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QUALITY EVALUATION OF POTATO AND VEGETABLE CRISPS IN LATVIAN MARKET

Ilze Kalnina, **Evita Straumite**, **Zanda Kruma**, **Martins Sabovics**, **Tatjana Kince**
Latvia University of Agriculture
kalnina_ilze@yahoo.com

Abstract
Salty snacks are popular appetizers consumed between meals and are one of favourite components of menu at different social gatherings and private celebrations. Consumers base their choice of snacks not only on flavour and smell of product, but also on different kinds of parameters like colour, texture and nutritional value as well as other information labelled on packaging. Typically salty snacks are associated with potato (*Solanum tuberosum*) crisps, but in present paper there were viewed also vegetable crisps and snacks. The aim of this research was to evaluate nutritional value and physical quality of potato and vegetable crisps and wholegrain snacks in Latvian market. From January to March 2017, 22 potato and vegetable crisps and wholegrain snack samples from Latvian market were analysed. For all samples, information on the labels was analysed as well as salt content, thickness, crispness and colour using standard methods. For 31.8% of the investigated samples, presented information on label and determined salt content do not differ significantly ($p > 0.05$). That means that 68.2% of the analysed potato, vegetable crisps and snacks on the packaging labels have represented incorrect salt content. Positive moderate correlation ($r = 0.489$) between potato and vegetable crisps thickness and crispness was found out. Raw materials and ingredients of samples directly impact colour values. If a sample contains beetroot, the colour results would indicate dark red. All potato crisps colour values point out light yellow colour.
Key words: potato and vegetable crisps, salt content, quality.

Introduction

Potato (*Solanum tuberosum*) crisps are well known as salty snacks, which make an essential part of the snack market not only in Latvian market, but also in many other countries. Potato crisps are thin slices of potato, which have been deep fried or baked. They can be used like snack, side dish or appetizer (Salvador *et al*., 2009). Lately vegetable crisps and other similar snacks like wholegrain, crisp spelt (*Triticum spelta*), corn (*Zea mays*) and potato based snacks have become very popular and have grown into significant competitors. The most important quality indicators for crisps are flavour, smell, colour and also texture or crispness. Colour is seriously assessed by consumers and can be one of their main reasons for selecting or rejecting crisps (Mendoza, Dejmek, & Aguilera, 2007). Colour of crisps is impacted by several causes – potato and vegetable type, natural defect in raw products (black spots), frying process, used oil, seasonings. Amount of absorbed oil also in post-frying process can turn colour of crisps darker and even leave oily spots on their surfaces (Mendoza, Dejmek, & Aguilera, 2007). Therefore, overall assessment of crisp colour includes colour itself, quantity, shape, allocation and intertwining of the small details distributed on crisps (Romani *et al*., 2009).

Crispness and crunchiness are terms frequently used to characterize texture of crisps. These crunchy and crispy attributes are important factors on which consumers set up their evaluation of crisps (Salvador *et al*., 2009). Crispness is not only relevant for crisps but it also makes essential impact on total consumer's appreciation level for every kind of food products. The contribution of texture of product has been studied for more than 50 years and main conclusions are that crispness is a complex group of attributes resulting from both multiple sensations and multiple physical indicators, uniting molecular, structural and production processes, and also storage conditions (Roudaut *et al*., 2002). Texture of crisps is also affected by type of oil used for frying and frying temperature (Kita, Lisińska, & Gołubowska, 2007). Efforts have been made to measure crispness of product and there are developed several techniques, one of the most popular is a puncture test using a cylindrical probe, where fracture force suggests level of crispness (Pedreschi, Segnini, & Dejmek, 2004), studies show that there is strong correlation between magnitude of force drop and the level of crispness (Vincent, 1998), force and hardness measure the power for breaking, the power and these mechanical tests can be used to rate and compare crispness of product (Rojo & Vincent, 2009), but for confirmation of this correlation, it is suggested taking into account also acoustic measurements, sounds transmitted when crisp breaks (Taniwaki & Kohyama, 2012).

Salt content and reduction of salt consumption is popular discussion object for scientific community and overall society because raised salt (sodium chloride) intake can lead to different health problems and diseases. It is proven that even small reduction of salt in dietary, would grant considerable health improvement (Bibbins-Domingo *et al*., 2010). That is why, based on recent studies, the WHO strongly recommends decrease of sodium dietary intake to less than 2 grams per day (less than 5 grams of salt per day) for adults (WHO, 2012). It is possible to reduce amount of sodium in processed foods by applying different strategies, and in result there are not any losses of salty taste (Mueller, Koehler, & Scherf, 2016). So it is important to remind the public that salt reduction is advisable and necessary for both consumers and manufacturers. A great way to keep track of product's quality indicators is nutrition information on food labels. Although nutrition information is useful, studies show that understanding this it is one thing, but using it to make healthier choices is completely other (Grunert, Wills, & Fernández-Celemín, 2010).

The aim of this research was to evaluate nutritional value and physical quality of potato and vegetable crisps and wholegrain snacks in Latvian market.

Materials and Methods

Samples

In the research from January till March 2017 different potato and vegetable crisps and wholegrain snacks available in Latvian market were analysed. The abbreviations of analysed potato crisps (16 samples), vegetable crisps (2 samples) and snacks (4 samples) shown in Table 1 will be used in the further text. In Table 1, there is also shown information from crisp labels per 100 g – salt, fat, saturated fat content and energy value. All samples were in original packaging and kept at room temperature (21 °C), and each selection of samples for testing was in similar size. Crisps were evaluated immediately after opening the packaging.

Determination of salt content

The salt content of crisps samples was determined using Vardavas *et al*. modified Mohr method (1981) (Vardavas *et al*., 2007). Fine ground sample (2.000 ± 0.010 g) was dissolved in 100 mL of distilled water. One millilitre of 5% K_2CrO_4 solution was added and titration performed with 0.1*M* $AgNO_3$ solution to the first appearance of an orange colour. Calculation of salt

Table 1

The abbreviation and nutrition information of samples used in the research

Sample	Brand	Nutritional information, g 100 g^{-1}			Energy value, 100 g^{-1}
		Salt	Fat	Saturated fat	kJ
Potato crisps					
KC_1	The Original Taffel Snacks	1.0	32.0	3.3	2254.0
KC_2	Lorenz Snack-World	2.0	32.0	2.5	2189.0
KC_3	Adazu Istie Cipsi	1.4	25.0	1.8	1944.0
KC_4	Lay's	2.0	30.0	10.0	2139.0
KC_5	Adazu Istie Cipsi	1.6	32.0	14.0	2222.0
KC_6	Estrella	1.8	33.0	15.0	2203.0
KC_7	Rimi	1.5	36.0	16.0	2255.0
KC_8	Rimi	1.2	32.0	15.0	2245.0
KC_9	Pringles	1.4	33.0	3.4	2161.0
KC_10	Estrella	1.9	33.0	15.0	2194.0
KC_12	Trafo Bio-Organic Snacks	2.0	37.0	3.5	2247.0
KC_13	Lisa's Kartoffel-Chips	1.2	28.7	3.4	2116.0
KC_14	Biona Organic	1.2	37.0	3.5	2247.0
KC_17	Lisa's Kartoffel-Chips	2.0	26.9	3.4	2062.0
KC_18	Lisa's Kartoffel-Chips	1.7	25.8	3.4	2067.0
KC_19	Long Chips	1.5	29.3	3.2	2246.0
Vegetable crisps					
DC_15	De Rit Organics	1.6	30.0	2.6	2074.0
DC_16	De Rit Organics	1.9	36.2	2.9	1954.0
Wholegrain, crisp spelt snack					
U_11	Adazu Istie Cipsi	2.2	21.0	1.0	2074.0
U_20	Adazu Istie Cipsi	3.0	21.0	1.0	2085.0
U_21	Rosen Garten	3.0	12.8	8.5	1726.0
U_22	Rosen Garten	5.0	15.8	10.3	1690.0

content of crisps was 1 mL 0.1*M* $AgNO_3$ = 0.005844 g NaCl (Vardavas *et al*., 2007). In the article, the mean values from six measurements of each sample are given.

Determination of sample crispness

Texture analyser TA.HD plus (Stable Micro Systems, UK) was used for determination of sample crispness. For measuring a spherical probe was used; for even contact with probe samples were placed on the HDP/CFS (Crisp facture support). The test settings were: test speed – 1 mm s^{-1}, trigger force – 0.049 N and distance – 3 mm. Each kind of crisps was measured fifteen times to determine crispness. In the article, the mean values of peak force (N) from all measurements of each sample are given.

Determination of thickness

Thickness of crisps samples was measured using an electronic digital outside micrometer (Conrad Electronic, Germany), range – 0–25.000 ± 0.001 mm. Ten crisps of each sample at two random locations on the surface were measured. In the article, the mean values from all measurements of each sample are given.

Determination of colour

Objective crisps sample colour (CIE L*a* b*) measurement was carried out using a Tristimulus Colorimeter (ColorTec Associates, Inc., USA). Crisps sample colour was measured for 10 crisps at three random locations on the surface of each sample. Colour values were recorded as L *– lightness, a* – redness or greenness, and b* – represents blueness or yellowness values (Liu *et al*., 2016). In the article, the mean values from all measurements of each sample are given.

Statistical analysis

All obtained results were processed by statistical methods – mean and standard deviations, Pearson correlations coefficient, hierarchical clusters. For interpretation of results, it was assumed that p = 0.05 with credibility of 95% (significance was defined at $p < 0.05$).

Results and Discussion

Crisps are the most popular products obtained from potatoes, but they are with high salt (2.0 – 5.0 g 100 g^{-1}) and fat content (30.0 – 40.0 g 100 g^{-1}). In Figure 1, summarised data (salt and fat content and energy value) from packaging labels about commercial potato and vegetable crisps and wholegrain snacks from Latvia market are presented.

Dendrogram (Figure 1) shows that samples can be divided into three clusters based on the information (salt and fat content and energy value) on their labels: the first cluster includes

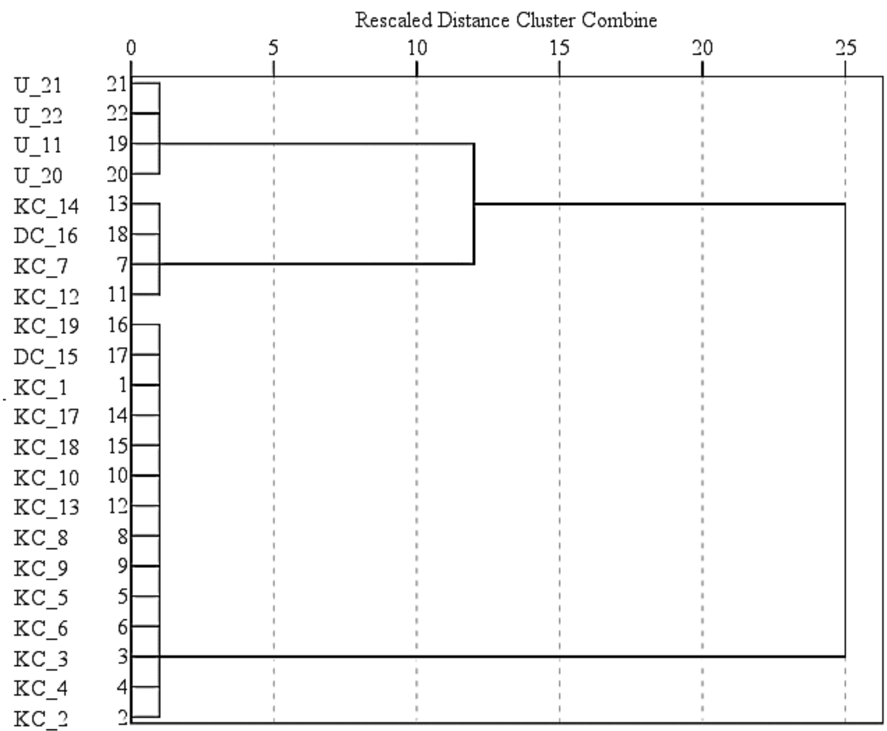

Figure 1. Division of analysed samples in clusters, based on their labels – salt, fat content and energy value. KC – potato crisps, DC – vegetable crisps, U – wholegrain, crisp spelt snacks.

Table 2

Determined and labelled salt content, g 100 g^{-1}

Sample	Salt content, g 100 g^{-1}		Difference, %	Sample	Salt content, g 100 g^{-1}		Difference, %
	determined	labelled			determined	labelled	
KC_1	1.178 ± 0.008	1.000	17.80	KC_13	1.469 ± 0.064	1.200	22.42
KC_2	2.709 ± 0.049	2.000	35.45	KC_14	1.203 ± 0.041	1.200	0.25
KC_3	1.400 ± 0.117	1.400	0.00	KC_17	2.209 ± 0.140	2.000	10.45
KC_4	2.124 ± 0.051	2.000	6.20	KC_18	1.152 ± 0.128	1.700	-32.24
KC_5	1.549 ± 0.153	1.600	-3.19	KC_19	1.951 ± 0.079	1.500	30.07
KC_6	1.927 ± 0.045	1.800	7.06	DC_15	1.514 ± 0.081	1.590	-4.78
KC_7	1.446 ± 0.186	1.500	-3.60	DC_16	1.720 ± 0.090	1.900	-9.47
KC_8	1.303 ± 0.058	1.200	8.58	U_11	2.144 ± 0.035	2.200	-2.55
KC_9	1.187 ± 0.059	1.400	-15.21	U_20	3.820 ± 0.216	3.000	27.33
KC_10	2.107 ± 0.047	1.900	10.89	U_21	1.343 ± 0.221	3.000	-55.23
KC_12	0.722 ± 0.158	2.000	-63.90	U_22	5.289 ± 0.062	5.000	5.78

KC – potato crisps, DC – vegetable crisps, U – wholegrain, crisp spelt snacks

14 samples, second cluster – 4 samples, third cluster – 4 samples.

In the first cluster, there are samples with moderate fat content (25.0 – 33.0 g 100 g^{-1}), avarage salt content (1.5 – 2.0 g 100 g^{-1}) and average energy value (2022 – 2252 kJ 100 g^{-1}), second cluster includes samples with high fat content (36.0 – 37.0 g 100 g^{-1}), but salt content (1.2 – 2.0 g 100 g^{-1}) and energy value (1964 – 2260 kJ 100 g^{-1}) are similar to the first cluster. In the third cluster, there are combined samples with low fat content (12.8 – 21.0 g 100 g^{-1}), higher salt content (2.2 – 5.0 g 100 g^{-1}) and lower energy value (1680 – 2031 kJ 100 g^{-1}). The first cluster contains both potato and vegetable crisps, just as the second cluster. Snack samples group does not really fit with crisps samples, and all four samples make the third cluster. As products from the third cluster show good results in low fat content and energy value, manufacturers should focus on salt content reduction in order to produce better and healthier product. Regarding potato and vegetable crisps, producers should pay attention to reducing fat content as first two clusters show higher values of fat and energy.

For more than million years our ancestors, like other mammals, ate food that contained less than 0.25 g of salt per day and, when there were discovered salt preservation properties, intake of salt considerably increased, and then again after invention and development of refrigerators and similar devices, salt intake started decreasing until recent decades (He & MacGregor, 2009). A significant rise of highly salted food consumption like processed food, snacks, soft drinks etc., has led to an increase of salt intake (He & MacGregor, 2009). In this research, the salt content of potato and vegetable crisps and wholegrain snacks was determined, and results were compared with information on the packaging label about salt content (Table 2). Analysing information on the potato and vegetable crisps labels, it was observed that salt content was from 1.0 g 100 g^{-1} (sample KC_1) to 5.0 g 100 g^{-1} (sample U_22), where 81.8% of samples contained salt between 1.0 g and 2 g 100 g^{-1}. However, determined salt content was from 0.722 ± 0.158 g 100 g^{-1} (samples KC_12) to 5.289 ± 0.062 g 100 g^{-1} for sample U_22 (Table 2).

A significant error limit of 5% considered that statistically is displayed as the first significant, thus it can be concluded that 31.8% of the investigated samples presented on label and determined salt content does not differ significantly ($p > 0.05$). That means that 68.2% of the analysed potato and vegetable crisps on the packaging labels have represented incorrect salt content. For 22.7% of all analysed samples salt content was determined lower than indicated on packaging, the highest negative differences between measured and labelled salt content were for samples KC_12 (-63.9%), where determined salt content was 0.722 ± 0.158 g 100 g^{-1} but labeled – 2.0 g 100 g^{-1}, U_21 (-55.2%) and DC_15 (-32.3%). However, the significant positive differences were for samples KC_2 (35.4%), where determined salt content was 2.709 ± 0.049 g 100 g^{-1} but labelled – 2.0 g 100 g^{-1}, DC_16 (30.1%) and U_20 (27.3%). Results show that the highest salt content is for snacks' samples group (from 2.2g to 5g 100 g^{-1}).

Nutrition information on food labels should promote consumer comprehension about food quality and it should encourage people make healthier choices, reduce salt intake, help identify and seek solutions to obesity problems (Cheftel, 2005). If a

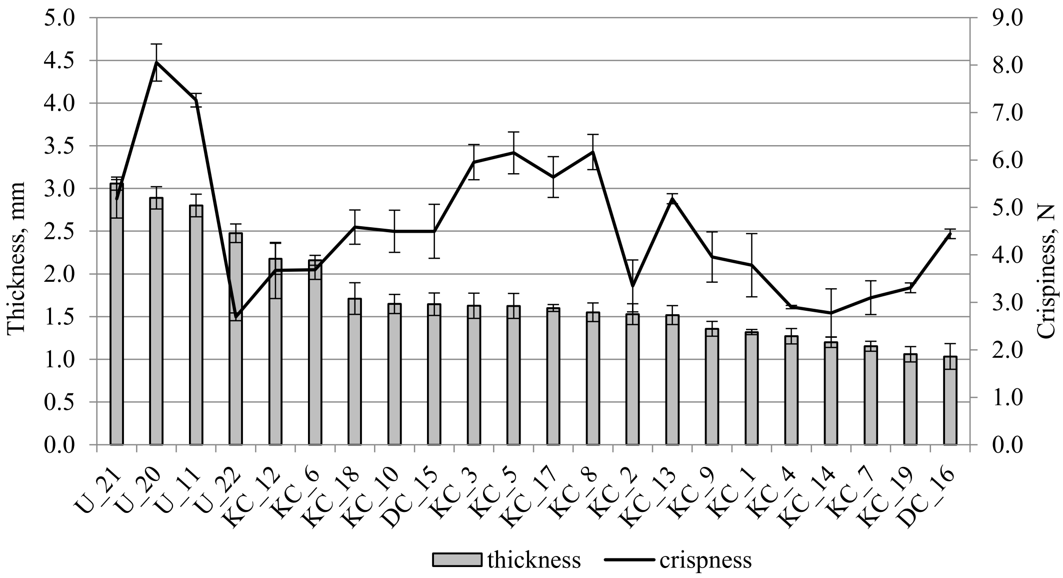

Figure 2. Thickness and crispness of analysed crisps samples.
KC – potato crisps, DC – vegetable crisps, U – wholegrain, crisp spelt snacks.

person consumes 100 g of salty snacks a day, then salt intake is already more than 7 times higher than evolutionary intake of WHO suggested salt intake amount (less than 5 g). If a person eats 100 g of KC_1 sample crisps, salt intake by crisps would make 20% of total daily intake of salt, whereas if a person eats 100 g of U_22 samples, then salt intake would make 100% of suggested daily intake only by snack consumption. Salty snacks typically contain a lot of salt and, it is essentially important to find ways to decrease amount of it. Even if there are consumed crisps with low salt content, it still makes a large part of recommended daily amount of salt.

Crisps are a very good example of consumer acceptance reasons, as in this case consumer relies more on texture than flavour (Rojo & Vincent, 2009). That is why there have been different researches with the aim to determine crispness, factors, which impact it, and measurement possibilities. As crispness is one of key causes that defines consumer's choice, food producers need to develop their recipes and technologies in order to deliver product that meets consumer expectations. The most important for the producer is to choose appropriate variety of raw product (potato, vegetable variety). Regarding potato crisps, it is confirmed that texture mainly depends on starch contents of potato tubers and after that on the sum of nitrogen substances and non-starch polysaccharides (Kita, 2002).

There was measured thickness and crispness (hardness) of all samples (Figure 2). Results show that the thickest samples were revealed in the snack group (U_21, U_20, U_11 and U_22), from 2.48 to 3.06 mm, the crisps were thinner than snacks – from 1.03 to 2.18 mm, and the thickest were samples KC_12 (2.18 mm) and KC_6 (2.16 mm), while the thinnest samples were DC_16 (1.03 mm) and KC_19 (1.06 mm). Although vegetable crisps sample was the thinnest, fat content for this exact sample is second highest. For better combination of product quality indicators, manufacturers should reassess their technological process in order to improve finished product. The hardest samples also mainly were from the snack group – U_20 (8.1 N), U_11 (7.3 N) and then KC_8 (6.2 N), but the most fragile samples were U_22 (2.7 N), KC_14 (2.8 N) and KC_4 (2.9 N). It can be explained by the number of different producers (together 13 brands for 22 samples), where every manufacturer has their own recipe, ingredient's proportion, selected oil, varieties of raw materials and production process special nuances and parameters.

Average crispness for potato crisps was 4.3 N, for vegetable crisps – 4.5 N and for snacks – 5.8 N. If mean values are compared by product groups, then the hardest are snacks, while potato and vegetable crisps have more similar results.

Positive moderate correlation between thickness and crispness, $r = 0.489$ ($p < 0.05$), which means positive moderate correlation was found out. This result confirms that these indicators are connected, but this connection does not have high correlation level.

The first thing consumers evaluate when choosing a food product is its colour, one of the most important characteristics, which is often also connected with the notion of quality. Table 3 represents colour values of the potato and vegetable crisps samples.

Value L* of the potato crisps colour component, characterising the light and dark colour nuances of the

Table 3

Characterization of potato and vegetable crisps colour

Samples	Colour value		
	L*	a*	b*
KC_1	71.34 ± 1.34	-5.80 ± 1.29	24.35 ± 1.15
KC_2	60.39 ± 4.97	-2.87 ± 1.19	18.48 ± 2.90
KC_3	62.18 ± 5.99	-4.81 ± 1.59	28.44 ± 3.14
KC_4	60.61 ± 5.66	-6.40 ± 4.14	26.21 ± 1.53
KC_5	63.82 ± 3.68	-5.2 0± 1.06	23.11 ± 2.36
KC_6	70.02 ± 2.13	-6.51 ± 1.02	28.40 ± 1.89
KC_7	71.20 ± 2.16	-7.76 ± 1.63	26.27 ± 3.91
KC_8	67.24 ± 1.26	-5.04 ± 1.61	24.60 ± 1.35
KC_9	68.75 ± 1.50	-6.54 ± 1.84	17.22 ± 3.61
KC_10	63.56 ± 4.33	-6.56 ± 1.92	28.13 ± 3.03
KC_12	60.25 ± 5.90	-5.40 ± 1.40	29.55 ± 5.99
KC_13	61.24 ± 4.61	-4.54 ± 1.94	22.94 ± 4.24
KC_14	67.69 ± 5.84	-5.08 ± 1.12	27.38 ± 4.51
KC_17	60.34 ± 5.25	-6.50 ± 1.80	24.55 ± 3.11
KC_18	55.84 ± 4.71	-1.62 ± 0.27	24.12 ± 6.64
KC_19	79.42 ± 1.38	-4.68 ± 0.40	23.22 ± 1.75
DC_15	20.60 ± 3.99	5.56 ± 1.61	-1.16 ± 0.77
DC_16	39.40± 5.43	5.10 ± 1.48	22.40 ± 6.94
U_11	50.24 ± 5.24	0.43 ± 0.11	22.50 ± 5.97
U_20	52.25 ± 5.14	1.12 ± 1.01	17.67 ± 5.41
U_21	40.32 ± 0.59	16.49 ± 0.85	9.85 ± 1.38
U_22	56.83 ± 1.35	-0.51 ± 0.76	20.37 ± 1.03

samples, varies from 55.84 ± 4.71 (sample KC_18) to 79.42 ± 1.38 (sample KC_19). KC_18 samples have darker results in terms of colour, as these were crisps with tomato flavour, thus the colour L* and a* values stand out. For potato crisps b* values are between 17.22 ± 3.61 (sample KC_9) and 29.55 ± 5.99 (sample KC_12), which means that the colour of the samples is light yellow. Both vegetable crisps samples are different from each other regarding b* and L* colour values, but have similar values for a* colour value. DC_15 vegetable crisps were from beetroot, which explains low L* value (20.60 ± 3.99) and also other two colour indicators, which points out dark red colour, while DC_16 contained vegetables like carrots, potatoes and beetroots and that accords to results that these samples are between yellow and red. Snack samples do not have significant differences ($p > 0.05$) in the colour values; the results are similar, except the sample U_21, which has different values for all three colour indicators, and it has a solid explanation, as the sample's U_21 one of ingredients is beetroot concentrate (13%).

Conclusions

All analysed samples can be divided into three clusters, based on the information (salt and fat content and energy value) on their labels: the first cluster includes samples with moderate fat content, average salt content and average energy value, second cluster – samples with high fat content, average salt content and energy value similar to first cluster, third cluster – samples with low fat content, higher salt content and lower energy value. The first cluster contains both potato and vegetable crisps, just as the second cluster, while the third cluster includes snack samples. For 31.8% of the investigated samples, information presented on label and determined salt content does not differ significantly ($p > 0.05$). That means that 68.2% of the analysed potato and vegetable crisps and wholegrain snacks on the packaging labels have represented incorrect salt content.

Positive moderate correlation ($r = 0.489$) between potato and vegetable crisps thickness and crispness was found out.

Potato crisps, vegetable crisps and snacks colour affects the used raw materials – carrots, potatoes and beetroots or other.

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