Non-alcoholic beverages with plant additives as a case of product innovation – A Systematic Review of scientific articles

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Abstract

Purpose of the study: The study compared selected non-alcoholic beverages with plant additives developed by various researchers and determined the innovative potential of these beverages.

Methodology: The beverages described in 22 scientific articles in both English and Polish were analyzed. Scientific articles were searched using the Google search engine, Google Schoolar , a multi- search engine based on the e-resources of the University Library, and the official websites of selected journals. The phrases 'herbal beverages' 'novel plant beverages' and related in English and Polish were used in the search.

Main findings: The paper showed that the addition of plant material to the drink can determine the innovative character by changing the physicochemical characteristics, changing the organoleptic characteristics, storage ability, but most of all giving it a health-promoting and functional character.

Application of this study: It has been shown that scientific articles, as an external source of knowledge, may provide some inspiration to create an innovative drink, however, in most cases, the desire to introduce such a product to the market will require more research on the use of a specific plant raw material.

Originality of this study: New innovative beverages with plant additives are described in many scientific articles, but there are no papers that would constitute a collective discussion about their innovativeness.

INTRODUCTION

The topic of innovation has become an increasingly popular issue in recent years. It is discussed in research undertaken by experts from various fields of science, from exact sciences through social sciences and humanities to fine arts (Damanpour, Sanchez- Henriquez & Chiu, 2018) and presented in numerous scientific publications. At the same time interest in it show the companies (including plants producing food products), which are aware that the introduction of innovations can result in several positive consequences for them (Lee et al., 2016).

In enterprises, innovation may support adaptation to the environment, give the possibility of survival or development, or even constitute a factor in increasing competitiveness, reducing unemployment, increasing economic growth, rising the standard of living, and prosperity of citizens (Demircioglu, Audretsch & Slaper, 2019). Properly carried out the processes of implementation of innovation in enterprises, such as the introduction of new products on the market, being an active reaction to market changes and the changes of environment gives the company the possibility of success (Badowska, 2012).

This phenomenon can be observed particularly strongly in the beverages market, as the beverage industry is the branch of the food industry in which the most innovative products are introduced (KO, 2019).

Due to the considerable interest of researchers and enterprises in the subject of innovation, as well as the openness of the beverage industry to new products, this publication deals with the topic of non-alcoholic beverages with plant additives as an example of product innovation.

The study aimed to compare selected non-alcoholic beverages with plant additives developed by various researchers and to determine the innovative potential of these beverages.

The beverages described in 22 scientific articles in both English and Polish were analyzed. Scientific articles were searched using the Google search engine, Google Schoolar , a multi- search engine based on the e-resources of the University Library (the Main Library of Captain Karol Olgierd Borchardt), and the official websites of selected journals. Articles in open access or those to which access was possible through the PROXY library server were selected. The phrases 'herbal beverages' 'novel plant beverages' and related in English and Polish were used in the search.

1. Product innovation and sources of innovation

The concept of innovation appearing in scientific publications is interpreted in various ways, and there is no universal definition of this term in world literature. Differences in defining what innovation is not only result from the periods when selected definitions were created but also from different perspectives of various disciplines. Innovation as understood by Thompson (1965) is *the generation, acceptance and implementation of new ideas, processes, products or services*. West and Anderson (1996) found that *innovation can be defined as the effective application of processes and products new to the organization and designed to benefit it and its stakeholders*. The definition of Plessis (2007) states *innovation as the creation of new knowledge and ideas to facilitate new business outcomes, aimed at improving internal business processes and structures and to create market driven products and services.* (Baregheh, Rowley & Sambrook, 2009).

Innovation may refer to both an action (process) and the result of an action (product). In the Oslo Manual 2018, product innovation is a new or improved good or service that differs significantly from the company's previously marketed goods or services (Oslo manual, 2018). The implementation of product innovation is aimed at meeting the needs of the future user (Damanpour, Sanchez-Henriquez & Chiu, 2018).

A key element of innovation, apart from the concepts of novelty and usefulness, is the role of knowledge as its basis (Oslo manual, 2018). Sources of knowledge concerning innovation in the enterprise can be divided into internal (employees and other sources inside the company) and external (universities, customers, suppliers, consultants, and other sources outside the company). The knowledge derived from both types of knowledge sources is necessary to develop different types of innovation (Demircioglu, Audretsch & Slaper, 2019, Lee & Moon-goo, 2016) and as the key sources of knowledge are considered employees of companies and universities (Demircioglu, Audretsch & Slaper, 2019). The latter, together with research institutions, enable enterprises to acquire advanced knowledge and technology while reducing R&D costs and the risk of innovation (Si, Liu & Cao, 2020)

Knowledge sources divide innovative activities into two types: open innovations using external knowledge and closed innovations using internal knowledge (Lee & Moon-Goo, 2016, p. 449; Lee et al., 2016). The open innovation model, even though it concerns the involvement of external sources of knowledge, does not mean total dependence on them and the reduction of the importance of internal knowledge (Gómez, Salazar & Vargas, 2016). However, the authors of scientific articles emphasize that the external sources of knowledge are key for achieving successful innovation in the companies (Lee & Moon-Goo, 2016, Gómez, Salazar & Vargas, 2016).

As a source of inspiration for creating innovation can also be indicated science and research results (Badowska, 2012). This means that published scientific articles can be an external source of knowledge for interested companies.

2. Ingredients, additives, and plant additives in non-alcoholic beverages

The primary component of the soft drink is water, which should fulfill the requirements of potable water and meet the relevant parameters like the taste, odor, color, and hardness (Dłużewska & Krygier, 2004). The basic ingredients of traditional non-alcoholic beverages also include fruit juices, sweeteners, flavor, aroma, and color substances (aromatics, food acids, dyes), as well as durability extending additives. The latter, which include preservatives, antioxidants and emulsifiers, are designed to stabilize the color, aroma, taste, and texture (Antolak & Kręgiel, 2017; Dłużewska & Krygier, 2004, Smith et al., 2015).

Plant additives are an ingredient in many drinks. In recent years, producers' interest in these ingredients has increased in the beverage market. Different parts of the plant are used. The most common are fruits in the form of juices or mousses, herbs, leaves or flowers in the form of extracts or infusions, and roots, or bark in the form of extracts or decoctions. Beverages are formed both with the addition of a plant extract, for example, leaves of balm, as well as beverages containing plant infusions, for example, energy drinks tea, or herbs based. An example of this type of beverage popular in many countries is "Ice Tea" drinks (Bogacz, 2019). An innovative example an additive to beverages on the Polish market is hemp. In recent years, many beverages with this additive have been introduced to the market, e.g. carbonated and non-carbonated drinks, alcohols, low-alcohol drinks, or water enriched with this plant extract (Bogacz, 2020).

Plant additive in the beverage has different roles. One of them is the influence on the functional potential of the drink. Giving a functional potential to a drink is closely related to product innovation. Increasing the functional potential makes a product new, improved, distinguished from the products introduced to the market by a company or competitors. According to the European Commission, a functional product is a product that, *together with the basic nutritional impact has a beneficial effect on one or more functions of the human organism, thus either improving general and physical conditions and / or decreasing the risk of the evolution of diseases* (Corbo et al., 2014). The group of functional products also includes functional drinks. Such beverages are fortified e.g. fiber, vitamins, minerals, microorganisms, amino acids, oligosaccharides, or plant extracts (Przeor et al., 2016,). The addition of plant materials or their components to functional food can be identified as a promising research field. This results from the growing interest in bio-compounds, such as polyphenols and carotenoids, with a wide spectrum of biological activity, including antioxidant and antibacterial properties (Dantas et al., 2021). Examples of beverages enriched with plant materials are milkshakes with the addition of fruit, vegetables, and other plants, such as passion fruit, mango, coconut, matcha, turmeric, ginger, chia, acerola, rosehip, and kale, characterized by a high content of bioactive ingredients (Zaręba et al., 2019). Sterols are another additive in beverages and functional foods. The addition of plant sterols to fruit juice, which is a regular drink, will affect its

functional and innovative potential, as sterols have physiological benefits supporting the body in reducing cholesterol levels (Spano, 2010,). Such an increase in the functionality of the drink may not only affect health, but also the decision to buy the product by a consumer who has been showing increasing awareness for many years about the impact of diet on health and well-being. This trend contributes to the systematic decline in the production scale of traditional carbonated drinks. At the same time, there is an increase in the popularity of bottled functional drinks and flavored waters, which are characterized by the fastest development in the beverages market (Antolak & Kręgiel, 2017). Also, the choice of a plant ingredient as a product enrichment ingredient as a substitute for animal or synthetic compounds may be a factor prompting consumers to purchase the product. Plant functional components are perceived to be more healthy and natural (Gaudette, 2011,). In addition, soft drinks with plant ingredients fit in the contemporary world trend of developing new products with nutraceutical properties i.e. products providing additional health or medical benefits such as prevention and treatment of diseases. (Kalra, 2009, Frizon et al., 2018).

Observing the above-mentioned contemporary trends, changes in consumers' lifestyle and dietary preferences, as well as the market of food products, great development potential can be seen in the beverage, especially functional beverages industry. This is the branch of industry that makes it possible to develop new and innovative products, and the ingredients worth paying special attention to are plant ingredients.

3. Non -alcoholic beverages with plant additives as a product innovation

In recent years, there have been changes in the behavior of consumers who attach more and more importance to proper nutrition, increasing physical activity, and taking care of their health. Dynamic changes in consumer lifestyles, current trends, and market behavior have also been noticed by researchers. Many of them became interested in this subject and undertook the creation of new non-alcoholic beverages with functional potential. A significant role in creating this potential has been noticed in plant raw materials.

This publication reviews the beverages prepared by the authors within the selected scientific articles. The drinks are divided into 4 groups. Listed are fruit and vegetable drinks with the addition of tea or herbs, drinks based on tea or herbs, milk drinks fortified with plant ingredients, and fermented Kombucha beverages based on plant materials other than tea. The innovative character of these products and the impact of the raw material on the final product are described in this paper.

3.1. Fruit and vegetable drinks with the addition of tea or herbs

On the domestic and international market, there is a noticeably increased interest in the production of various types of innovative drinks, juices, smoothies, and lemonades based on fruit, which are fortified with herbal or tea extracts to increase their potential health-promoting effect on the consumer's body. The subject of innovative vegetable or fruit drinks also aroused the interest of the research community. Such drinks with the addition of tea or herbs have been developed by different teams of scientists from different countries around the world among others by Tamer et al., Łysoniewska, Kalisz and Mitek, Heena et al., Owczarek et al., Verma, Shiva et al., and Kumar et al. which indicates a global trend and interest in the discussed subject by researchers from around the world. The innovative nature of the drinks resulted from the addition of tea or herbs to the juice, juice diluted with water, fruit nectar, or vegetable juice. Selected publications provide the exact proportions of raw materials and the method of obtaining the drink.

Table 1: Characteristics of the articles on innovative vegetable or fruit drinks with the addition of tea or herbs

Authors of the article and year of publication	Test product	Type and purpose of modification
Heena, Kumar V., Kaur J., Gat J., Chandel A., Suri S., Panghal A. (2017)	cucumber-based drink with the addition of mint, coriander leaves, and sugar cane	fortification of cucumber juice with plant raw materials to obtain a pro-health drink that is sensory acceptable
Łysoniewska E., Kalisz S., Mitek M. (2011)	blackcurrant nectars and drinks fortified with purple coneflower and green tea extracts	fortification of nectars and blackcurrant drinks with additives with health-promoting properties to obtain a product rich in biologically active ingredients
Owczarek L., Jasińska U., Osińska M., Skąpska S. (2004)	drinks based on blackcurrant, cranberry, and raspberry juices with the addition of black and green tea, as well as elderberry decoction	fortification of fruit juices with plant infusions and decoctions to obtain sensory acceptable products with a high content of phenolic compounds and high antioxidant capacity
Shiva K., Adiyaman P., Naik R., Marimuthu N. (2018)	beverage based on banana pseudostem with the addition of ginger and nannari roots	fortification of banana pseudostem juice with plant raw materials to obtain a health-promoting drink with an extended shelf life, making it possible to use the waste from the banana harvest

Tamer C., Yekeler F., Çopur Ö., İncedayi B., Suna S. (2017)	lemonade fortified with herbal extracts (linden, heather, green tea, lemon verbena, clove, peppermint, ginger, and mate)	fortification of lemonade with herbal extracts to develop alternative nutritionally enhanced cold drinks (rich in flavonoids and vitamin C) that are willingly consumed by consumers
Verma A. (2017)	drink based on orange, celery, and mint	fortification orange juice with celery juice and mint extract to obtain health-promoting drinks

Source: Own study based on the articles of the authors listed in the table

The change in the raw material composition of beverages changed its quality characteristics. The selected plant additives modified selected physicochemical properties of beverages based on fruit or vegetables (eg pH, TSS.) This is shown by the research of Heena et al. (2017) on herbal drinks based on cucumber juice. Depending on the proportion of cucumber juice, herbal extract (mint, coriander leaves with addition of citric acid), sugar cane juice, and black and white salt, the content of total soluble solids (TSS) was between 9 – 15 °Brix, titratable acidity was determined at the level of 0.22 - 1.30%, pH at the level of 2.96 - 5.30. Such changes have not been observed in other studies. In the study by Tamer et al. (2017), concerning lemonade fortified with herbal raw materials (linden, ginger, heather, mint, yerba mate, lemon verbena, green tea, clove), it was shown that 8 different plant additives did not significantly affect the amount of water Soluble dry matter content, titratable acidity or pH of the drink. Also in a study by Shiva et al. (2018), no changes in TSS or titratable acidity were observed after adding ginger or nannari extract to a banana pseudostem drink.

The addition of plant material influenced the differentiation of organoleptic characteristics and the acceptability of beverages. Łysoniewska et al. (2011) demonstrated a negative effect of added plant materials to nectars or blackcurrant juices on the organoleptic characteristics of beverages. Sensory analysis showed that the fortifying beverages in extracts of purple coneflower or green tea resulted in a negative effect on the smell and taste of the product (increased perceptibility of foreign and pungent smells, reduced currant smell, reduced perceptibility of currant taste, and increased perceptibility of sour, foreign and tart flavors). The sensory analysis undertaken by the team of Tamer et al. (2017) carried out on lemonade with plant additives proved that the overall impression of lemonade with plant additives was similar (6.92 - 7.54 on a 9-point scale) or equal to lemonade without additives (7,54). This means the possibility of introducing plant materials into this type of beverage without significantly deteriorating their sensory properties. Banana pseudostem drinks (both with ginger, nannari, and without additives), designed in the study by Shiva et al. (2018) had also a positive evaluation. The organoleptic evaluation showed that the overall acceptability of these drinks was in the range of 7.38 - 8.38 on a 9 point scale. Similar results were obtained by Owczarek et al. (2004) who researched fruit drinks with the addition of elderberry, green and black tea. A high hedonic evaluation of the tested products was obtained. The assessment of the taste of the beverages was in the range of 7.2 - 8.8 (on a 10-point scale). Also, drinks with orange juice, celery, and mint extract were found to be sensory acceptable (Verma, 2017, p. 84).

In addition to the impact of plant material on physicochemical properties and the acceptability of the drink, many articles emphasize the increased potential positive impact of fruit or vegetable drinks enriched with plant materials on the human body. Creating beverages by diluting selected juices with tea infusion increased the phenolic content and increased antioxidant capacity (Owczarek et al., 2004). Similarly, the fortification of lemonade with plant extracts increased the antioxidant activity and the content of phenolic compounds. In the case of these beverages, the addition of the extract also differentiated the content of minerals (K, Na, Mg, P). The highest amount of minerals was determined in the sample with green tea and lemon verbena. The addition of ginger extract and the addition of yerba mate reduced the amount of minerals per kg of the product compared to the control sample (Tamer, 2017). The increase or decrease in the content of individual minerals was also determined by other plant additives (ginger, nannari, mint extract) and should be analyzed separately for individual drinks and individual minerals (Shiva et al., 2018; Verma, 2017,). In most of the designed beverages, the addition of plant extract decreased the content of vitamin C (ascorbic acid) in the drink per 100 ml. Only the addition of linden increased its content (Tamer et al., 2017, Shiva et al., 2018, Verma, 2017). The addition of celery juice and mint extract fortified the drink with carotene in an amount close to 230 micrograms / 100 ml (Verma, 2017,). A significant variation in the nutritional and health-promoting value of beverages depending on the raw materials was observed for 20 samples presented in the above-mentioned study by Heena et al. (2017). The changes concerned the amount of proteins, sugars (total and reducing), phenolic compounds, ascorbic acid, antioxidant activity, and the content of tannins. The introduction of plant additives to banana pseudostem beverages resulted in a slight reduction in the amount of total sugar and a reduction in total CHO per 100 ml by up to 2.16 g with a simultaneous higher consumer acceptance rating (Shiva et al., 2018). Some plant additives (e.g. linden, lemon verbena, mint) increased the content of sucrose and glucose in the product, but these were not significant values - not more than 0.51 g / 100 ml of the product) (Tamer et al., 2017). The total carbohydrate content also increased with the increase in the mint extract content in the drink (Verma, 2017).

The effect of some plant additives on the shelf life of fruit or vegetable drinks was also observed. The addition of ginger to the drink from the banana pseudostem had a positive effect on the storage process of the product. Nutrient loss (based on TSS, titratable acidity, total sugars and carbohydrates, vitamin C, and minerals) was found to be minimal during the 6-month storage of this product, attributable to the antibacterial gingerols in ginger (Shiva et al., 2018). The results of these studies indicate a potential chance to reduce the number of substances extending the shelf life (artificial food preservatives) by using selected plant raw materials, which is in line with the current pro-health trends.

Mostly, the positive assessment of beverage acceptability presented in the above studies indicates the possibility of using plant additives in fruit or vegetable drinks to create innovative beverages. Such additives mostly did not have a significant impact on the selected physicochemical properties of this type of product. However, they had a clear impact on the innovative, unconventional nature of fruit or vegetable drinks by changing the organoleptic characteristics, increasing the potential health-promoting and functional effects of the product, or enabling long-term storage of the product without additional use of substances extending the shelf life.

3.2. Beverages based on tea or herbs

Another group of non-alcoholic beverages that fit in with pro-health trends and are innovative is beverages based on tea or herbs. In addition to the popular Chinese tea infusions, nettle, horsetail, mint, and many other raw materials are used. Numerous researchers have also taken up the topic of beverages based on such plant materials. The innovation of the products listed below is based on the use of mixtures of herbs and plants not found in the market as the base of beverages. Innovation in tea drinks from Rooibos comes from the use of various ingredients that give it a sweet taste (sucrose, agave, aspartame, and acesulfame–K). Some of the selected articles contain the exact proportions of raw materials and the method of production.

Table 2: Characteristics of the articles on innovative beverages based on tea or herbs

Authors of the article and year of publication	Test product	Type and purpose of modification
Frizon C., Perusello C., Sturion J., Hoffmann-Ribani R. (2018)	an innovative drink made of yerba mate and soy	use of two high-nutritional products (soybeans and yerba mate) to create a functional drink rich in bioactive compounds and protein.
Ibrahim F., El-Khateeb A. (2013)	drink with fennel and Halfabar	use of fennel and Halfabar to create beverages that inhibit or prevent the formation of calcium oxalate crystals in the body
Perera P., Ekanyake S., Ranaweera K. (2017)	an herbal drink made from the bark of a java plum for diabetics	use of the bark of the java plum to create a herbal drink containing anti-diabetic compounds
Sadalge S., Yardi V. (2017)	drinks made from lemongrass, lemongrass with mint, and lemongrass with ginger and basil	use of lemongrass as an ingredient in beverages with increased nutritional and functional value
Sangma C., Kumar V., Gat Y., Kaushal M., Suri S., Panghal A. (2018)	beverage developed from chayote, sugarcane, and mint and coriander extract	use of chayote as an ingredient with healing properties to create a health-promoting drink
Suna S. (2017)	tea beverage from rooibos	use of herbal teas to develop innovative, safe microbiological beverages with nutritional and functional properties of rooibos

Source: Own study based on the articles of the authors listed in the table.

Depending on the plant raw material used as a base and its proportion, different physical and chemical characteristics of the product were noticed. In a study of a chayote drink by Sangma et al. (2018) the pH of the drink was in the range of 3.51 - 4.43. However, the significant differences resulted from the diversified addition of citric acid. In Suna's research (2017) on the drink with rooibos, the pH values ranged from 3.42 - 3.55. Similarly, the drink from yerba mate and soy was characterized by a pH value of 4.36 - 4.46. The plant material and the additives used also differentiated the content of soluble solids. The TSS values in the drink made of chayote, sugar cane, mint, and coriander leaves were 10.50 - 17.00 °Brix, and in the drink with Rooibos 0.12 - 4.03 °Brix (Frizon et al., 2017, Sangma et al., 2018, Suna, 2017).

The plant raw material determined the acceptability of plant-based drinks, and all of them had positive acceptance ratings. In studies Ibrahim El- Khateeb for the overall acceptability was assessed in the range of 6.5 - 7.68 on a 9-point scale, wherein the scores were higher for a higher content of fennel and less Halfabar (Ibrahim & El - Khateeb, 2013). Similarly, lemongrass, mint and basil beverages were accepted (overall acceptability was 5.4 - 6.0 on a 7 point scale) (Sadalge & Yardi, 2015). Also, drinks made of chayote, mint, coriander leaves, and sugarcane juice were positively rated at 5.72-7.68 on a 9-point scale (Sangma et al., 2018). The above results show the potential of using plant materials as a base in beverages.

In beverages, not only the types of plant materials are important, but also the other ingredients used, such as sugar or its substitute. In the drink from Rooibos, drinks with sucrose were rated as the most favorite one in the sensory analysis, while the drink sweetened with agave was considered as most nutritious and beneficial (the greatest total antioxidant capacity) (Suna, 2017,). Some parameters, such as the antioxidant potential or pH, could also be influenced by other ingredients of the drink, such as citric acid (Sangmaet al., 2018,).

Scientific publications often emphasize the health-promoting potential of tea or herbal drinks. An indicator of this potential may be the amount of phenolic compounds and the antioxidant potential. The raw material used and its amount

can significantly modify the amount of phenolic compounds in beverages based on plant raw materials. Use of rooibos infusion resulted in the presence of phenolic compounds in an amount of 371.08 - 9419.76 mg / 100 ml beverage, while in the beverage made of chayote, sugar cane, mint and coriander leave the content of phenolic compounds was 16.1 - 33 48 mg / 100ml. Despite this, the latter drink was characterized by antioxidant activity at the level of 59.8 - 73.71%. This activity depended on the proportion of the ingredients used (mint and chayote juice) (Sangma et al., 2018, Suna, 2017). Some plant materials fortified products in methylxanthines e.g. caffeine (Frizon, 2017).

Developing a beverage based on plant raw materials is also a potential opportunity to support the human body in specific disease entities. The presence of compounds with antidiabetic and antioxidant properties (gallic acid, umbeliferone, and ellagic acid) has been demonstrated in the tests of the drink made from the bark of the java plum (Perera, Ekanyake & Ranaweera, 2017). On the other hand, the developed fennel and Halfbar - based drink were effective in inhibiting the formation of kidney stones from calcium oxalate in rats. This effectiveness increased with increasing concentration of Halfbar (Ibrahim & El- Khateeb, 2013).

Potential storage stability of beverages based on plant raw materials has also been demonstrated. Lemongrass, lemongrass and mint as well as lemongrass, ginger and asian basil beverages could be stored for up to 35 days without the addition of chemical preservatives (Sadalge & Yardi, 2015).

As in the case of fruit or vegetable drinks with the addition of tea or herbs, also drinks based on plant materials can be considered innovative drinks. The innovativeness of the drinks resulted, among others, from giving healthy and functional character, especially in support of specific disease entities, eg. diabetes through the use of plant materials. Moreover, all of the presented drinks were characterized by positive acceptance ratings. The influence on the physicochemical features was varied. There was no significant effect of the amount of plant materials on the pH, while changes were observed in the TSS value. A positive aspect of creating beverages based on plant raw materials is also the possible reduction of the amount of preservatives in food. Such beverages were characterized by good storage stability.

Milk drinks fortified with plant ingredients

Currently, there is a wide range of milk products and drinks on the global market. These products are different through the base material (type of milk), the method of preparation (fermented and non-fermented), or additives. Often plant ingredients are added to fortify milk drinks and emphasize the health-promoting nature of products (Pavyluk et al., 2019). The issue of innovative milk drinks aroused the interest of not only producers but also researchers. Milk drinks fortified with plant components have been developed, among others, by Hanus, Znamirowska and Kuźniar, Chourasia, Pavyluk et al., Kobus-Cisowska et al., El- Abasy et al. and Yadav, Yadav and Kalia. The basis of these drinks was milk, chocolate-flavored milk, or fermented milk drinks (buttermilk, goat's milk kefir, yogurt, bio-yogurt, rayeb), or whey. Plant raw materials were added before, during or after the fermentation process. Their addition determined the innovative nature of the product by changing the physicochemical and organoleptic characteristics and giving it a potential health-promoting effect. Selected scientific publications are presented in Table 3.

Table 3: Characteristics of the articles on innovative milk drinks fortified with plant ingredients

Authors of the article and year of publication	Test product	Type and purpose of modification
Chourasia S. (2011)	herbal flavored innovative sterilized milk with cinnamon, black pepper, cardamom, bay leaf, nutmeg ,and poppy seeds	fortifying milk with herbs and spices to improve the image of the product, increase the consumption of dairy products, provide additional health benefits ,and improve storage stability
El-Abasy A. E., Abou-Gharbia H. A., Mousa Hamida M., Youssef M. M. (2012)	yogurt and rayeb with the addition of red and yellow carrot juices	fortification of fermented milk products with carrot to obtain new functional drinks containing bioactive ingredients, vitamins, antioxidants, and probiotics
Hanus P., Znamirowska A., Kuźniar P. (2016)	Goat's milk kefir with barley and/or wild garlic	fortification of goat's milk with plant additives to create new products combining the advantages of goat's milk and the highly valued, important for human health properties of these additives
Kobus-Cisowska J., Flarczyk E., Przeor M., Kmiecik D., Hęś M., Szymandera-Buszka K. (2016)	chocolate milk and buttermilk with white mulberry, cocoa, cranberry, and chokeberry	fortification of milk drinks with plant additives to obtain new, attractive drinks with good sensory quality and containing bioactive ingredients
Kumar K., Singh J., Chandra S., Samsher (2017)	whey-based pineapple and mint herbal beverages	use of ripe pineapple juice, whey, and mint extract to develop a drink of high nutritional value and flavor

Pavyluk R., Pogarskaya V., Balabai K., Pogarskiy A., Kravchuk T. (2019)	healthy milk drinks with the addition of natural plant nano-additives (with cryo-additives of apples, carrots, Jerusalem artichoke, lemon, and extracts of spices and herbs - coriander, melilot, oregano, echinacea)	fortification of dairy beverages with nano-additives to increase the amount of biological active substances and extend the shelf life of beverages
Yadav R., Yadav B., Kalia N. (2010)	Whey-based drink with banana and mint	fortification of whey with banana juice and mint extract to obtain a new product with medicinal and nutritional properties, while using and managing by-products from cheese production (whey)

Source: Own study based on the articles of the authors listed in the table

The selected plant raw materials influenced the physicochemical properties of beverages. This is shown by the results of the studies by Kumar et al. (2017) regarding the herbal drink based on whey, pineapple, and mint. The differentiation in the amount of mint extract added (0%, 1%, 2%, 3%) influenced the increase in pH from 5.8 - 6.1 compared to the zero sample - 5.5 (although no differences were observed in the acidity percentage) and the content of soluble solids (TSS) - an increase of 15.2 – 16 °Brix compared to the zero sample - 15.1^{o} Brix. However, there was no significant effect on the amount of protein. Changes in physicochemical characteristics were also observed in the beverages studied by Chourasia (2011) who showed that the mint extract in beverages had a slight effect on pH (increase by approx. 0.1) and total solids (increase by approx. 0.2 - 0.3%). In a study by Yadav, Yadav and Kalia (2010) on whey-based drinks with banana and mint, no significant changes in the physicochemical characteristics (pH and TSS) of the drink were observed after adding different amounts of plant extract. There was also no increase in total sugar with an increased amount of mint extract (Yadav, Yadav & Kalia, 2010), even though in the above-mentioned studies by Verma (2018) conducted on fruit and vegetable juices, increased values of total carbohydrates were observed with an increase in the amount of mint extract.

The plant raw material influenced the organoleptic characteristics of the product, such as the color and consistency of the milk drink. The research of Hanus et al. (2016) showed that the drink with barley was darker, while the garlic was greener. The same studies also showed the differentiation of the structural parameters and the size of kefir syneresis, which decreased (Hanus, Znamirowska & Kuźniar, 2016). In another study, these researchers showed differences in the size of syneresis, which were up to about 24% in comparison to natural kefir with plant additives. On the other hand, the hardness increased when barley was added to dairy drinks (Hanus, Znamirowska & Kuźniar, 2016; Hanus, Znamirowska & Kluz, 2016).

Fortification of dairy drinks with plant ingredients is a factor influencing their sensory characteristics and their acceptance. In studies of goat's milk kefir with a plant additive, a variable perceptibility of certain flavors, e.g. goat or yeast, was shown, depending on the additive used (Hanus, Znamirowska & Kuźniar, 2016). Increased overall acceptability was observed for the whey drink with banana juice, fortified with mint extract in the amount of 1 and 2 ml per 100 ml of drink (Yadav, Yadav & Kalia, 2010). Consumer assessment carried out in the research by Kobus-Cisowska et al. (2016) showed varying ratings depending on the additives used. The addition of mulberry leaf extract to chocolate milk in an amount of 0.3% resulted in increased overall desirability compared to the control sample. However, the remaining samples tested with an increased amount of this extract, an increased amount of extract and cocoa, or samples of buttermilk with added mulberry extract, chokeberry fruit, cranberry, and sugar were assessed worse than the control sample. This means that a plant additive can also positively and negatively affect the overall desirability of the dairy drink. The tests of yogurts with the addition of red and yellow carrot juice showed lower ratings of the overall acceptability of the drink with plant additives compared to the control sample (only 1 out of 8 samples received a higher rating than the drink without plant additives) (El- Abasy, 2011). Despite lower overall acceptability scores for beverages with a plant additive compared to the control, both the beverages designed by El- Abasy et al. and drinks designed by Kobus-Cisowska et al. were characterized in most cases (86%) by positive evaluations. A similar phenomenon of varying overall acceptability depending on the amount of plant additive was observed in studies on a milk beverage with the addition of cinnamon extract, cardamom, nutmeg, black pepper, bay leaves, and poppy seed paste (Chourasia, 2011). Consumer assessment at Kobus-Cisowska et al. research confirmed the color differentiation specified in the physicochemical tests and depending on the presence or absence of plant additives in the milk drink. However, the values of hedonic assessment of color in most of the cases were similar or even higher for beverages with plant addition - chocolate milk with mulberry leaf extract (5.5 - 5.80 when the control sample was assessed at 5.53 on a 7-point scale) and buttermilk with mulberry extract and fruit (5.43 - 6.60 when the control sample is assessed at the level of 6.20) (Kobus-Cisowska, 2016).

All researchers suggest the potential positive effect of a plant addition in a drink on consumer health. Research on this subject was undertaken by Pavyluk et al. (2019), who showed that milk drinks fortified with plant materials can be extremely attractive for people who want to follow a healthy diet. The yogurts developed by this research team based on whey with fruit and vegetable cryo-additives (apple, carrot, Jerusalem artichoke, lemon) as well as spice and non-traditional herb extracts (purple coneflower, coriander, yellow melilot, oregano) were characterized by the presence of easily digestible amino acids, significant content of biologically active substances and phytonutrients such as phenolic

compounds (detoxifiers, antioxidants, and immunomodulators) in amounts much greater than the human body needs every day. Additionally, 200 ml of the yogurt contained β- carotene in the amount of 1.5 the daily requirement and the daily dose of ascorbic acid. Despite the high nutritional value, the products developed by the team of Pavyluk et al. (2019) had the original taste and aroma of the natural product, and the orange and yellow bright colors. Also in the research of the team of El- Abasy et al. (2012), increased health value of the studied milk drinks was observed after adding vegetable juice (yellow and red carrot) to yogurt. The addition of red carrots increased i.a. twice the vitamin C content in the product, increased antioxidant content, the content of β- carotene, and provided a source of anthocyanins. Yogurt with yellow carrot juice was characterized by almost twice the amount of antioxidants in comparison to a control sample and significantly increased content of β- carotene. The plant fortification increased the probiotic effect of the drink. The amount of lactic acid bacteria (LAB) for the control, the 3: 1 mix and the 2: 1 mix (milk to juice ratio) was 2.3×10^{6}, 2.8×10^{6}, and 3.99×10^{6}, respectively. The advantage of plant additives to this type of product is the increase in the availability of minerals derived from the added raw material through the degradation of some metal chelates during fermentation. However, the mineral content may also be decreased in favor of the development of more LAB (El-Abasy et al., 2012). A similarly positive effect on the health-promoting features of the drink was also observed after adding carrot juice to the rayeb drink (El- Abasy et al., 2012).

The research results allowed us to state that the plant raw material influenced the product storage time. Pavvluk et al. (2019) have shown, that drinks plant nano-additives added can be stored two times longer than those produced conventionally.

Plant additives in dairy drinks may require modification of the technological process. When planning this process, it is necessary to take into account the possibility of changing the dynamics of fermentation by plant materials. Such an effect was demonstrated in the studies by Hanus et al. (2016), which determined that the addition of wild garlic, characterized by high antimicrobial activity, reduced the dynamics of lactic acid fermentation (higher pH of the final product).

The presented research results of milk drinks with the addition of plant raw materials indicate a potential chance to create innovative beverages. Giving the innovative character of beverages by adding plant raw material resulted from changes in selected physicochemical parameters (e.g. the possibility of achieving lower acidity of the product), differentiated color and consistency of beverages, differentiated sensory characteristics, and product acceptability, increased potential health-promoting effect of milk drinks and extension of the shelf life. Although in most cases milk drinks with the addition of herbal raw materials were characterized by positive acceptance ratings, some of the raw materials negatively influenced the assessment of the desirability of the product. When designing this type of product, attention should be paid not only to the possible negative impact on organoleptic characteristics but also to the need to modify the production process in the case of fermented beverages, because plant additives can change the dynamics of the fermentation process.

3.4. Kombucha type fermented beverages

The existing pro-health trends, such as the interest in minimally processed food, contributed to the increased interest of consumers in fermented drinks known as Kombucha (Villarreal-Soto et al., 2018). A drink of Manchurian origin is gaining more and more favor in the world as a health-promoting, probiotic drink that is an alternative to popular carbonated drinks. Increased interest in this beverage is also showing global researchers. In Poland, the subject of kombucha was studied, among others, by Jakubowski and Śmiechowska (Jakubowski & Śmiechowska, 2017). Some researchers are trying to innovate this drink. The innovative Kombucha fermented drinks were designed by the following researchers: Pure and Pure, Waisundara, and Vitas et al. The innovative nature of the drinks resulted from the use of an infusion other than that obtained from black or green tea. All articles describe the exact ratio of the beverage ingredients and the manufacturing process.

Table 4: Characteristics of the articles on innovative kombucha type fermented beverages

Authors of the article and year of publication	Test product	Type and purpose of modification
Pure A., Pure M. (2016)	kombucha beverages prepared using a banana peel, common nettles, and black tea infusions	use of herbal raw materials and plant waste materials to obtain new Kombucha drinks with antioxidant properties
Waisundara V. (2018)	kombucha made of herbal teas (babul tree, bengal quince root bark, sunny khur, sambiloto, avartaki, indian sarsaparilla, barley, emblic myrobalan, guduchi)	use of the tea mushroom for the fermentation of herbal infusions to obtain functional drinks with increased antioxidant potential with the simultaneous use of local raw materials
Vitas J. S., Cvetanović A. D., Mašković P. Z., Švarc-Gajić J., V., Malbaša R., V. (2018)	an innovative kombucha drink made of yarrow flowers	use of yarrow infusions to develop an innovative kombucha beverage as an example of functional food with competitive quality features and antioxidant, antimicrobial, and antiproliferative effects

Source: Own study based on the articles of the authors listed in the table.

The change of the raw material from tea to others plant materials resulted in changes in the physicochemical parameters of the drink. Pure and Pure (2016) in a study on kombucha drinks prepared from infusions of black tea, nettle, and banana peel showed that the pH of kombucha after fermentation was higher for the nettle drink and banana peel, which could be due to the content of ingredients inhibiting the process. acetic acid formation. The variability of pH and titratable acidity depending on the raw material used was also demonstrated in the research conducted by Waisundara (2018) comparing 9 different plant materials. Despite the differences in the pH, the test showed that all drinks were acceptable for consumption. The amount of raw material and the method of obtaining the infusion also influenced the fermentation process of beverages. Vitas et al. (2018) showed a significant discrepancy in pH, total acidity, and the yield of biomass with different content of yarrow flower and different infusion methods (traditional infusion and SWE). Significant differences in total acidity were observed, and the values were ranging from 1.26 to 17.76 g of acetic acid per liter.

The sensory analysis of the innovative kombucha drink was carried out by Vitas et al. The descriptive test showed that the designed type of drinks kombucha with yarrow flowers had sensory properties consistent with the quality of traditional kombucha products (Vitas et al., 2018). This means the possible acceptance of the product by consumers while changing the plant raw material, and thus modifying the characteristics or functionality of the drink. Articles by Waisundara (2018) and Pure and Pure (2016) emphasize the validity of sensory analysis in future research.

The innovative drinks presented in the articles also had a potentially positive effect on the human body. The research of Pure and Pure (2016) proved that both the traditional black tea product and innovative drinks (banana peel and nettle leaves) were characterized by significant antioxidant activity (92.9%, 92.4%, and 94.6% DPPH inhibition for 2 ml samples). The use of other herbal infusions in kombucha can also be significant for the food intended for diabetics. Waisundara (2018) observed a varied content of starch hydrolase inhibitors, e.g. inhibiting the effects of alpha-amylase in beverages. This activity was increased by fermenting the brew and producing a kombucha. Reasearching in this direction may result in the development of innovative drinks reducing the postprandial increase in plasma glucose concentration in diabetic patients (Waisundara, 2018). Other research about kombucha yarrow flower drinks showed anti-cancer effects. All samples showed antiproliferative activity to three different cell lines (Vitas, 2018). On the other hand, replacing the traditional raw material, which is tea, may also have negative effects on the health-promoting nature of the drink. Replacing this plant material with yarrow flower resulted in a decrease in the content of vitamin C (synthesized largely by microorganisms during fermentation) in the drink from 15.19 mg / l for the black tea drink and 7.88 mg / l for green tea to 0.48-1, 14 mg / l for the yarrow flower drink (Vitas et al, 2018).

The choice of plant raw material can also affect the safety and storage ability of a kombucha. While no antimicrobial activity was observed in kombucha drinks made of black tea, nettle, and banana peel (Pure & Pure , 2016), it was observed with yarrow flower drinks (Vitas et al, 2018).

The results of the cited studies indicate the possibility of using various plant materials to create innovative kombucha drinks. Depending on the ingredient used, the sensory, physicochemical, potentially positive effects on the human body, and antimicrobial activity will be modified. The considerable variety of beverage characteristics emphasizes the need for research on individual plant raw materials in this type of beverage.

SUMMARY AND CONCLUSIONS

As it has been shown, there are many studies on the subject of innovative alcohol-free beverages fortified with plant materials. Despite numerous articles, they take up selected issues, and the articles themselves cover the subject of very diverse plant additives.

Scientific articles may provide some inspiration for the production of innovative drinks, but in most cases, the desire to introduce such a product to the market will require more research on the use of a specific plant raw material. However, scientific articles are not the only external source of knowledge, as well as the open innovation model also uses internal knowledge. Moreover, such articles convey very important knowledge from the point of view of developing an unknown product.

The plant materials modified in some cases physical properties of beverages, as well as their chemical composition. They also influenced the organoleptic characteristics of the product, but the results of most studies show that the assessment of acceptance of this type of beverage was positive. These additives also gave the drinks a potential health-promoting and functional character. The last parameter should be considered not only in terms of the antioxidant activity of the product but also the possible support in specific disease entities, such as diabetes, cancer, or nephrolithiasis. Additionally, selected plant materials, thanks to their antimicrobial properties, made it possible to limit the use of additional preservatives.

Particular attention should be paid to creating a product innovation among fermented beverages, because plant raw materials not only affect the final product, but also modify the fermentation process.

The above-mentioned impact of plant raw materials on the final product shows the possibility of developing an innovative, functional product that stands out on the market, which would not only suit the consumer in terms of organoleptic characteristics, had a positive effect on his health, but would also fit in with contemporary nutritional trends. Despite numerous scientific studies, the use of plant raw materials, especially in innovative and functional drinks, requires further research, and the possibility of creating drink recipes with different raw materials from different regions

of the world, with different functional effects creates almost unlimited research possibilities. These possibilities, as well as the openness of the beverage industry to new, innovative products, according to the authors, create development opportunities for both researchers interested in this subject and producers of this type of beverage.

LIMITATIONS AND STUDY FORWARD

The literature review only concerned articles in English and Polish. Cooperation with researchers from other countries is a potential chance for an even clearer discussion of the issue.

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DECLARATION OF INTEREST

None.

CO-AUTHORS CONTRIBUTION

Michał Świtalski's contribution was as follows: conception, acquisition of data, and analysis, as well as interpretation. Agnieszka Rybowska's contribution was as follows: conception and analysis and interpretation.

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