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Nutritional composition and energy value of different types of beer and cider

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Abstract

Consumers are increasingly interested in the nutritional composition of food and beverages, including beer. Therefore, nutritional values of beer became an integral part of the beer label information. It specifies, in particular, the energy value stipulated by law for beer with alcohol content lower than 1.2% vol.; in some cases also the concentration of carbohydrates, particularly sugars, proteins and salt. This work is a brief practical review of nutritional composition and energy value of different beer types and discusses the contribution of individual nutrients and alcohol to the total energy value. These values were measured in 172 samples of beer (24 pale lagers with the original gravity (OG) ranging from 9.00–10.99%, 45 pale lagers with the OG ranging from 11.00–12.99%, 18 dark lagers with the OG ranging from 11.00–12.99%, 9 special beers with the OG higher than 13%, 31 non-alcoholic beers, 19 beer-mixes, and 26 ciders). The highest average energy value was measured with pale special beer (215 kJ/100 mL), cider (208 kJ/100 mL), and dark lager (181 kJ/100 mL). The average value of a standard Pils lager is 144 kJ/100 mL and 175 J/100 mL for beers with OG 9.00–10.99% and 11.00–12.99%, respectively. The lowest energy value is measured in non-alcoholic beer (75 kJ/100 mL). In common lagers, alcohol mostly contributes up to 60% to the total energy value, while the energy value of non-alcoholic beer is formed especially by carbohydrates (about 90%). The concentration of salt (sodium) is very low in beer (about 4 mg/100 mL) in comparison with the other food in general.

Key words: alcohol, beer, cider, sugars, saccharides, proteins, energy value, nutrition value, food labelling

1 Introduction

Nutrition labelling is a topic which attracts attention of both researchers and general public (Hieke et al., 2012). Such a great interest arises primarily from the recently increasing rates of obesity and obesity-related diseases (Wansink et al., 2006). The interest of consumers in the nutritional value of what they eat is currently increasingly frequent and has led to new regulations. The Global Status Report on non-communicable diseases of the World Health Organization (2014) states that 'Nutrition labelling can be useful in orienting consumers to products that contribute to a healthier diet. (Cavaliere et al., 2018). This statement is supported by studies showing benefits of using nutritional information on labels because it may impact positively on consumer food choices. Subsequently, in a longer period it contributes to improvements in overall diet quality of consumers (Banterle et al., 2014; Cannoosamy et al.,2014; Cavaliere et al., 2017; Cecchini et al., 2016; Grunert et al., 2010; Loureiro et al., 2006; Mhurchu et al., 2018; Post et al., 2010; Variyam, 2008).

With the relatively recently introduced Regulation (EU) 1169/2011 (2011) on the provision of food information to consumers (FIR), any previous supra-national European legislation on food and nutrition labelling has been revised and amended. This regulation was published in the Official Journal of the European Union on 22 November 2011; the regulation coming into effect on 31 December 2011. The new rules are intended to consolidate and update Food Labelling Directive 2000/13/EC and Directive 90/495/EEC on nutrition labelling. In

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Table 1 *Table of nutrition values*

Table of nutrition values	number of samples	salt (sodium chloride)	total saccharides	mono- and disaccharides	energetic value	proteins	alcohol w/w
		mg/100 mL	g/100 mL	g/100 mL	kJ/100 mL	g/100 mL	g/100 g
Pale lager (OG 9.00–10.99%)	24						
average		3.5	2.92	0.27	144	0.38	3.19
median		3.3	3.01	0.23	146	0.39	3.19
confidence interval		2.2	1.24	0.29	28	0.11	0.36
minimal value		1.7	1.23	0.13	113	0.22	2.87
maximal value		6.6	3.86	0.59	159	0.45	3.50
Pale lager (OG 11.00–12.99%)	45						
average		4.0	3.52	0.32	175	0.48	3.84
median		4.1	3.52	0.26	175	0.48	3.85
confidence interval		2.6	0.75	0.29	16	0.13	0.46
minimal value		2.0	2.56	0.16	158	0.33	3.26
maximal value		8.2	4.52	0.78	193	0.61	4.32
Dark lager (OG 11.00–12.99%)	18						
average		4.8	4.01	0.38	181	0.52	3.67
median		5.4	3.99	0.26	184	0.51	3.67
confidence interval		2.7	1.01	0.73	18	0.20	0.49
minimal value		2.5	3.35	0.17	162	0.38	3.18
maximal value		6.7	5.41	1.57	194	0.76	4.14
Pale special beer (OG 13.00–16.99%)	9						
average		4.0	4.33	0.76	215	0.48	4.86
median		3.4	4.26	0.64	210	0.47	4.73
confidence interval		4.4	1.07	0.89	43	0.06	1.44
minimal value		2.2	3.73	0.25	178	0.45	3.77
maximal value		9.6	5.47	1.61	248	0.53	5.98
Non-alcoholic beer	31						
average		5.7	4.13	2.09	75	0.20	0.26
median		5.2	4.20	1.91	76	0.20	0.28
confidence interval		6.8	2.15	1.91	32	0.11	0.14
minimal value		1.4	2.51	0.79	51	0.09	0.08
maximal value		16.2	7.16	5.58	123	0.31	0.36
Beer-mix	19						
average		4.5	5.85	4.79	140	0.18	1.32
median		3.1	5.60	4.73	139	0.17	1.37
confidence interval		6.3	2.37	2.29	30	0.08	0.82
minimal value		2.4	4.25	3.12	118	0.12	0.24
maximal value		15.0	8.45	8.12	169	0.25	1.99
Cider	26						
average		17.2	6.55	5.83	208	0.04	3.67
median		17.5	6.68	6.16	213	0.02	3.67
confidence interval		26.2	3	2	41	0	1
minimal value		2.4	3.47	2.81	161	0.01	3.37
maximal value		41.2	8.22	7.42	254	0.24	0.36

the U.S., the rules of food labelling are determined in the Code of Federal Regulations, Part 101 Food Labelling, Section 101.9 Nutrition Labelling of Food from April 1, 2012.

The issue of nutrition labelling relates of course not only to food but also to beverage commodities including beer and beverages based on beer (for example beer mixes, etc.). Due to its long-lasting worldwide tradition and the fact that beer is an important source of main nutritional compounds such as carbohydrates and proteins, beer has become a basic part of diet in many cultures (Bamforth, 2004). Beer is often a great source of energy and contributes significantly to daily energy intake. According to beer composition, only the macronutrients such as saccharides including polyols, sugars, proteins, and sodium are recommended (beer with alcohol content higher than 1.2% vol.) and/or regulated (beer with alcohol content lower than 1.2% vol.) to be labelled. Simultaneously, the alcohol content, which contributes together with these macronutrients to the total energy value, is determined (EU 1169/2011, 2011). The concentration of proteins (or total nitrogen) is commonly determined according to Kjeldahl, for beer modified according to EBC 9.9.1. Nitrogenous compounds in beer are mineralized with hot sulphuric acid in the presence of catalyst to form ammonium sulphate. The resulting solution is alkalinized with sodium hydroxide solution and the released ammonia is distilled into an excess of boric acid solution. The ammonia is titrated with standard acid solution (EBC 9.9.1, 2012).

The saccharides following the meaning of Regulation (EU) 1169/2011 are all saccharides including polyols metabolized by a human. They could be determined by liquid chromatography (HPLC) with the Refractive Index (RI) detector according to the method of Jurková et al. 2014 (Jurková et al., 2018). Enzymatic cleavage of saccharides to glucose is performed and, subsequently, the glucose is determined by HPLC-RI on an ion exchange chromatographic column in the Ag^+ cycle. The same chromatographic method is used for the analysis of sugars defined by Regulation (EU) 1169/2011 as mono- and disaccharides excluding polyols. In this case, the sample of beer is only diluted prior to the analysis (Jurková et al., 2018). The last parameter used for beer labelling is salt; the term ‘salt’ has been used since 2011 instead of the corresponding term of the nutrient ‘sodium’. „Salt’ means the salt equivalent content calculated using the formula: salt (mg/L) = sodium (mg/L) × 2.5 (EU 1169, 2011). The content of fat in beer presented in the form of fatty acids is negligible and its contribution to the energy value is therefore minimal. Since it is regulated to label nutrition values of beer when the alcohol content is lower than 1.2%, it is necessary to mark the label with either 0 g/100 mL of fat or “it contains negligible amount of fat”. From this point of view, organic acids and fiber are unimportant as well. The Regulation (EU) 1169/2011 prescribes a standard method of Energy Value (i.e. Caloric Content). The total energy value of food/beverage is calculated as a sum of energy values of significant components determined by relevant methods. The concentration of individual nutrients is multiplied by conversion factors. The formula for beer can be expressed as:

$$EV\ (kJ/g) = c_{carbohydrate}*17 + c_{polyols}*10 + c_{proteins}*17 + c_{alcohol}*29$$

(Equation 1)

The energy value (EV) is expressed in kilocalories or kilojoules; 1 kcal = 4.1868 kJ. Brewing analysis conventions such as EBC (European Brewery Convention), MEBAK (Mitteleuropäische Brautechnische Analysenkommission), and ASBC (American Association of Brewing Chemists) use simplified methods for the EV determination (MEBAK, 2012; ASBC, 2009). The EBC 9.45, method which is designed for the energy value determination in beer (EBC 9.45, 2012), uses a simplified alternative, where an estimated energy value can be calculated from alcohol and the real beer extract. Mostly, beer analyzers are equipped with SW directly calculating EV the from real extract, alcohol, and density.

$$EV_{EBC}\ (kJ/100ml) = \rho*(E_r*15 + c_{alcohol}*29)$$

(Equation 2)

where ρ is density of beer (g/mL), E_r is real extract in % w/w, and 15 is an experimentally determined conversion factor considering both the major components of the extract, carbohydrates and proteins, and also glycerol, betaglucans, organic acids, amino acids, phenolic, sulphuric, heterocyclic and inorganic substances, etc. As has been published recently, this formula is not valid for all types of beer. If the ratio of saccharides and alcohol is more different from the ratio in common lager or ale, different formula (conversion factors for the real extract) or the original calculation method must be applied (Olšovská et al., 2015).

The aim of this study is a brief overview of beer nutrients values in different types of beer and cider. The contribution of the nutrients to the total energetic value is discussed. The data were obtained within a 3-year monitoring of various types of beer produced in Czech breweries.

2 Materials and methods

Beer samples were obtained directly from Czech producers, namely, 24 samples of pale lagers with the original gravity (OG) ranging from 9.00–10.99%, 45 samples of pale lagers with the OG ranging from 11.00–12.99%, 18 samples of dark lagers with the OG ranging from 11.00–12.99%, 9 samples of special beers with the OG higher than 13%, 31 samples of non-alcoholic beer, 19 amples of beer-mix, and 26 samples of cider.

The real extract measurement was performed on DMA 4500 densitometer (Anton Paar, Austria) according to the EBC 9.4 method (EBC 9.45, 2012). The alcohol content was measured on Alcolyzer (Anton Paar, Austria) according to the EBC 9.2.6 method (EBC 9.2.6, 2012) based on NIR (Near InfraRed) spectroscopy. The OG was automatically calculated from these values by embedded SW.

The carbohydrate concentration was determined by HPLC with a column thermostat (SISw, Czech Republic), an autosampler Midas (Spark, Holland) and a high-sensitivity RI detector Shodex RI 101 (Japan). The chromatographic data were collected and processed by the DataApex Clarity data system, version 3.0.5.505. The measurement procedure and its conditions are described by Jurková et al. (2014).

Proteins were determined as the total nitrogen content multiplied by a factor of 6.25. The nitrogen compounds were mineralized on a mineralization unit SK-06-RXT (MK Servis s.r.o., Czech Republic) and released ammonium was distilled on Büchi 323 (Büchi Labortechnik AG, Switzerland) according to EBC 9.9.1 (2012).

Sodium was analyzed using atomic absorption spectroscopy on Varian SpectrAA 240FS using the EBC 9.16 method (2012). The total energy value was determined using the calculation method (Equation 1, Olšovská et al., 2015).

3 Results and discussion

The values of the monitored nutrients, including alcohol of tested beers, are summarized in Table 1. The table gives the minimum and maximum values, the average, the confidence interval (calculated as 1.96 multiple of a standard deviation) and the mean value. Hence the resulting values do not have a normal (symmetric) distribution in all cases; the median was also calculated for better clarity. The average energy value of pale lager with the OG ranging from 11.00–12.99%, dark lager, pale lager with OG 9.00–10.99% and non-alcoholic beer is 175, 181, 144 and 75 kJ/100 mL, respectively. The energy value of special beers is higher than that of common lagers in relation to the higher OG, the energy value of beer-mixes depends on the individual composition and ranges from 120 to 170 kJ/100 mL. The highest energy value was found in ciders, on average 208 kJ/100 mL.

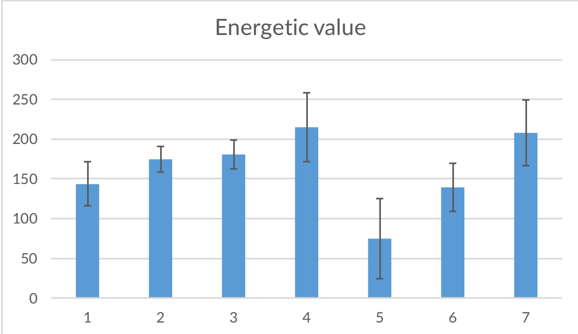
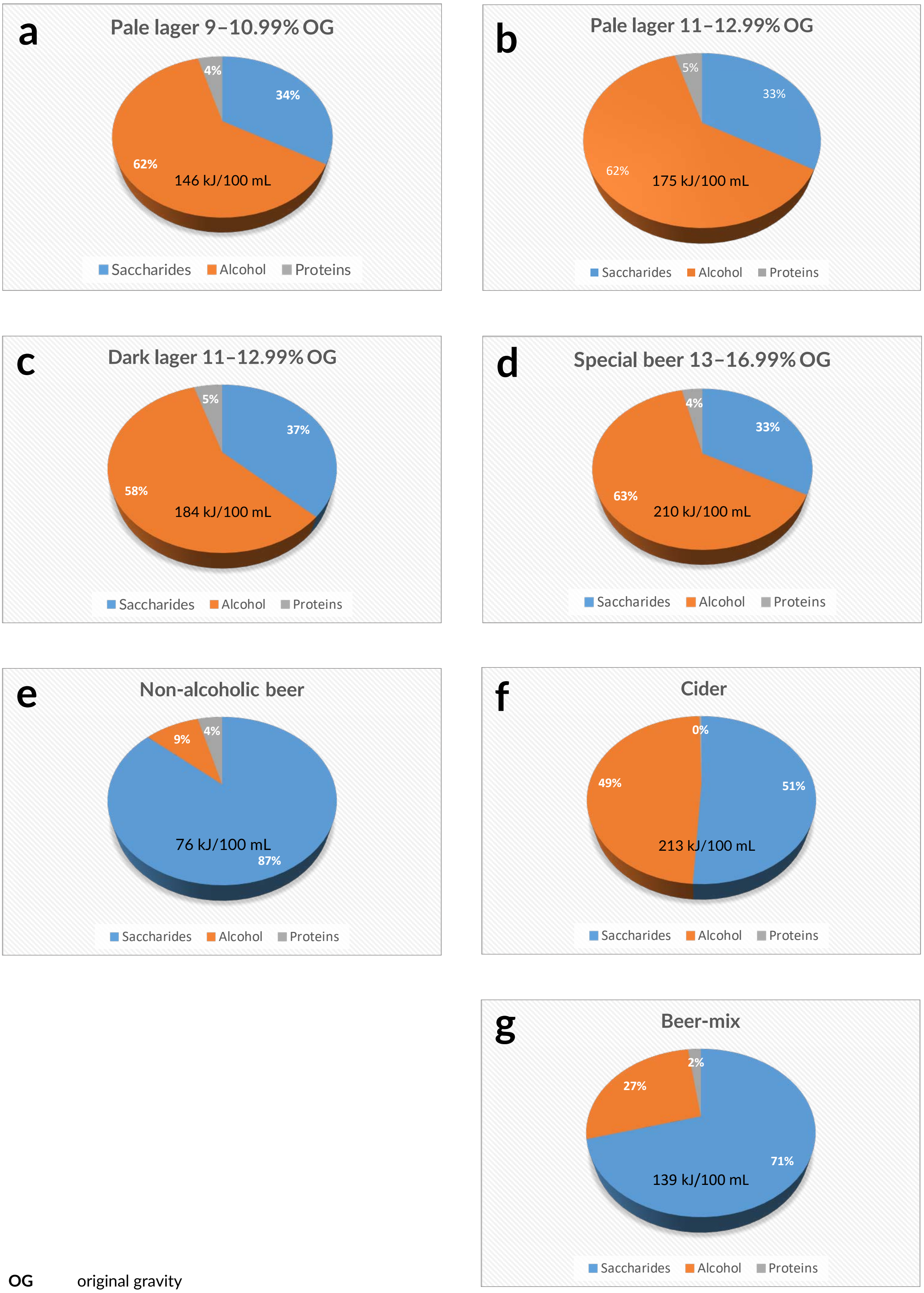


Figure 1 *The average values of energy value (kJ/100 ml) in tested beer types*

1-pale lagers 9.00–10.99%, 2-pale lagers 11.00–12.99%, 3-dark lagers 11.00-12.99%, 4-special beer 13.00–16.99%, 5-non-alcoholic beer, 6-beer-mix, 7-ciders

Further, from the Table 1 it is also evident that the obtained values of salt amount vary in a wide range; for example, the lowest salt value of 2.4 mg/100 mL and the highest one of 15.0 mg/100 mL were found in the group of beer mixes. Similarly, the concentrations of salt in the group of non-alcoholic beers range from 1.4 to 16.2 mg/100 mL, ciders even range from 2.4 to 41.2 g/100 mL. Due to the large diversity of the beer-mixes group, also a wide concentration range of carbohydrates (from 4.25 to 8.45 g/100 mL), sugars (from 3.12 to 8.12 g/100 mL) and energy values (from 118 to 169 kJ/100 mL) were obtained. The average value of sugars in lagers with OG (9.00–10.99% and 11.00–12.99%) is low, namely,0.23 and 0.32 g/100 mL, respectively, because they are well-fermented beers.

The average concentration of sugars in lagers with OG (9.00–10.99% and 11.00–12.99%) is 2.92 and 3.52 g/100 mL, respectively. The range of sugar concentrations in the group of non-alcoholic beer is wide (from 0.79 to 5.58 g/100 mL), the average concentration is 2.09 g/100 mL. These big differences among the samples are caused by the brewing technology. If beer is prepared by fermentation process with subsequent dealcoholization, then the concentration of sugars decreases and the resulting concentration is low. Non-alcoholic beer, which contains high concentration of sugars, was prepared by a special technology (the fermentation by a special strain of yeasts). It could be basically stated that the concentration of individual nutrients and alcohol is increased with the value of the original wort extract.



OG original gravity

Figure 2 a–g *Contribution of individual nutrients and alcohol to the total energy value of beer, expressed as median*

As shown in Fig. 1, similarly as in Table 1, non-alcoholic beer and beer-mixes have the lowest energy value in general. Ciders and special beers with the high alcohol content have the highest energy value. Figs 2a–2g shows the contribution of individual nutrients and alcohol to the total energy value of beer. In case of pale and dark lagers with OG 9.00–16.99%, the major contributor to the total energy value is alcohol (about 60%), followed by carbohydrates (about 35%). A completely opposite distribution was found in non-alcoholic beer, where the total energy is made almost exclusively by carbohydrates (about 90%). Alcohol contributes to the energy depending on its content (about 8%). In case of beer-mixes, carbohydrates are energetically dominant (about 70%) and the contribution of alcohol is also not negligible (about 30%). In the group of all these beers and beer-based beverages, proteins contribute to the total energy by about 5%. Proteins are

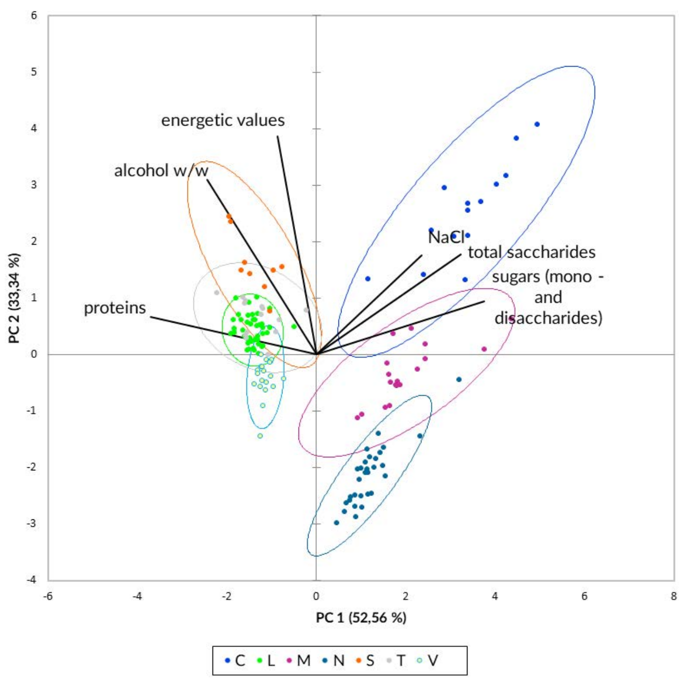


Figure 3 *Principal component analysis of obtained data*

1-pale lagers 9.00–10.99%, 2-pale lagers 11.00–12.99%, 3-special beer 13.00–16.99%, 4-non-alcoholic beer, 5-beer-mix, 6-ciders, 7-dark lagers 11.00–12.99%

missing mostly completely in ciders, alcohol and sugars contribute roughly evenly to the total energy value.

The obtained data were also processed by principal component analysis (PCA), the result of which is shown in Fig. 3, where clustering of different types of studied samples is evident based on their nutritional composition. A group of ciders was very well separated, based on sugars, carbohydrates and the salt content. Beer mixes and non-alcoholic beers are significantly separated from the other groups because of their very low alcohol concentration. Lagers (OG of 9.00–10.99%), pale and dark lagers (OG 11.00–12.99%), and special beers (OG higher than 13.00%) differ from the above-mentioned groups by the presence of proteins. PC2 (the second component) differentiates these samples according to the alcohol content and the energy value (the lowest value – lager beers with OG of 9.00–10.99%, the highest value – special beers).

4 Conclusion

The basic nutrients of beer are sugars, carbohydrates and proteins, which together with alcohol contribute to its total energy value. Another observed nutrient is sodium labelled as salt, which is calculated as 2.5-fold multiple of the sodium concentration. The average salt concentration of 4 mg/100 mL classifies beer into the category of food with minimal concentration of sodium. The average energy value of lager with OG ranging from 9.00–0.99% and OG ranging from 11.00–12.99% is 144 and 175 kJ/100 L, respectively. The lowest energy value is measured in non-alcoholic beer (75 kJ/100 mL). In general, concentration of individual nutrients and alcohol increase with higher OG, which is reflected in the energy value. The contribution of alcohol and carbohydrates to the energy value of beer is dominant, their share differing according to the type of beer. In other words, it reflects its composition. When lager is considered, the energy value is formed primarily by alcohol (about 60%), followed by carbohydrates (about 35%). The opposite ratios are valid for non-alcoholic beer. The energy value is formed almost exclusively by saccharides (90%). Finally, proteins contribute to the total energy by about 5% in beer with OG ranging from 9.00 to 13.00.

Cider is a beverage with a high energy value (208 kJ/100 mL) due to its composition. Both alcohol and saccharides contribute evenly to the energy value.

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