein and energy bars enriched with the cricket flour.

Sample	Energy Value		Total Fat	Saturated fatty acids	Total Carbohydrate	Sugars	Fibre	Protein	Salt
	kJ	kcal	g.100 g^{-1}	g.100 g^{-1}	g.100 g^{-1}	g.100 g^{-1}	g.100 g^{-1}	g.100 g^{-1}	g.100 g^{-1}
T1	2207	530	34.2	9.8	22.0	12.3	2.7	33.3	0.14
T2	2277	535	36.5	11.3	17.2	7.3	4.8	33.3	0.19
T3	1724	412	16.4	7.0	49.2	42.6	8,4	13.0	0.09
T4	1706	408	17.4	5.8	42.0	34.4	10.6	15.4	0.08
T5	1650	395	20.4	3.4	44.0	21.4	6.1	13.5	0.21
T6	1621	388	15.4	1.6	60.4	26.5	6.6	13.4	0.23
T7	1580	378	15.9	2.0	63.1	24.5	5.8	13.6	0.24

preference of the producers. Respondents were also asked to answer questions about their willingness to eat insect in the future.

Electronic nose measurement methodology

Measurement of gas concentration (smell) was carried out on an experimental prototype of electronic nose (Figure 1), which was realized as a simple, cheap and portable device. The device was based on the Arduino Mega platform controlled by the ATmega1280 microcontroller with the ability to record data on a memory card and communicates with the web server. The measuring chamber was equipped with sensors based on the chemorezistive principle. It uses the MQ-6 sensor, which is most sensitive to propane or isobutane (300 – 10000 ppm) and less sensitive to alcohol. Furthermore, the MQ-3 sensor, which is very sensitive to alcohol (25 – 500 ppm) and the MQ-8 sensor, designed for hydrogen detection (100 – 1000 ppm) were used. As this device was meant only to compare its previous measurements with each other and accurate measurement of the absolute values of the individual gas concentrations in the measured odour was not expected, the recommended manufacturer's setting with no additional calibration was used to detect the absolute values of the individual gas concentrations. The U_S voltages [V] of the individual sensors were converted using the internal 10-bit A/D converter of the microcontroller to a digital value of d [-] (Voltage 0V and 5V corresponds to the digital level 0 and 1023). These values were further mathematically processed.

Statistic analysis

Data was evaluated using Excel 2013 (Microsoft Corporation, USA), STATISTICA Cz version 12 (StatSoft, Inc., USA) and Gnuplot 5.0: an interactive plotting program **(Williams and Kelley, 2016)**. Results were expressed by average ± standard deviation. Kruskal-Walllis test ($\alpha = 0.05$) was used to compare the taste and smell of individual samples.

RESULTS AND DISCUSSION

Sensory evaluation of protein and energy bars, enriched with cricket flour

Seven samples of energy bars, enriched with cricket flour, T1 – T7, were evaluated for sensory properties, results are in Table 2. Respondents after sensory evaluation (taste and smell) preferred samples T1 – T4 over T5 – T7. T4 had the best score (1.9) and T7 the worst (4), considering the smell. In general, samples T1 – T4, produced by Czech manufacturer, had better acceptance, than bars T5 – T7, made in the USA. This smell evaluation corresponded with taste assessment, where again bars from Czech produce had better scores than from American producers. Consumers best loved T4 (2.4), worst score was gained by T7 (3.6). The questionnaire showed that, consumers would buy insect bars because they considered the product to be healthy, and also that they prefer a Czech producer over American.

The results showed that, differences between evaluation made by men and women are not statistically significant

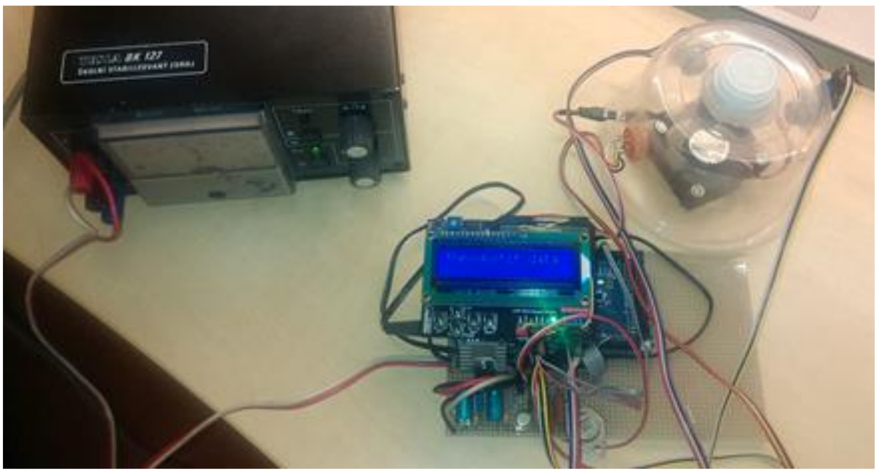

Figure 1 Experimental prototype of the electronic nose.

Table 2 Evaluation of the smell and taste of energy and protein bars enriched with the cricket flour (1 – very pleasant, 5 – unpleasant).

Sample	Name	Evaluation			
		Smell		Taste	
		M	SD	M	SD
T1	Protein bar Peanut Butter & Cinnamon with Cricket Flour	2.5	1.0	2.9	1.1
T2	Protein bar Dark Chocolate & Sesame with Cricket Flour	2.4	0.7	3.1	1.2
T3	Energy bar Pineapple & Coconut with Cricket Flour	2.4	1.2	2.5	1.4
T4	Energy bar Dark chocolate & Orange with Cricket Flour	1.9	0.9	2.4	1.3
T5	Energy bar Peanut Butter, Cherry and Cacao	2.9	0.8	3.4	0.8
T6	Energy bar Cranberry, Blueberry and Pistachio	3.0	1.0	3.1	1.0
T7	Energy bar Kale, Green Tea, Seaweed and Ginger	4.0	1.5	3.6	1.1

(p >0.05). Similar results were presented by **Adámková (2017)** while evaluating the bars enriched with cricket flour. However, **Adámková (2017)** stated that, women more often preferred bars with higher content of cocoa powder than men. This may be because women in general like food with cocoa powder, such as chocolate confectionery, more than men **(Kozelová et al., 2014)**.

Another beneficial fact is the interest of especially young people in this survey. That proves the change of Czech consumers' attitude towards edible insect as a novel food. This change was already documented by **Bednářová et al. (2013)** and **Adámková (2017)**. **Adámková (2017)**, who evaluated the acceptance of edible insect before and after the first consumption, declared the increase of the acceptance by more than 27%.

The resulting acceptance after the tasting of the bars was more than 60%. A similar result is provided on the website of the American company, producing bars T5 to T7. The manufacturer states that 58% of respondents tasted his bars without problems and most of these respondents liked them. 30% of respondents tasted a bar only after they learned about the benefits of edible insect.

The positive approach and willingness of respondents to consume these samples could be caused by the hidden form of edible insect additions. More than 80% of respondents said they were willing to consume food with the addition of edible insect in the future.

The conditions of acceptability of edible insects in the Czech Republic were also examined by **Bednářová et al. (2013)**. Based on her questionnaire survey, it was possible to divide European consumers into two groups – one group preferred consuming foodstuffs with highly visible insect, while the other group welcomed the consumption of insect in a hidden form.

Bednářová et. al. (2013) stated that in case of the field cricket, (*Gryllus assimillis*) Czech respondents were willing to consume this species in the visible form. **Capparos Megido et al. (2014)** evaluated in their study the acceptance of edible insects among Belgian consumers. The study was conducted with mealworm larvae and house cricket adults after various treatments. Although mild neophobia was revealed, people agreed to the evaluation of insect specimens and, after a hedonic test, respondents were willing to eat and cook insects in the future.

Furthermore, sample recognition test was done for samples T1-T7. Sample recognition test for various culinary treatments was carried out also by **Adámek et al. (2017)**, using an electronic nose. Available literature presents no other comparable data for this kind of edible insect evaluation.

Using the measured data for individual samples of the bars for the individual sensors MQ-8, MQ-6 and MQ-3, time-dependent curves were created. The measurement time was set to 600 s. An example of the time dependency is shown in Figure 2.

Based on the individual curves, the basic statistical variables were calculated - mean and standard deviation. Average values are listed in Table 3 and processed in a 3D graph (Figure 3**)**, using the Gnuplot program.

In T1 – T4 bars, the electronic nose detected the statistically significant difference between the individual bars. It is clear from the graph on Figure 3 that the point

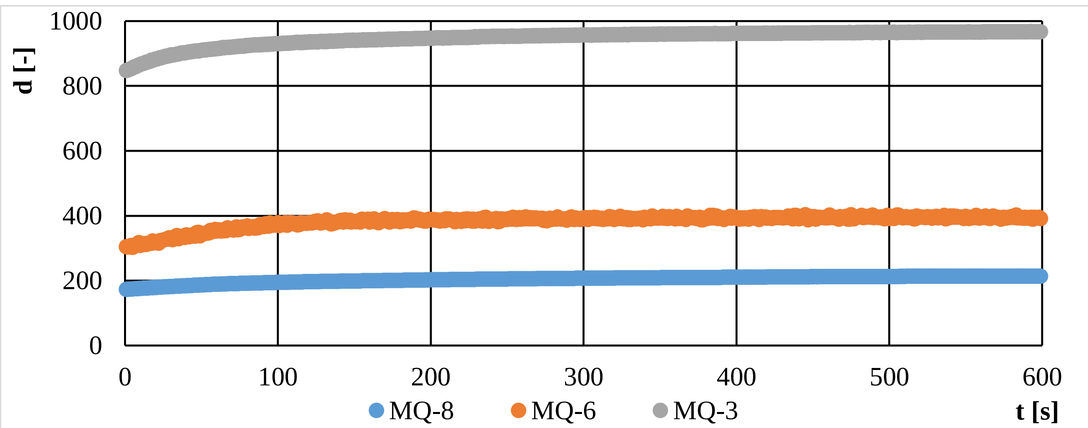

Figure 2 Example of time dependency of the measured data for sensors MQ-8, MQ-6 and MQ-3 in sample T4 (Energy bar Dark chocolate & Orange with Cricket Flour).

Table 3 Evaluation of the smell and taste of energy and protein bars enriched with the cricket flour (1 – very pleasant, 5 – unpleasant).

Sample	MQ-8		MQ-6		MQ-3	
	M	±SD	M	±SD	M	±SD
T1	158.0	2.5	263.7	4.0	768.4	13.0
	145.5	3.0	262.7	4.7	745.8	5.9
T2	163.7	1.8	313.2	6.4	830.7	13.6
	162.4	3.4	306.0	7.7	826.9	9.2
T3	181.7	7.8	317.4	15.8	868.1	15.5
	183.7	7.8	315.3	15.9	866.0	15.6
T4	204.4	9.9	383.5	20.5	947.9	23.0
	191.9	6.2	357.4	21.9	957.0	7.7
T5	105.6	1.1	243.4	4.7	753.2	5.2
	104.6	2.3	234.5	4.0	739.9	3.1
T6	104.6	1.9	242.7	7.5	748.7	9.7
	102.1	1.8	236.6	6.2	741.1	7.1
	100.0	2.6	228.8	5.2	730.4	4.9
T7	103.9	2.9	244.8	6.1	757.2	10.3
	99.8	1.1	238.6	6.5	751.8	8.9
	100.5	1.3	233.8	7.1	742.1	9.5

range for the T4 bar is further from the other points and is more easily detectable than other bars. The electronic nose did not notice any significant difference between T5 – T7 bars.

In general, the smell of food is caused by the presence of different oils, terpenes, flavonoids, etc., and different people respond to them differently. The presence of these substances can be determined by technical devices, e.g. an electronic nose. Although the electronic nose used in this work is not equipped with sensors for detecting these substances, in Figure 3 it is possible to see a certain similarity between the evaluation of the respondents and the results from the electronic nose (increasing the signal on all three sensors improves the evaluation of the individual samples).

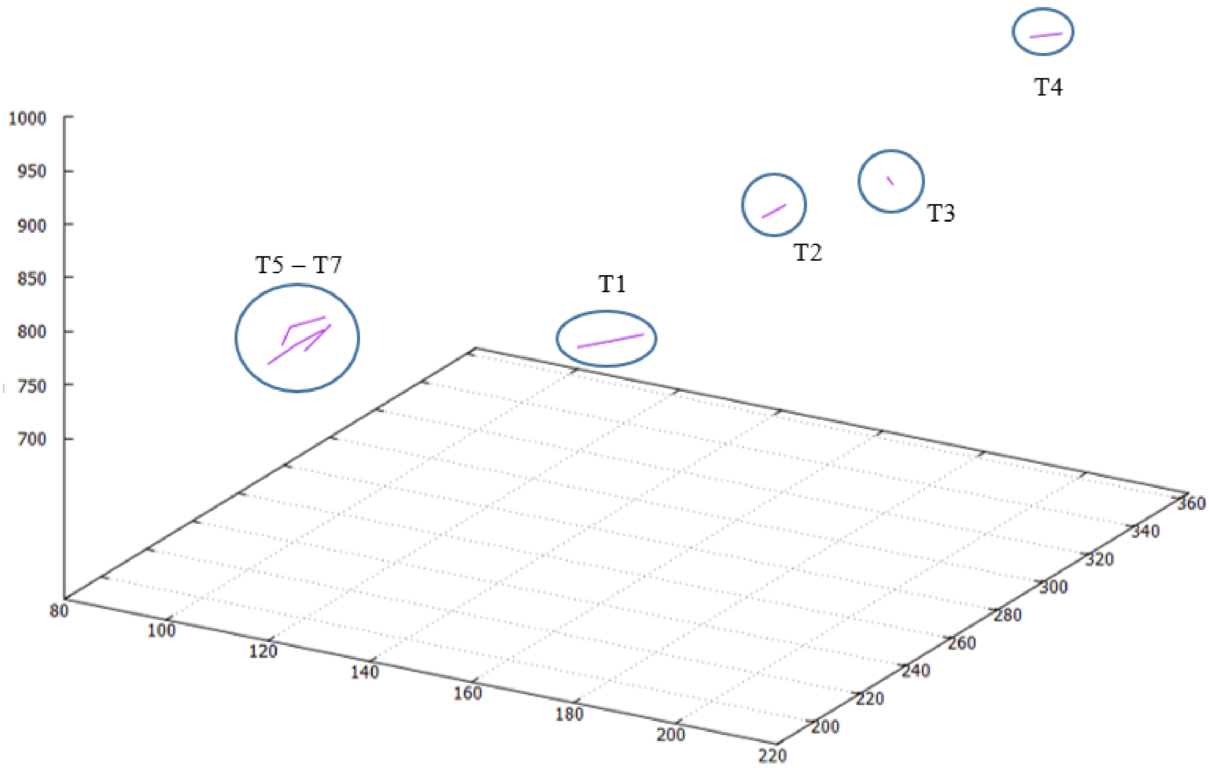

Figure 3 Electronic nose – Measured points for individual energy and protein bars enriched with the cricket flour.

CONCLUSION

Changes in public attitudes to eating edible insects were confirmed. The tasting of energy and protein bars, enriched with cricket flour by lay public, followed by a questionnaire survey confirmed that, these bars are acceptable to the Czech consumer as a novelty food under **Regulation EU 2015/2283** valid from 1st January 2018. The research also confirmed that preference is given to the Czech manufacturer's bars over the American bars. Regarding the taste and smell, the bars smelling of tropical fruit were more acceptable to consumers. Questionnaire surveys in the general public, especially young people, showed a willingness to taste samples of edible insects in the Czech Republic. The fact that respondents did not refuse the possibility of conscious consumption of edible insects in the future is positive.

Evaluated protein and energy bars are, according to the producers' advice, meant to serve as a dietary supplement for people with special needs (sportsmen), people interested in a healthy lifestyle and people with special nutrition. These bars, as the Czech producer puts it, are not a treat.

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