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An overview on the possibilities of fortifying yogurt with various natural ingredients

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Abstract

This paper summarizes literature data on possibilities of fortifying yogurt with various natural products. Improvements in nutritive properties and sensory attributes of fortified yogurt, as well as health benefits of the consumer, various sensory, physico-chemical or microbiological results of fortified yoghurts have been presented.

Keywords: fortified yogurt, fruits, vegetables, cereals, aromatic/medicinal plants, honey and bee products.

1. Introduction

Research to date has focused both on understanding biochemical mechanisms involved in process of obtaining yogurt and possibilities of improving its sensory and nutritional properties in context in which the consumption of yogurt has been associated with many health benefits [1, 2, 3, 4].

Popularity of yogurt among consumers, on one hand, and increased digestibility and bioavailability of nutrients, on the other hand, have led to its use as a carrier of exogenous bioactive substances of high nutritional value [1, 2, 5]. Thus, fortified yogurts with various additives were obtained [6, 7], Madhu and Neetu, (2020) quoted by [5].

Yogurt began to be commercially successful with the inclusion of jam in its manufacturing recipe as an ingredient rich in bioactive compounds [2]. Solutions to improve its nutritional value [3]. As evidence, yogurt production and consumption have increased by more than 10% in the last decade worldwide [1, 3].

In general, most regulators in the world consider yogurt to be an acidic dairy product obtained by fermenting milk in presence of production starter cultures consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* spp *bulgaricus*. Add other microorganisms, such as: *L. helveticus*, *L. casei*, *L. jugurti* or various species of bifidobacteria [1, 2, 3].

To enhance beneficial effects of yoghurt, other strains such as *Lactobacillus acidophilus* and *Bifidobacterium bifidus* can be added [2]. In terms of cultures used to obtain yogurt, it can be classified into two different groups: *L. bulgaricus* and *S. thermophilus*) and probiotic yogurt (with probiotic strains of *Bifidobacteria* and *L. acidophilus*) [1]. In addition to health benefits, probiotic yogurts are more popular, have improved sensory properties (softer flavor, creamier consistency and lower acidity) [1, 3].

Cow's, buffalo's, goat's and sheep's milk are usually used to make yogurt, but in some geographical areas mare's and camel's milk is also used as a raw material [1].

Local traditions and lifestyles contribute to consumption of certain types of yogurt. For example, in Eastern Europe and Asia, acidic dairy products that have undergone both lactic and alcoholic fermentation (Kefir, Koumis) are

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consumed, while in Germany and Spain, yogurt is heat-treated to kill bacteria, and in other states it is common to add various probiotics and / or prebiotics [2].

Yogurt technology exploits the symbiosis of the two patches of bacteria *S. thermophiles* and *L. bulgaricus* in a sterile environment at a temperature of 36–42°C for 3–8 hours [2, 3]. The fermented yogurt base, through its acidity, inhibits growth of unwanted microorganisms and calcium and phosphorus in milk are transformed into soluble form, thus most proteins are better digested by proteolytic enzymes, substantially contributing to increased digestibility and general bioavailability [2]. Having a yogurt base, the production can be adapted to obtain yogurt with various additives [3, 7].

Over time, countless additions have been used, from most varied, to fruit [4, 5, 8 , 9, 10, 11, 12, 13], vegetables [1, 5, 14, 15, 16, 17, 18], aromatic / spice / medicinal plant [2, 19, 20, 21, 22, 23, 24, 25, 26], cereals / bran [10, 27, 28, 29], seeds and nuts [1, 30, 31, 32, 33], honey and / or bee products [6, 34, 35]. The way in which these additives have been used is very varied, from pieces as such [10, 34, 36, 37], to purees [18, 38, 34, 39], flours [40, 41, 42, 43], juices [7, 15, 44], oils or extracts [1, 5, 6, 17, 45, 46, 47]. Some studies have consisted of combined use of plant mixtures [5, 21].

Our laboratory-scale experiments in field of yogurt fortification have focused on obtaining healthy, tasty and energizing desserts. One of these experiments consisted of introducing bee honey and bee products (pollen, pasture, royal jelly) into yogurt. Another study focused on fortifying beetroot yogurt.

Considerations underlying yogurt fortification were diverse: to capitalize on nutritional / therapeutic potential of additives [1, 3, 4, 37, 48], to improve sensory, physico-chemical and microbiological characteristics of yogurt [5, 7, 10, 11, 23, 31, 40, 49, 50, 51, 52, 53], for introduction in diet of foods that usually are not consumed, especially among children [5, 6, 7, 15, 17].

In line with the above mentioned considerations, purpose of this bibliographic synthesis is to evaluate the advantages and disadvantages of yogurt fortification, to identify natural materials that are suitable to be included as ingredients in yogurt recipe for industrial application and to assess the benefits for consumers, especially for those with special nutritional needs.

2. Key trends in yogurt fortification and the qualitative characteristics of obtained products

2.1. Yogurt wuth fruits

Use of fruits or fruit-based products in yogurt making recipe was a way to improve nutritional and sensory properties of yogurt.

Sensory examination results

Process of fortifying yogurts with papaya, apple, banana and mango fruits has led to higher scores than plain yogurt, in terms of color, appearance, flavor, texture [32]. Sensory examination of grape-fortified yogurt with grape flour noted a loss of textural quality [9], while the use of apple pomegranate showed good acceptability [54].

After examining organoleptic properties, it was found that strawberry and raspberry yogurt best retained its sensory characteristics [36]. Results of sensory evaluation of samples of fortified yogurt with jam from cherries, peaches and kiwis showed significant differences between samples, the variant with kiwi recorded the lowest scores of general acceptability [55]. Use of cupuassu fruit (*Theobroma grandiflorum*) in form of pulp has improved consistency of fortified yogurt and changed its color [56]. Addition of melon in yogurt has changed its consistency [37]. While Pawar, (2019) argues that strawberry pulp yogurt was better appreciated by evaluators than control yogurt, Rahman et al (2020) argue opposite, that is, control yogurt had better acceptability, only with addition of 5% strawberry juice was found to be close to fortified and unfortified yogurt. Yogurt with the addition of unripe banana flour was also accepted, with variants with lower concentrations of addition being preferred [40].

Physico-chemical examination results

The study by Voşgan et al (2016), which consisted in fortifying cow's milk yogurt with cherries, bananas and nuts, showed that fruits influence evolution of yogurt acidity over time, highest being reported in case of cherry yogurt. Increases in acidity have also been reported in fortifying yogurt with strawberry juice [57], watermelon juice [58], neem (*Azadirachta indica*) [Shori and Baba, (2011a), quoted by 1], papaya [32, 59], apple, banana, mango, grape flour [9, 32], cherry, peach and kiwi jam [60] and pear cactus [59].

Supplementation of goat's milk yogurt with chokeberry juice and cranberry juice coagulated faster and at a lower acidity than unfortified yogurt [61] by enriching cantaloupe melon or watermelon, the pH value was lower during storage [37, 58].

Addition of cantaloupe melon, strawberry juice, grape skin flour reduced level of lipids in yogurt [9, 37, 57]. Nateghi et al, (2018) claim that the addition of cherry, peach and kiwi jam (7% and 10%) also reduced fat content of yoghurt. Chokeberry juice compared to unfortified yogurt [61].

Supplementation of different types of fruit pulp, almonds has positively influenced carbohydrate content of fortified yogurt [32]. Addition of *Siraitia grosvenorii* fruit, unripe banana flour, cherry, peach and kiwi jam to the yogurt determined demand for carbohydrate content [42, 55]. Presence of apple pomace in yogurt determined increasing dietary fiber content [62].

The study by Nateghi et al (2018) shows that addition of cherries, peaches and kiwis in form of marmalade has improved the protein level of fortified yogurts [55]. Yogurt with addition of melon has been found to improve the amino acid content [37].

Protein content of yogurts with papaya, apple, banana, mango and Siraitia grosvenorii has increased significantly compared to plain yogurt [32, 71].

In addition to fruit, removed whey content was higher in case of cherry yogurt [8], and addition of cherry, peach and kiwi jam increased water retention capacity and decreased yneresis throughout [55]. When fortifying cantaloupe watermelon yogurt, water retention capacity was remarkable for 14^{th} and 28^{th} days of dry melon yogurt, respectively [37].

Syneresis process has been reduced to addition of grape skin flour to yogurt [9], apple pomace [62].

Incorporating strawberry juice into yogurt has been reported to increase humidity [57].

Data published by Salehi, (2021) show that: by-products of passion fruit [Espírito-Santo *et al.*, 2013, quoted by [64]], apple pomace [54], Kristo, *et al.*, 2019 quoted by [64], date fiber [Hashim *et al.*, 2009 quoted by [64]], apple and inulin fiber [Staffolo *et al.*, *(*2004) quoted by [64]], orange fiber [García-Pérez *et al*., (2005) quoted by [64]], and pineapple and pomace peel powders [51] confirmed that they improve the structure and decrease the synergy of yogurts.

Following fortification of yogurt with cherries, bananas, chokeberry, raspberries and walnuts, level of vitamin C was almost double that of unfortified yogurt, highest content of beef C being detected in banana yogurt [13], [Shori and Baba, (2011a), quoted by [1]].

When fortifying yogurt with papaya, apple, banana and mango fruit, neem was observed to increase level of phenolic compounds [32], [Shori and Baba, (2011a), quoted by [1]]. And addition of cantaloupe melon, chokeberry, raspberry, strawberry has led to increased levels of antioxidant compounds (polyphenols, carotenoids, β-carotene) [37].

Apple-fortified yogurt fortified with grape peel flour showed significantly higher polyphenol content and antioxidant activity than control [9, 62]. Phenolic compounds found in fortified yoghurts include procyanidin B_1 and vanilla acids (in Pinot noir grape fortified yoghurts), gallic acid, catechin and quercitrin (in yogurts in fortified yoghurts Moscato or Chardonnay grape skin flour) [9].

Addition of melon, banana, cherry jam, peach and kiwi to yogurt has contributed to significant increase in ash [32, 37, 55]. Rahman *et al* (2020), at introduction of strawberry juice reported a reduction in ash content of fortified yogurt. Similar results were reported for yogurts with added papaya, apple and mango when it was found that they all had slightly lower values than the control [32].

Microbiological examination results

Introduction of fruit in yogurt has generally stimulated development of lactic acid bacteria in yogurt with chokeberry and blueberry juice [61], cantaloupe melon [37], cherries [8]. However, goji berries did not affect activity of lactic acid bacteria [11]. Due to increase in content of reducing carbohydrates in yogurt with addition of flour from unripe bananas, development of lactic acid bacteria was stimulated [42].

Fortified yogurt with the fruit *Siraitia grosvenorii* stimulated development of *Lactobacillus casei* and *Lactobacillus bulgaricus*, but did not influence activity of *Streptococcus termofili* [63].

Addition of strawberry juice to yogurt has acted on certain types of microbes (TPC - Total Plate Count, TCC - Total Coliform Counts, TFC - Total Fungal

Counts) reducing their activity due to the high acidity of strawberry juice [57].

Cranberry yogurt supplementation has significantly improved stability of lactic acid bacteria [65].

2.2. Yogurt with vegetables

Sensory examination results

Yogurts that have been fortified with fiber obtained from inedible part of asparagus shoots have increased consistency of yogurts. Fibers reduced clarity and gave yoghurt a yellow-green color [14]. Sensory characteristics of fortified yogurt with carrot juice were inferior to version of unfortified yogurt [7], while version with carrot "caviar" enjoyed a high rate of acceptability among children [17]. Addition of pumpkin pulp, beetroot improved texture of yogurts [16, 66]. Approach of enriching yogurt with flour from a mixture of beets and unripe bananas has been well received by consumers, especially variants with lower content of addition [5]. Use of spinach extract in combination with kiwi flavor has been well accepted by evaluators [67]. Fermented mixture consisting of mashed sweet potatoes, milk, sugar, gelatin and freeze-dried yogurt inoculum changed its color, becoming slightly darker and more orange as sweet potato supplemented. Sensory scores were elevated for this yogurt [68].

Physico-chemical examination results

Spinach, carrot juice, beetroot used to fortify yogurt have increased titratable acidity [7, 16, 67]. Fortification of sweet potato puree yogurt (along with milk, sugar, gelatin and freeze-dried yogurt inoculum) has been reported to decrease in acidity as sweet potato and sugar levels have increased [68].

Flour from a mixture of beets and unripe bananas added to yogurt has led to an increase in fat content [5]. Presence of carrot juice in yogurt has reduced the lipid content of fortified yogurts [7]. Similar results were observed in sweet potato-enriched aurtles in reverse correlation with the level of supplementation [68].

Fibers obtained from inedible part of asparagus substantially increased fiber content of yoghurts in which they were added [14]. Also, added carrot juice caused increases in carbohydrate levels and crude fiber in yogurts [7].

Content of reducing sugars and total carbohydrates in fortified yogurts with a mixture of beets and bananas (in the form of flour) increased compared to the control [5].

Protein content of fortified yogurts with a mixture of beet and banana flour, carrot juice increased [5, 7].

Pumpkin pulp yogurts showed lower syneresis than control sample during storage [66]. Incorporation of pea fiber into yogurt significantly reduced syneresis compared to control yogurt [69], but addition of spinach extract to yogurt increased syneresis [67]. Water retention capacity and susceptibility to syneresis have been improved by adding chickpea flour to yogurt [70]. Improving structure and reducing syneresis of yogurts has also been observed when fortifying with carrot juice or carrot cell wall particles Cliff *et al.*, 2013, McCann *et al.*, 2011 quoted by [64] or when adding fiber peas [28].

While water content of yogurt with beet and banana flour was higher than in control [5, 68] observed a reduction in humidity in yoghurts prepared with sweet potato, inversely proportional to level of supplementation.

Compared to control samples, content of yogurt fortified with carrot juice or sweet potato was richer in vitamin C [7, 68] and vitamin A [68].

In fortified yogurts with beetroot, pepper juice, there was an increase in antiradical activity, content of total phenols [15, 16] and carotenes [7, 15].

Use of chickpea flour, flour from beet-banana mixture has increased ash content [5, 70].

Microbiological examination results

Supplementing yogurt with pepper juice has, in general, reduced number of lactic acid bacteria, but has stimulated growth rate of *L. rhamnosus*, due to composition of juice containing complex carbohydrates and dietary fiber [15]. When incorporating eggplant puree into yogurt, Jooyandeh *et al.* (2020) reported a reduction in probiotic bacteria at beginning of storage time. At the end of storage period, however, situation was reversed, so that yogurt variants with a higher content of eggplant puree, had a higher number of bacteria [18].

2.3. Yogurt with aromatic / spicy / medicinal plants

Sensory examination results

Rosemary and ginger yogurts obtained scores comparable to unfortified ones [24], as well as those with *Aloe vera* [71]. Addition of dill extract to yogurt positively influenced aroma and taste, but negatively affected texture [72]. *Mentha pulegium* L. (pennyroyal) powder introduced in various proportions in yogurts has improved their textural properties [25] which has also been costly when replacing milk fat with aloe gel, leading to better acceptability by consumers [73]. *Mentha pulegium* powder can be used in yogurt up to 0.10% [25].

Textural properties (firmness, adhesiveness, cohesion and elasticity) of fortified yogurt with *Gnaphalium affine* extract have been improved compared to control [47].

Addition of *K. odoratissima Mozaff* essential oil has been shown to improve the flavor of fortified yogurt [20].

Results of addition of *Vernonia amygdalina Del.* (African bitter leaf) showed that yogurt with a ratio of 83.75: 1.25 was selected the most appreciated by evaluators [45].

Fortification of yogurt with *Moringa oleifera* resulted in sensory characteristics inferior to the control sample [41, 49], even in combination with bananas, sweet potatoes or avocados [49, 50]. The study by Zang et al, (2019) states that when adding *Moringa oleifera* extract to yogurt, sensory characteristics were not negatively influenced compared to the control.

Physico-chemical examination results

Addition of anise volatile oil and its oleoresin does not adversely affect the physicochemical properties of yogurt [19]. Mofarrah (*Nepeta crispa Wild*) yoghurts with dill have increased lactic acid content and implicitly increased acidity compared to control samples [24, 72, 74]. Presence of extracts of rosemary, oregano and ginger, white tea (*Camellia sinensis*), during storage was noticed an increase in acidity of fortified samples compared to control, pH value decreasing significantly [24, 75].

Use of *Aloe vera* gel in yogurt has led to a reduction in acidity [76] compared to control, which increases with storage time [73].

Addition of *Gnaphalium affine* extract did not influence pH and titratable acidity [47] and essential oil of *K. odoratissima Mozaff* kept acidity of yogurts under control and increased their shelf life [20]. Anise oil and aniseed oleoresin can also be used to increase shelf life of yogurt [19].

Suplemetation of *Aloe vera* gel in yogurt has led to a reduction in lipid content [76] compared to the control.

In yogurts with dill extract, a decrease in water retention capacity during storage was observed [72].

Water content of yoghurt containing 5% dill extract was lower than in other samples [72]. Use of Aloe vera gel in yogurt has led to a reduction in humidity [72], syneresis of yogurt increasing over time [73]. Lower susceptibility to syneresis [47] *Kelussia odoratissma Mozaffarian* essential oil added to yogurt has reduced water retention capacity [20].

In fortified yoghurts with *Moringa oleifera* extract, syneresis was reduced and water retention capacity was increased [52].

It was noticed improving antioxidant activity of yogurt samples with *Moringa oleifera* [52], with hibiscus flower jam [53], with *Camellia sinensis* [75] with those with rosemary extract, dill, oregano and ginger [24], all herbal yogurts showed higher FRAP values than control.

Yoghurt with *Gnaphalium affine* extract showed remarkable antioxidant potential against the radicals 2, 2-azinobis-3-ethylbenzthiazoline-6-sulfonate (ABTS), 1,1-diphenyl-2-picrylhydrazyl (DPPH), superoxide and hydroxyl [47].

Mineral profile of yogurt samples with hibiscus flower jam has changed substantially, with significant increases in Fe, Mn, B and Ba [53],

Presence of dill extract in yogurts studied by Tizghadam et al, (2021) led to an increase in polyphenol content compared to control groups. Same was observed for yogurts with extract of rosemary, garlic, Turkish oregano, mint, basil and ginger [24, 26], extract of *Vernonia amygdalina* leaves [45], jam from hibiscus flowers [53].

Microbiological examination results

Camel milk yogurts with the addition of *Cinnamomum verum* and those with the addition of garlic contain a higher number of lactobacilli than plain yogurt [1, 21, 24]. Addition of *Gnaphalium affine* in yogurt contributed to greater viability of

Lactobacillus bulgaricus and *Streptococcus thermophilus* than the control [47].

Number of lactic acid bacteria varied inversely with concentration of *Mentha pulegium L.*, but figures were still above the minimum requirement for yogurt [25]. Following addition of *Aloe vera* to yogurt, number of coliforms and number of yeasts and molds was zero [71].

Moringa oleifera extract inoculated in yogurt significantly accelerated fermentation rate by promoting growth of lactic acid bacteria [52].

Addition of white tea showed an increase in *Lactobacillus* spp. VCC in both cow's and goat's milk yogurt compared to plain yogurt [75].

2.4. Yogurt with cereals / bran

Sensory examination results

By incorporating rice bran in yogurt with strawberry pulp, aroma and appearance were well appreciated, but the texture was depuncted compared to control sample, and consistency was better. The best overall acceptability was observed in 0.9% rice bran variants [10]. Addition of insoluble triticale fibers (wheat or oat fibers) gave yoghurt a yellowish-brown hue [27], and addition of buckwheat and oat fiber changed texture of yoghurt [28]. Barley or oat-based β-glucan-supplemented yogurts were well appreciated, oat-based β-glucan (OB) yogurt received higher scores for appearance, smell, color, taste, and general acceptance than β-containing yogurt -glycan based on barley [77].

Physico-chemical examination results

Presence of rice bran in yogurt has led to a significant decrease in pH and syneresis as their concentration increases and their shelf life, and a significant increase in titratable acidity [10].

Yoghurts with addition of 0.9% rice bran had a lower lipid content than control [10]. Fiber content of rice bran yogurt was higher than that of control sample [10].

Moisture content of rice bran yogurt was lower than that of plain yogurt [10]. There were no significant differences in water retention capacity [78]. Improving structure and reducing syneresis of yogurts has also been observed in fortification with wheat fiber, bamboo [Staffolo *et al.*, 2004, quoted by [64]].

Incorporation of inulin, oat or wheat fiber in yogurt does not substantially alter pattern of structural organization in samples, increasing fiber content leads to reduced syneresis due to water retention capacity of fibers to absorb whey released by gel structure [[28], Garcia-Perez *et al.*, 2005 quoted by [79]]. Barley or oat β-glucan supplementation significantly reduced whey separation, which is explained by high gelling capacity of β-glucans and their high ability to bind gel network and elastic matrix casein-protein-glucan [77].

Oat bran supplementation did not significantly affect level of phenolic compounds in yogurt or antioxidant activity [78].

Microbiological examination results

Study conducted by Ozcan and O. Kurtuldu, (2014) showed that by supplementing yogurt with barley or oats based on yogurt, development and viability of *Bifidobacterium* was favored. Oat bran introduced into yogurt has significantly increased the viability of B. lactis [78], and chia seeds have contributed to stability of lactic acid bacteria in fortified yogurts [65].

2.5. Yogurt with seeds and nuts

Sensory examination results

Introduction of almonds into yogurt has been well accepted by evaluators, even with higher scores than yogurts with some fruit or compared to unfortified yogurts and has contributed to their better consistency [32].

Flaxseed and gum from basil seeds have improved texture and sensory attributes of yogurt [29, 31], yet hazelnut skin has lower scores for texture, but as a whole showed acceptable sensory properties similar to control yogurts [33].

Physico-chemical examination results

Use of basil gum as a fat substitute in yogurt has reduced pH of fortified yogurt [31], while addition of hazelnut skin has reduced titratable acidity [33].

Addition of walnuts, almonds or hazelnut skin to yogurt has increased lipid content compared to unfortified yogurt and other types of fruit yogurt (cherries, bananas) [8, 32, 33]. N-3 and n-6 fatty acids recorded higher values in fortified yogurts with walnuts, hazelnuts, almonds or pistachios [30].

Presence of almonds in yogurt has enriched dietary fiber content [32].

Almond supplementation has led to an increase in protein levels in fortified yoghurts compared to control yoghurts [32]. Walnuts, hazelnuts, almonds or pistachios incorporated in yoghurts have improved protein content [30].

Water content of yogurt samples with added gum from basil seeds decreased compared to unfortified samples [31]. In samples of fortified yogurt with walnut, hazelnut, almond or pistachio, a reduction in syneresis was observed compared to control yogurt [30].

Folic acid, α-tocopherol levels were higher in fortified yoghurts with walnuts, hazelnuts, almonds or pistachios compared to control yogurt [30].

Antioxidant activity of fortified yoghurts has been significantly improved by addition of hazelnut skin [33]. Level of polyphenols and flavonoids increased significantly in almond fortified yogurt, hazelnut skin compared to control yogurt [32, 33]. A direct correlation between percentage of addition and content of polyphenols and flavonoids has also been reported in use of gum from basil seeds [31].

Microbiological examination results

Enrichment of yogurt with flaxseed, hazelnut skin in yogurt significantly affected viability of L. acidophilus acted to stimulate its development (up to 8.82 CFU / mL) compared to the control sample (6.87 CFU / mL) [29, 33]. Addition of hazelnuts, almonds or pistachios also increased the number of *S. thermophilus* and *L. bulgaricus* [30].

2.6. Yogurt with honey and bee products

Sensory examination results

Sensory examination showed an excellent acceptability of yogurt samples with addition of honey, pollen and propolis. However, control sample was in top of preferences. Honey has positively influenced color of fortified yogurts, which are better appreciated than control ones [34, 80]. Yogurt variant with addition of pollen in small quantities obtained higher scores than plain yogurt variant [81] due to characteristics of texture and color, taste and smell Naseron *et al*, (2016).

Physico-chemical examination results

The pH value of yogurt with pollen and / or honey was lower than that of plain yogurt [34, 65, 80]. Acidity of yogurt with pollen was directly correlated with amount pollen from product [81]. Titratable acidity of pine honey fortified yogurt has increased with increase in ratio of added honey [80]. Combination of honey, royal jelly and pollen stabilized acidity of fortified yogurt [82]. Addition of propolis reduced acidity in direct proportion to amount added [34]. Naseron *et al*, (2016) using pasture as a substitute for production starter cultures to obtain yogurt observed an increase in pH value of those samples compared to pH of traditional yogurt traditionally obtained with starter cultures.

Compared to plain yogurt, the replacement of starter cultures with bee pasture has reduced the acidity of yogurt [83].

Supplementation with royal jelly has reduced fermentation time [83]. Similar results have been reported in case of addition of pine honey to yogurt [80].

Addition of honey in yogurt was directly correlated with the carbohydrate content [34].

Moisture content of yogurt with added pollen was lower compared to blank sample [81]. Water content of plain yogurt varied very little from that of yogurt obtained by using feed for intake of lactic acid bacteria [83] increasing ratio of added honey [80].

Yogurt samples with addition of royal jelly and / or pollen were more stable during cold storage, syneresis being significantly reduced compared to control sample [35]. Addition of royal jelly has led to an increase in water retention capacity and viscosity of yogurt in direct correlation with the level of supplementation [84].

Antioxidant activity of yogurt samples was strongly influenced by additives. While honey and pollen improved antioxidant activity of yogurts, propolis (extract) reduced antioxidant activity of samples in which it was added [34]. Significant increase in polyphenol content has also been reported in case of fortification of donkey milk kefir with increasing amounts of honey [Perna et al (2019) quoted by [84]]. Presence of royal jelly in yogurt has substantially improved its antioxidant activity compared to the control [84]. Also, polyphenol content of yogurt has increased in proportion to level of supplementation of royal jelly [84]. Pollen and propolis have made a modest contribution to increasing content of mineral salts in yogurts in which they have been added, but honey has contributed substantially to increasing the content of minerals [32].

Microbiological examination results

During storage, in yogurts with added honey, number of viable cells of *L. bulgaricus* and *S.*

thermophilus decreased [65, 80]. During storage of pine honey yogurt, number of *Streptococcus thermophilus* did not change much and was higher than control samples Coskun and Dirican (2019). Compared to yogurt without addition of royal jelly, fortified yogurt had significantly more probiotics *Lactobacillus helveticus* [80], possibly due to beneficial effect of royal jelly on the growth of microorganisms and availability of lighter sugar (glucose) [Caplice and Fitzgerald, 1999, quoted by [84]].

3. Consumer benefits

The popularity of yogurt, combined with the benefits of its consumption has major advantages for obtaining fortified yogurts. Studies on yogurt fortification have provided valuable information for both producers and consumers and researchers. Various conclusions have been drawn that converge on several ideas: use of yogurts for intake of lactobacilli and exogenous nutrients, improvement of nutritional value and sensory / physico-chemical characteristics, prolongation of the validity of yogurts, respectively ways of ingesting valuable bioactive substances. consumers may be reluctant. Thus, for example, addition of carrots in form of "caviar" is an alternative to increase the consumption of carrots among children, promoting healthy eating habits. At same time, fortified carrot yogurt can be a way to fight vitamin A deficiency [7,17].

Major benefit of consuming fruit yogurt is potential of fruit prebiotics that act to maintain viability of probiotic bacteria in yogurt, contributing to proper activity of colon [4].

Yogurt consumption can be recommended in various pathologies: hypertension, diabetes, cancer. It has been observed that introduction of *Cinnamomum verum* into yoghurt inhibits enzymes such as α-amylase and α-glucosidase whose activity is associated with diabetes [[21, 17], Shori and Baba, (2012, 2018), quoted by [1]]. Also, addition of rosemary, dill, oregano and ginger inhibited the activity of α-amylase about 5 times, which makes these yogurts can be used successfully in the treatment of postprandial hyperglycemia [24, 26].

Similar inhibitory effects of acetylcholine esterase, α-amylase and α-glycosidase inhibition have been reported in yogurts prepared with dill, mint, basil [Amirdivani, (2007) quoted by [1]] oregano, garlic [26], compared to plain yogurt, providing premises for effective use of these fortified yogurts in the treatment of hypertension and type II diabetes and degenerative diseases [[26], Amirdivani, (2007) quoted by [1]]. Addition of neem in yogurt has had a beneficial effect on activity of enzymes involved in diabetes and high blood pressure [Shori and Baba, (2011a), quoted by [1]]. Strengthening yogurt with dietary fiber from various natural sources increases the health benefits [79]. Prebiotic properties and immunogenic effects of wheat bran, blueberries, horns make it possible to use yogurt as a product with properties, neuroprotective, cardioprotective, antioxidant, immuno-modulatory and anti-inflammatory [38].

Fortified yogurt can be an effective tool for reducing oxidative stress. For example, yogurt with *Gnaphalium affine* extract could improve activity of antioxidant enzymes, including superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px), and could also lead to a significant decrease in of malondialdehyde (MDA) in animal sera [47]. Addition of royal jelly has significantly improved the antioxidant, antimicrobial and anticancer activities of probiotic fermented milk [84].

Supplementing yogurt with Moringa oleifera provides exceptional nutritional benefits [41, 49, 52].

3. Conclusions

Recent studies have highlighted the reasons to evaluate possibilities to use various natural sources of valuable nutritional compounds in yogurt technology. Results reported in this paper may be useful for dairy industry in order to improve nutritional and sensory properties of yogurt with natural compounds with proven benefits on consumer health, and also to extend the assortments range of yogurt. All studies show improvement of sensory, nutritional properties, with real benefits for consumers.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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