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Development of innovative energy drink based on cold brew-spruce sprout and its comparison to commercial energy drinks

K. Karklina[1,*], L. Ozola[1] and M.N.G. Ibrahim[2]

[1]Latvia University of Life Sciences and Technologies, Faculty of Agriculture and Food Technology, Food Institute, Lielā iela 2, LV-3001 Jelgava, Latvia
[2]Estonian University of Life Sciences, Institute of Veterinary Medicine and Animal Sciences, Chair of Food Science and Technology and ERA-Chair for Food (By-) Products Valorisation Technologies, Kreutzwaldi 56/5, EE51006 Tartu, Estonia
[*]Correspondance: klinta.RKL25@gmail.com

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Abstract. Commercial energy drinks have high content of caffeine and sugar that can lead to various health problems. Spruce sprouts could have beneficial effects on human health. This research aims to prepare alternative energy drinks with less caffeine and sugar that are based on spruce sprout, cold brew, and fruit juice. In the study, three commercial energy drinks were used - RedBull original (RBo), RedBull zero sugar (RBzs), and RedBull Tropical fruits (RBt) - and three spruce sprout - cold brew energy drinks were prepared. The spruce sprout - cold brew energy drinks were - cold brew coffee 96.8% with spruce sprout juice 3.2% (SCB), cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2% (SCBo), and cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2% (SCBaa). All energy drinks were evaluated for their Vitamin C content, titratable acidity, pH, soluble solids, colour evaluation, total phenolic content, and anti-radical activity by DPPH. The results showed that Vitamin C increased significantly ($p < 0.05$) by 30 times in the spruce sprout - cold brew energy drinks (104–244 mg 100 g^{-1}), compared to its content in commercial drinks (4.23–6.24 mg 100 g^{-1}). Comparing the total phenolic content in commercial energy drinks (6.67–10.69 mg GAE 100 g^{-1}), its content increased significantly ($p < 0.05$) by 20 times in the spruce sprout - cold brew energy drinks (128.46–253.93 mg GAE 100 g^{-1}). In conclusion, spruce sprout - cold brew energy drinks could be considered as an alternative to commercial energy drinks.

Key words: biochemical composition, caffeine, cold brew, energy drink, spruce sprout.

INTRODUCTION

The functional beverage sector is the largest and fastest-growing food, beverage, and food supplement sector. Functional beverages include nutrients and bioactive compounds characterised by various properties that improve the physical condition of the human body or reduce the risk of disease progression, such as reducing the risk of cancer, strengthening the immune system, improving physical condition, anti-stress, anti-ageing, and anti-inflammatory properties. Different types of functional beverages in the market include dairy alternatives, probiotic drinks, energy drinks, and sports drinks

(Tolun & Altintas, 2019). Functional beverages have an essential role in modern life. In the last decade, there have been efforts to develop functional beverages to promote healthy drinks for well-being (Yilmaz-Akyuz et al., 2019).

The consumption of energy drinks has been increasing in demand over the last two decades, especially among the youth and young adults, aged 18 to 35 (Alsunni, 2015). Energy drinks contain either caffeine or taurine; in some cases, both are added. In addition, they include added sugar of 15–69 g 100 g^{-1}, Vitamin B, colourings, flavourings, etc. (Nadeem et al., 2021). The amount of caffeine in commercial energy drinks can range from 50 to 505 mg per 250 mL can. However, a cup of cold brew coffee (200 mL) has a caffeine content of 265 to 295 mg (Costantino et al., 2023). Caffeine is good in small amounts, but higher concentrations of caffeine can cause nausea, irritability, heart rhythm problems, and sleep deprivation. And the high sugar content of energy drinks can lead to diabetes and obesity (Subaiea et al., 2019).

Conifers are a rich source of bioactive compounds. Spruce sprouts *Picea abies L. Karst* are rich in Vitamin C and other antioxidants (Mofikoya et al., 2022) and also a good source of minerals, carotenoids and chlorophylls (Sirgedaitė-Šėžienė et al., 2022). Traditionally, spruce sprouts are used as herbal tea in folk medicine. Spruce sprouts contain phenols, polyphenols, chlorophyll, and terpenoids (Rahul, 2019). Terpenoids such as α- and β-pinene have antioxidant and anti-inflammatory properties. It can also speed up the process of renewing weak mitochondrial cells (Salehi et al., 2019). Weak mitochondrial cells can affect many parts of the human body, such as the brain, heart, muscles, etc. (Chen et al., 2023). The chlorophyll in spruce sprouts has detoxing properties; it can help eliminate harmful substances, reducing the impact on brain health. Detoxing can prevent neurological diseases such as Parkinson's and Alzheimer's (Martins et al., 2023).

Coffee is the most popular and most consumed beverage in the world. Coffee consumption is growing by 4.1% every year. There is evidence that coffee consumption can have health benefits. The primary growth in coffee markets has been attributed to the development of innovative types of brewed coffee drinks (Samoggia & Riedel, 2019). The chemical composition of coffee depends on many factors - beans, post-harvest treatments, fermentation, and the extraction method and brewing method (Angeloni et al., 2019). The content of bioactive compounds in coffee types depends on the coffee roasting level and the place of origin. Coffee beans from Colombia and India have potentially higher antiradical activity DPPH compared to those from Peru and Rwanda. However, polyphenol concentration in coffee beans from Rwanda may be relatively high. Water temperature can also affect the content of bioactive compounds (Muzykiewicz-Szymańska et al., 2021).

Cold brewing is one way of making coffee. The coffee is brewed at room temperature at 20 ± 2 °C and then kept for 8 to 24 hours at refrigerator temperature at 3 ± 2 °C (Rao et al., 2020). Cold brew coffee taste is not so acidic and it preserves better bioactive compounds than French-pressed coffee (Karklina & Kampuse, 2021). Cold-brew coffee, like spruce sprouts, contains phenols that have many beneficial properties for human health, such as regulating metabolism and weight, which can help treat chronic diseases (Cory et al., 2018). A correlation between coffee consumption and lower mortality has been noticed (Zhang et al., 2021). The main bioactive compounds in coffee like caffeic acid, caffeine and diterpenes have anti-cancer properties (Buldak et al., 2018).

This study aims to prepare higher-value energy drinks using spruce sprout, cold brew coffee, and fruit/berry juice. Additionally, compare the bioactive compound content of the innovative energy drinks with commercially available energy drinks.

MATERIALS AND METHODS

The research was carried out in the laboratories of the Institute of Food at the Latvia University of Life Science and Technologies for the development and analysis of innovative energy drinks. Meanwhile, the analyses of commercial energy drinks were carried out in the Department of Food Science and Technology at the Estonian University of Life Science. For the research, three innovative energy drinks were prepared as follows: cold brew coffee 96.8% with spruce sprout juice 3.2% (SCB), cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2% (SCBo) and cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2% (SCBaa). The added amount of spruce sprouts and other ingredients were based on a previous study (Karklina & Kampuse, 2021; Karklina & Ozola, 2022a) and sensory evaluation test. For the sensory evaluation test, 6 spruce sprout-cold brew samples, varied depending on the added amount of spruce sprout juice, were presented. For further analyses, spruce sprout-cold brew energy drinks, which got the highest consumers' preferences from the sensory point of view (sensory evaluation results not shown here), were used. Three commercial energy drinks - RedBull original (RBo), RedBull zero sugar (RBzs), and RedBull Tropical fruits (RBt) were selected from the Baltic market for comparison as representatives of commercially available energy drinks. All energy drinks were subjected to the following analyses Vitamin C, mg 100 g^{-1}, titratable acidity mg 100 g^{-1}, pH, total soluble solids, Bx°, total phenol content and anti-radical activity DPPH.

Energy drink preparation

For the innovative energy drink preparation, spruce sprouts from Norway spruce (*Picea abies (L.) Karst*) were used. Spruce sprouts were harvested in a private forest area of Latvia in May of 2023. Lofberg's Medium Roast coffee with a rich bouquet of flavours characterised by elegant and delicate aroma and a pleasant, long aftertaste was incorporated in the recipe. The preceding product was graded as follows: roasting-2, body fullness-4, and acidity-2. It was produced from 100% Arabica beans from South and Central America and East Africa. Solevita 100% orange juice and homemade apple-aronia juice were used in the innovative energy drink processing.

Figure 1. Prepared energy drinks. On the left SCBo- cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2%, in the middle SCBaa - cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2% and on the right SCB - Cold brew coffee 96.8% with spruce sprout juice 3.2%.

Cold brew coffee was prepared by ground coffee Lofbergs coffee and was poured over cold water at 3 ± 2 °C and left in the fridge for 18 h at 3 ± 2 °C.

Coffee extracts were filtered after 18 h, mixed, and pasteurized at 80 °C for 5 minutes. Energy drinks were prepared in 250 mL PET bottles and stored at room temperature 20 ± 2 °C until further analysis. The prepared energy drinks were presented in Fig. 1

Determination of Vitamin C

Vitamin C was determined by the iodometric titration method (Segliņa, 2007; Feszterová et al., 2023b). For titration, an iodine solution was used until a faint blue colour change was observed, which lasted for 30 seconds. The titrated iodine solution was recorded and expressed as mg 100 g^{-1}. Three measurements of each sample were made.

Determination of titratable acidity

Titratable acidity was determined, according to Karklina & Ozola (2023) and Fidaleo & Ventriglia (2022). Three measurements from each sample were analysed, and the acidity content was expressed as citric acid mg 100 g^{-1}.

Determination of pH

pH was determined according to Buck et al. (2002) method. pH meter JENWAY 3510 (Jenway, UK) was used for innovative energy drinks, and a pH meter (Seven Compact, Mettler Toledo, Switzerland) was used for commercial energy drinks. Three measurements from each sample were analysed.

Determination of soluble solids

The soluble solids were determined according to the International Organization for Standardization (ISO) 2173:2003 (ISO 2173, 2003) using a Refracto 30 PX/GS digital refractometer (Mettler Toledo, Switzerland) for innovative energy drinks and a refractometer (digital abbe Refractometer DR-A1, Atago, Japan) for commercial energy drinks was used. Three measurements from each sample were examined, and the Bx° was recorded.

Determination of colour

Colour analysis was determined according to the International Organization for Standardization (ISO) 11664-4:2008 (ISO 11664-4, 2008) in the CIEL L* a* b* coordinate system. Calculations were carried out according to the method of Esatbeyoglu et al. (2023). Innovative energy drinks were measured using ColorTech *PCM*, and commercial energy drinks were measured using X-Rite 962/964 handheld spectrophotometer supported by illuminant head D65 (X-Rite, Inc., Michigan, USA). The colour saturation parameter chroma C*, the intensity of colour hue angle h* and the differences in the colour ΔE were calculated. Five measurements for each sample were measured.

Preparation of extracts

Extracts were prepared according to the Karklina & Kampuse (2021) method with minor modifications. For extract preparation, an ultrasonic bath ('WUC-D06H' witeg, Labortechnik GmbH, Germany) for innovative energy drinks and an ultrasonic bath (Elmasonic S30H, Elma Schmidbauer GmbH, Singen, Germany) for commercial energy drinks were used for 20 min at 60 °C. The samples were filtered with filter paper, collected in a 50 mL volumetric flask, and then added to the solvent to the extracts to extend their volume until the mark. The extracts were placed in a refrigerator at 3 ± 2 °C until further analysis. Two extracts from each sample were prepared.

Determination of total phenols

The total phenolic content for the extracts of energy drinks was determined by the Folin-Ciocalteu spectrophotometric method (Singleton et al., 1999). The absorbance reading was determined with the spectrophotometer Jenway 6300 (Barloworld, Scientific Ltd., UK) at 765 nm for innovative energy drinks and spectrophotometer (Specord 250 plus, Analytik Jena, Jena, Germany) for commercial energy drinks at 765 nm, three measurements from each sample was measured.

Determination of antiradical activity DPPH

The antioxidant radical content of DPPH was determined according to the method of Semeniuc et al. (2016). The spectrophotometer Jenway 6300 (Barloworld, Scientific Ltd., UK) was used to read the absorbance at 517 nm for innovative energy drinks and spectrophotometer (Specord 250 plus, Analytik Jena, Jena, Germany) for commercial energy drinks at 517 nm.

Statistical analysis

All the experiments were carried out in triplicate. The mean and the standard deviation (± SD) of all the results were calculated using the mathematical and statistical methods using WPS Office 2021. The ANOVA-one-way analysis was performed to the results mean using mathematical statistical methods using WPS Office 2021 to establish the significant difference at ($p \leq 0.05$). The mean of results and their SD were presented graphically and in tables using the same WPS office 2021 program.

RESULTS AND DISCUSSION

Biochemical compound and physical parameters have been tested for both spruce sprout - cold brew and commercial energy drinks. The used spruce sprout - cold brew energy drinks were - SCB - spruce sprout and cold brew coffee, SCBo - spruce sprout, orange juice and cold brew coffee, and SCBaa - spruce sprout, apple-aronia juice and cold brew coffee. For comparison with commercial energy drinks, RBo - RedBull original, RBzs - RedBull zero sugar and RBt - RedBull tropical fruits were used.

Vitamin C was calculated for all of the spruce sprout-cold brew energy drinks, and commercial energy drinks (Fig. 2). Spruce sprout-cold brew energy drinks had noticeably higher Vitamin C content compared to commercial energy drinks ($p < 0.05$). The highest Vitamin C content was detected in spruce sprout-cold brew energy drink SCBo drink (244.90 ± 0.00 mg 100 g^{-1}), followed by SCB drink (161.64 ± 0.00 mg 100 g^{-1}) and SCBaa drink (104.87 ± 0.00 mg 100 g^{-1}) which was by 30 times higher than in commercial ones.

The research of Nowak & Gośliński (2020) analysed Vitamin C content in different types of commercial energy drinks, with and without added fruit flavours. Vitamin C content in commercial energy drinks without added fruit flavour was between 0.075 and

0.15 mg 100 g^{-1}, but in commercial energy drinks with fruit flavour, Vitamin C content ranged between 0.15 and 0.52 mg 100 g^{-1}. In the preceding study, the Vitamin C results in both commercial energy drink types were lower than in the commercial ones of the this study, where their Vitamin C content was in the range of 4.23–6.34 mg 100 g^{-1}.

The present research work (Fig. 2) showed that the Vitamin C results of the spruce sprout-cold brew energy drinks were higher than the average Vitamin C content of the fruit juices. According to Feszterová et al. (2023a), the Vitamin C content in grapefruit juices ranges between 22.40 to 34.50 mg 100 g^{-1}, but in apple juice, Vitamin C content varies from 3.30 to 4.40 mg 100 g^{-1}. According to Jyske et al. (2020), Vitamin C content in spruce sprouts harvested in Finland in late June was 406 mg 100 g^{-1}. However, based on the findings of Karklina & Ozola (2022b), Vitamin C content in spruce sprouts harvested in Latvia at the beginning of May was 267.78 ± 10.23 mg 100 g^{-1} which is higher compared to this study, it can be explained by the applied heat treatment to ensure product safety. Vitamin C content depends on harvest season and place. The latter means that the high Vitamin C content in spruce sprot-cold brew energy drinks in this study is because of the added spruce sprouts.

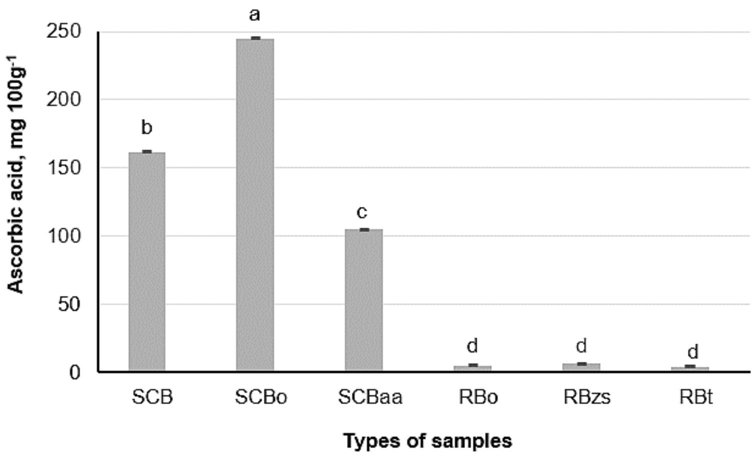

Figure 2. Variation of Vitamin C (ascorbic acid) content between the spruce sprout-cold brew energy drinks and the commercial ones. The spruce sprout-cold brew energy drinks were - SCB - Cold brew coffee 96.8% with spruce sprout juice 3.2%, SCBo - cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2%, SCBaa - cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2%, and the commercial energy drinks were - RBo - RedBull original, RBzs - RedBull zero sugar, RBt - RedBull Tropical fruits.The columns represent the means of Vitamin C content and its SD in each sample. The different small letters indicate significant differences ($p < 0.05$) between the Vitamin C content of the samples.

Total soluble solids content in beverages, including energy drinks represents the sweetness of the product. Most important it is for fruit juice because it also shows the maturity of fruits. The increase in the total solids of some energy drinks, especially most commercial ones, can result from adding syrups (Fei et al., 2015; Wenchuan et al., 2019; Wang et al., 2022). Compared to the results of all energy drinks' total soluble solids (Fig. 3), the commercial energy drinks RBo (11.5 ± 0.00 Bx°) and RBt (11.4 ± 0.00 Bx°) had significantly different ($p < 0.05$) the highest total soluble solids content. Although, the lowest total soluble solids content was detected in the commercial energy drink RBzs (1.3 ± 0.00 Bx°) and the spruce sprout-cold brew energy drink SCB (1.3 ± 0.06 Bx°) with a significant difference ($p < 0.05$) compared to all other drinks (Fig. 3).

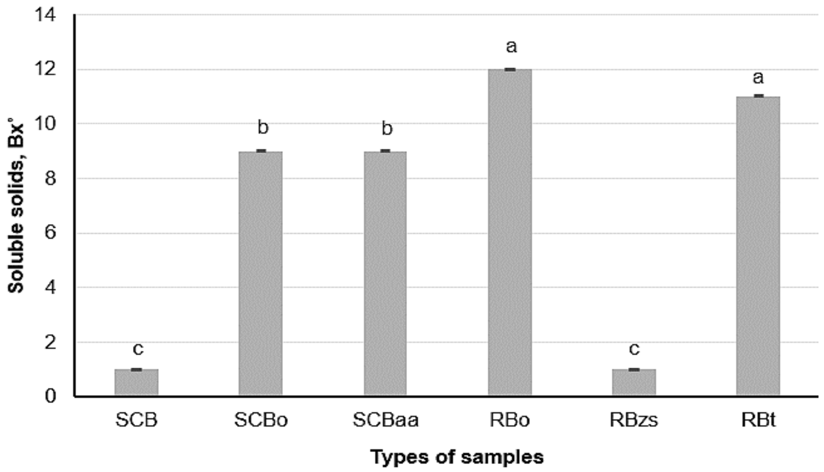

Figure 3. Variation of total soluble solids content between the spruce sprout-cold brew energy drinks and the commercial ones. The spruce sprout-cold brew energy drinks were - SCB - Cold brew coffee 96.8% with spruce sprout juice 3.2%, SCBo - cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2%, SCBaa - cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2%, and the commercial energy drinks were - RBo - RedBull original, RBzs - RedBull zero sugar, RBt - RedBull Tropical fruits. The columns represent the means of total soluble solids content and its SD in each sample. The different small letters indicate significant differences ($p < 0.05$) between the total soluble solids content of the samples.

According to Fikry et al. (2023), in energy drinks without ultrasonication treatment, the total soluble solids varied from 16.60 to 16.67 Bx°. In contrast to the energy drinks treated with the ultrasonication method, the total soluble solids increased in the range of 16.37 to 16.63 Bx° without a significant difference compared to the untreated ones. Total soluble solids in citrus fruit juices range from 2.90 to 3.16 Bx° (Tiencheu et al., 2021), which is higher than in SCB 1.33 ± 0.06 Bx° and RBzs 1.33 ± 0.06 Bx°, but it is less than in SCBo, SCBaa, RBo and RBt drinks. According to Rydzak et al. (2020), the total soluble solids in apple juice are higher than in other fruit juices, with an average between 11.0–12.4 Bx°, which is higher than in SCBaa energy drink-added apple juice. In cold brew coffee, according to Rao et al. (2020), total soluble solids can be from 1.88 to 2.06 Bx°. These findings can explain the higher total soluble solids content in the spruce sprout-cold brew energy drinks SCBo and SCBaa, particularly due to the incorporation of fruit juices. In the case of commercial energy drinks, RBo and RBt had the highest total soluble solids content than the other commercial ones due to the addition of glucose syrup.

The titratable acidity measures the total acid concentration in the food. Titratable acidity is a better indicator of food flavour than pH (Tyl & Sadler, 2017). In comparing the energy drinks, the titratable acidity (Fig. 4) was lower significantly ($p < 0.05$) in Spruce Sprout - cold brew energy drinks than in commercial ones. Between the commercial energy drinks samples, the RBo and RBzs had the highest titratable acidity, 0.79 ± 0.11 mg 100 g^{-1} and 0.84 ± 0.07 mg 100 g^{-1}, respectively, which are non-significantly different ($p > 0.05$) to each other. While in the spruce sprout - cold brew energy drink SCB had the lowest titratable acidity 0.03 ± 0.00 mg 100 g^{-1}. Compared to spruce sprout - cold brew energy drinks the highest was SCBaa 0.10 ± 0.00 mg 100 g^{-1}. The results of titratable acidity were significantly different ($p < 0.05$).

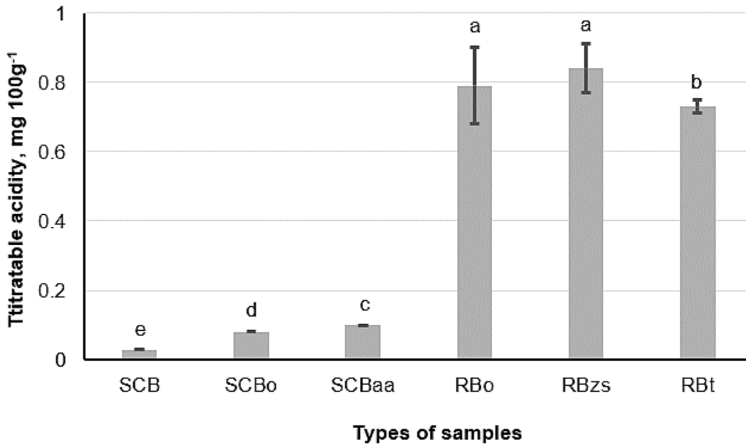

Figure 4. Variation of titratable acidity content between the spruce sprout - cold brew energy drinks and the commercial ones. The spruce sprout-cold brew energy drinks were - SCB - Cold brew coffee 96.8% with spruce sprout juice 3.2%, SCBo - cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2%, SCBaa - cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2%, and the commercial energy drinks were - RBo - RedBull original, RBzs - RedBull zero sugar, RBt - RedBull Tropical fruits. The columns represent the means of titratable acidity content and it's SD in each sample. The different small letters indicate significant differences ($p < 0.05$) between the titratable acidity content of the samples.

In the study of Brima & Abbas (2014), titratable acidity content between energy drinks, juice drinks, and soft drinks was tested. The research shows that in energy drinks, titratable acidity was 0.73 ± 0.06 mg 100 g^{-1}, but in juice drinks, it was 0.27 ± 0.04 mg 100 g^{-1}, and in the soft drinks, it was 0.17 ± 0.04 mg 100 g^{-1}. Compared to Brima & Abbas (2014) study, energy drinks have similar titratable acidity to the result of this study. However, for the juice drinks, titratable acidity is higher than the results of the spruce sprout - cold brew energy drinks in this study. In coffee, titratable acidity can vary according to the degree of coffee bean roasting and its preparation method. Cold brew coffee has lower titratable acidity than hot water prepared ones. In cold brews, titratable acidity ranges from 0.08 ± 0.03 mg 100 g^{-1} in medium roast coffee to 1.50 ± 0.37 mg 100 g^{-1} in dark roast coffee, which is similar to the results of the current studies' spruce sprout - cold brew energy drinks (Cordoba et al., 2019).

pH value has major role in food for maintaining texture, flavour and shelf life (Reddy et al., 2016). The pH of spruce sprout - cold brew energy drinks varied from 3.57 ± 0.00 in SCBaa to 4.47 ± 0.00 in SCB (Fig. 5), which was significantly different ($p < 0.05$) and evidently higher than the pH in the commercial drinks. Moreover, the pH values between the commercial energy drinks were significantly different from each other and varied from 3.36 ± 0.00 in RBt to 3.48 ± 0.01 in RBo (Fig. 5).

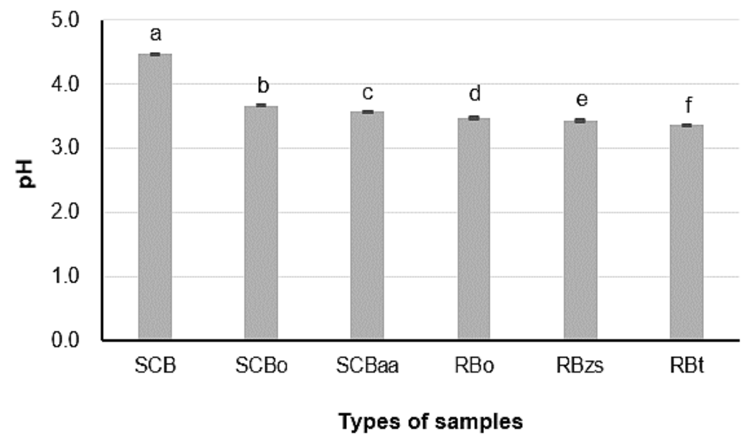

Figure 5. Variation of pH between the spruce sprout - cold brew energy drinks and the commercial ones. The spruce sprout-cold brew energy drinks were - SCB - Cold brew coffee 96.8% with spruce sprout juice 3.2%, SCBo - cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2%, SCBaa - cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2%, and the commercial energy drinks were - RBo - RedBull original, RBzs - RedBull zero sugar, RBt - RedBull Tropical fruits. The columns represent the means of pH and it's SD in each sample. The different small letters indicate significant differences ($p < 0.05$) between the pH of the samples.

In the study of Nowak & Gośliński (2020), the pH was tested in commercial energy drinks with and without added fruit flavour. Energy drinks with added fruit flavour had a lower pH (2.80–2.73) than the pH of energy drinks without added fruit flavour (3.18–3.60). The pH results of the preceding study are similar to the pH results of the commercial drinks and the SCBo and SCBaa innovative drinks of this study. In the Karklina & Kampuse (2021) study, a cold brew coffee from different regions with medium roast was tested for its pH, which ranged from 2.60 to 2.71. The last findings are lower than the pH of commercial and spruce sprout - cold brew energy drinks of the present study. The pH of the coffee drinks can change from one to another based on different factors as follows: the addition of other ingredients, such as milk, will increase the pH of the coffee drink. Basheer et al. (2022) found that the pH of black coffee was 5.11 ± 0.00, but the pH of coffee with milk increased to 6.19 ± 0.01. In fruit juices, the pH ranges between 3.50 and 3.97 (Romeo et al., 2020), which is similar to the results of innovative energy drinks to which juice is added. Added spruce sprouts can also affect the pH of energy drinks. Spruce sprouts belong to hardwood trees, according to Karklina & Ozola (2022b), with a pH that can range from 3.3 to 6.4 depending on the growth place of the tree and the product where spruce is used. The presence of spruce sprouts in a higher amount in the SCB drink could be the reason for its higher pH compared to the other innovative energy drinks.

Total phenol content is high in plants. The role is important for stabilising food and for preventing diseases that are caused by oxidative stress. It also has many health benefits like preventing neurological disease and type 2 diabetes (Michiu et al., 2022).

Total phenolic content was higher in spruce sprout - cold brew energy drinks by 20 times (Fig. 6) than in commercial energy drinks. The phenolic content in spruce sprout - cold brew energy drinks was significantly different ($p < 0.05$) from each other, where the highest content was in SCB 253.93 ± 1.97 mg GAE 100 g^{-1}, followed by SCBaa (170.86 ± 2.16 mg GAE 100 g^{-1}) and SCBo (128.46 ± 8.50 mg GAE 100 g^{-1}). While in commercial energy drinks, the phenolic content was non-significantly different ($p > 0.05$) between RBo (10.69 ± 1.48 mg GAE 100 g^{-1}) and RBzs (10.56 ± 3.28 mg GAE 100 g^{-1}) (Fig. 5), and it was the lowest content in RBt (6.67 ± 0.93 mg GAE 100 g^{-1}).

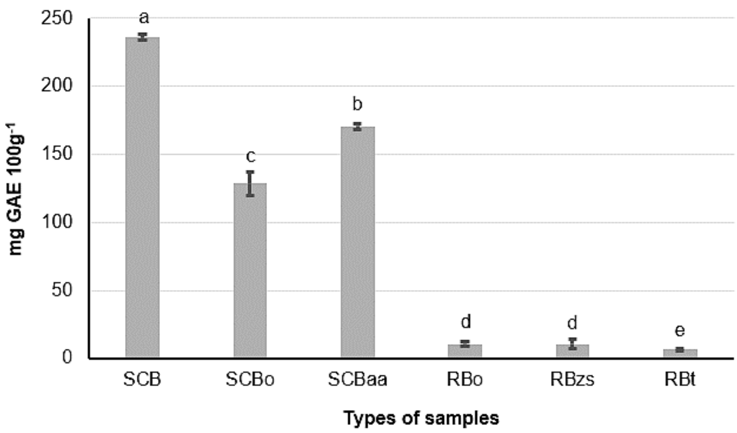

Figure 6. Variation of total phenolic content between the spruce sprout - cold brew energy drinks and the commercial ones. The spruce sprout - cold brew energy drinks were - SCB - Cold brew coffee 96.8% with spruce sprout juice 3.2%, SCBo - cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2%, SCBaa - cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2%, and the commercial energy drinks were - RBo - RedBull original, RBzs - RedBull zero sugar, RBt - RedBull Tropical fruits. The columns represent the means of total phenolic content and it's SD in each sample. The different small letters indicate significant differences ($p < 0.05$) between the total phenolic content of the samples.

Nowak & Gośliński (2020) evaluated the phenolic content in commercial energy drinks without added flavour, where it ranged from 11.5 ± 0.18 mg GAE 100 g^{-1} to 59.00 ± 1.06 mg GAE 100 g^{-1}, although in commercial energy drinks with added flavour, the phenolic content varied from 10.50 ± 0.54 mg GAE 100 g^{-1} to 70.30 ± 1.31 mg GAE 100 g^{-1}. The previous findings were higher than the phenolic contents of the current study's commercial drinks but lower than those of the spruce sprout - cold brew energy drinks. The total phenolic content was higher in spruce sprout - cold brew energy drinks because of added spruce, coffee, and fruit juice. The preparation method of coffee can alternate its total phenolic content (Karkliņa & Kampuse, 2021). Phenolic content can also be affected by the coffee roasting level. By comparing the total phenolic content in the different roasted coffee (light, medium, and dark roasted), the medium roasted has a higher content (1,655 mg GAE 100 g^{-1}) than the dark roasted (1,492 mg GAE 100 g^{-1}) and the light roasted (1,559 mg GAE 100 g^{-1}) (Alnsour et al., 2022). Like coffee, spruces are rich in total phenolic content (1,330 ± 5.5 mg GAE 100 g^{-1}). Phenolic content depends on where the spruce has been harvested, the year's harvesting time, and which part of the tree is used (Dziedzinski et al., 2020). In fresh spruce sprouts, the total phenolic content can be 161.79 ± 14.71 mg GAE 100 g^{-1} (Karklina & Ozola, 2022a), which is similar to the results of SCBaa drink but higher than the phenolic content in the SCBo drink, and less than the SCB drink. The latter can be due to the pasteurization of all the added ingredients in spruce sprout - cold brew energy drinks, which can decrease the total phenolic content (Khiralla & Ali, 2020).

Antiradical activity's purpose is to protect from free radicals that play an important role in the development of anemia, ageing and heart disease (Zehiroglu & Ozturk-Sarikaya, 2019). The antiradical activity DPPH was significantly different ($p < 0.05$) higher in spruce sprout - cold brew energy drinks, compared to the commercial ones (Fig. 7), where it was the highest in SCB drink (178.11 ± 6.44 mg TE 100 g^{-1}), followed by SCBaa (100.95 ± 1.79 mg TE 100 g^{-1}) and SCBo (91.55 ± 4.25 mg TE 100 g^{-1}). In the commercial energy drinks, the antiradical activity DPPH had non-significant differences ($p > 0.05$) between each other and varied from 53.16 ± 3.76 to 56.39 ± 6.94 mg TE 100 g^{-1} (Fig. 7).

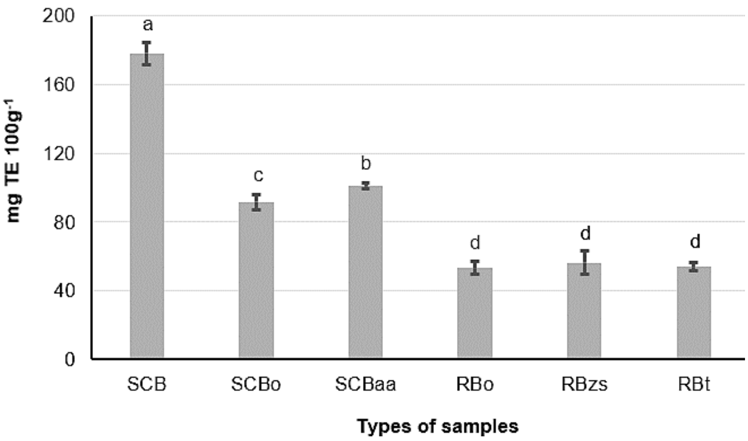

Figure 7. Variation of antiradical activity between the spruce sprout - cold brew energy drinks and the commercial ones. The spruce sprout - cold brew energy drinks were - SCB - Cold brew coffee 96.8% with spruce sprout juice 3.2%, SCBo - cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2%, SCBaa - cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2%, and the commercial energy drinks were - RBo - RedBull original, RBzs - RedBull zero sugar, RBt - RedBull Tropical fruits. The columns represent the means of antiradical activity and its SD in each sample. The different small letters indicate significant differences ($p < 0.05$) between the antiradical activity of the samples.

The antiradical activity of commercial energy drinks with and without added fruit flavour was tested by Nowak & Gośliński (2020). The study showed lower DPPH content in energy drinks without added fruit flavour. In energy drinks without added fruit flavour, DPPH ranged from 0.60 ± 0.03 mg TE 100 g^{-1} to 0.99 ± 0.04 mg TE 100 g^{-1}, but in energy drinks with fruit flavour, the DPPH ranged from 0.74 ± 0.03 mg TE 100 g^{-1} to 28.60 ± 0.34 mg TE 100 g^{-1} which was lower compared to this research energy drinks. The spruce sprout - cold brew energy drinks in this study could have higher antiradical activity due to the added coffee, spruce sprouts, and fruit juice. Fresh spruce sprouts can have high antiradical activity 1,097.37 ± 15.87 mg TE 100 g^{-1}, which is higher than the DPPH of this study. The latter can be explained by the thermolability of the antiradicals, which decreases their activity after the heat treatment antiradical activity decreases (Karklina & Ozola, 2022b). In coffee, antiradical activity depends on its country of origin. Coffee beans from Brazil and Ethiopia have an antiradical activity of 78.1 ± 7.3 mg TE 100 g^{-1}, higher than those from Colombia and Guatemala, 50.6 ± 5.3 mg TE 100 g^{-1} (Andrade et al., 2022). Hot and cold brew coffees don't significantly differ in antiradical activity (Karklina & Kampuse, 2021; Schwarzmann et al., 2022).

Colour in beverages is important, in some cases even more important than beverage flavour. Colour is the first thing that 'catches' the human eye (Spence, 2016). According to the colour results (Table 1), all energy drinks had a dark colour intensity (L*). The darkest spruce sprout - cold brew energy drink was SCB (8.76 ± 0.28) due to its highest concentration of cold brew coffee. The SCBaa drink, which contains apple-aronia juice and less concentration of cold brew coffee, had an L* value similar to the commercial drinks, RBo and RBzs. However, the SCBo drink showed a lighter colour (35.52 ± 0.26) in between the spruce sprout - cold brew energy drinks due to the presence of orange juice and the lower concentration of cold brew coffee. a* negative shows the reddish colour intensity, where the SCBo drink was the only one with a negative a* value and the highest value was for the RBt drink. All the energy drinks had a positive b* value representing the yellow colour. Compared to the innovative drinks, the SCBo sample, where the orange juice was added, had the significantly different ($p < 0.05$) highest b* value (22.91 ± 0.58), and the lowest value (3.56 ± 1.30) was in SCB drink, where the highest concentration of cold brew coffee was added. C* shows the intensity of colour, where the highest intensity was for commercial energy drink RBt, but the lowest was for innovative energy drink SCB. The Hue angle (h*) shows the degree in the colour wheel. All energy drink samples indicated red colour (0 to 120). The lowest result, which was closer to the red colour angle, was in the commercial energy drink RBzs, but the highest was for the spruce sprout - cold brew energy drink SCBaa. The most significant colour difference ΔE was in SCB, but the lowest was in RBo.

Table 1. Colour measurements of spruce sprout - cold brew and commercial energy drinks for assessing the variation of the energy drink's colour based on the variation of their ingredients.

Parameters	L*	a*	b*	C*	h*	ΔE
SCB	8.76 $_{(0.28)}{}^{e}$	4.04 $_{(0.68)}{}^{bc}$	3.56 $_{(1.30)}{}^{e}$	5.39 $_{(0.91)}{}^{e}$	1.02 $_{(0.55)}{}^{ab}$	2.18 $_{(1.14)}{}^{a}$
SCBo	35.52 $_{(0.26)}{}^{a}$	-1.77 $_{(1.06)}{}^{e}$	22.91 $_{(0.58)}{}^{c}$	22.97 $_{(11.16)}{}^{c}$	0.98 $_{(2.28)}{}^{abc}$	1.46 $_{(0.15)}{}^{b}$
SCBaa	20.49 $_{(0.30)}{}^{d}$	0.83 $_{(0.32)}{}^{d}$	7.37 $_{(0.97)}{}^{d}$	7.42 $_{(0.91)}{}^{d}$	1.32 $_{(1.81)}{}^{a}$	0.94 $_{(0.71)}{}^{bc}$
RBo	21.59 $_{(0.52)}{}^{c}$	4.02 $_{(0.02)}{}^{b}$	28.3 $_{(0.36)}{}^{b}$	28.59 $_{(0.36)}{}^{b}$	0.94 $_{(0.16)}{}^{cd}$	0.67 $_{(0.46)}{}^{de}$
RBzs	20.93 $_{(1.13)}{}^{cd}$	3.45 $_{(0.10)}{}^{c}$	22.55 $_{(1.30)}{}^{c}$	22.81 $_{(1.30)}{}^{c}$	0.27 $_{(0.26)}{}^{de}$	1.37 $_{(1.27)}{}^{ab}$
RBt	29.96 $_{(0.67)}{}^{b}$	4.31 $_{(0.07)}{}^{a}$	30.06 $_{(0.20)}{}^{a}$	30.09 $_{(0.20)}{}^{a}$	1.07 $_{(0.14)}{}^{b}$	0.84 $_{(0.24)}{}^{cd}$

The results represent the mean of each colour parameter; L* – range of colour from darkness to lightness; a* – range of colour from green to red; b* – range of colour from blue to yellow; C* –indicates chroma; h* – indicates hue angle, ΔE – shows the colour difference; in spruce sprout - cold brew energy drinks; SCB - Cold brew coffee 96.8% with spruce sprout juice 3.2%, SCBo - cold brew coffee 25% with orange juice 71.8% and spruce sprout juice 3.2%, SCBaa - cold brew coffee 25% with apple-aronia juice 71.8% and spruce sprout juice 3.2%, and commercial energy drinks; RBo - RedBull original, RBzs - RedBull zero sugar, RBt - RedBull Tropical fruits. The results between brackets represent the standard deviation values of each parameter (±SD). Data in the same column with different letters are significantly different ($p \leq 0.05$).

CONCLUSIONS

In conclusion, spruce sprout - cold brew energy drinks have higher bioactive compounds and Vitamin C than commercial energy drinks. Spruce sprout - cold brew energy drinks also have less sugar and lower caffeine content compared to the commercial ones. So, spruce sprout - cold brew energy drinks could be an alternative to commercial energy drinks. There is a need to conduct more research and development of the bioactive compounds in spruce sprout - cold brew energy drinks during storage. Also, it would be necessary to conduct a study of the nutritional value of energy drinks.

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