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Review

Tradition and Innovation in Yoghurt from a Functional Perspective—A Review

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Abstract: Yoghurt is one of the most consumed and studied dairy products, with proven functional effects on the human body. This review discusses the functional properties of traditional yoghurt products in comparison with different other yoghurts enriched with natural bioactive compounds like bee products, aromatic plants, fruit, vegetables, extracts, edible flowers, mushrooms, and high protein ingredients. The food industry aims to enhance the nutritional profile of final products, recognising the potential value they bring. Yoghurt, acknowledged as a functional food, has garnered significant attention globally in terms of production and consumption. Incorporating flavours through essences, fruit, fruit extracts, and honey is considered a preferable alternative to artificial flavours for innovating new dairy products. While the review underscores the positive properties of natural additives, it also addresses the possible changes in physicochemical properties and storage stability when yoghurt is enriched beyond the basic elements. A compelling synthesis of the data reveals the remarkable finding that the majority of functional yoghurts incorporate bee products. In recent years, the dairy industry has seen a rise in combining probiotics and functional foods, especially with the development of probiotic functional yoghurts.

Keywords: yoghurt; functional food; natural compounds

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1. Introduction

Yoghurt, a widely consumed dairy product, has a rich cultural and historical background. For centuries, fermentation has served as a method to enhance the longevity of perishable foods while simultaneously elevating the taste and aroma of the final product [1]. Yoghurt is the outcome of fermenting pasteurised or sterilised milk using protosymbiotic cultures of *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* [2].

The manufacturing of yoghurt on an industrial scale relies on numerous factors, such as the types and quantities of starter cultures used, raw materials, the variety of milk, as well as considerations like temperature, pressure, and various other aspects [3].

Fortification involves the addition of bioactive components, nutrients or non-nutrients, food ingredients or supplements. This practice serves several purposes, including addressing or preventing widespread deficiencies in nutrient intake, balancing the overall nutrient profile of a diet, restoring nutrients lost during processing, and catering to consumers who desire nutritional supplementation [4]. Yoghurt, in particular, stands out for its elevated concentrations of several micronutrients such as riboflavin, vitamins B-6 and B-12, calcium, potassium, zinc, and magnesium, surpassing levels found in other dairy products like milk [5].

In the present era, there is a trend of incorporating different food elements into food products to enhance their health-promoting properties [6]. An example of this is evident in functional probiotic yoghurt. Foods that extend beyond basic nutritional content and exert positive effects on physiological functions, contributing to health improvement or disease risk reduction, fall under the category of functional foods [7]. Consequently, functional foods not only contain nutrient-dense ingredients but can also be fortified with vitamins, minerals, probiotics, prebiotics, and fibres to further enhance their health benefits [8].

Functional foods are characterised by the intentional modification of concentrations in one or more ingredients to amplify their positive impact on a healthy diet [9]. These foods, whether natural or processed, are required to incorporate biologically active compounds that have been substantiated to provide proven health benefits, as researched by Meybodi et al. [9], a criterion that extends to include probiotic foods when consumed in sufficient quantities.

Initially, a probiotic was described as a live microbial food supplement capable of positively influencing the host by enhancing its intestinal microbial balance [10]. However, a subsequent reformulation of this definition emerged, defining probiotics as "live micro-organisms that, when administered in adequate amounts and consumed regularly, confer a health benefit to the host" [11].

In response to this evolving understanding, the food industry has displayed a growing interest in developing and marketing innovative dairy products incorporating probiotic micro-organisms with potential health benefits for humans [12].

In the past, functional compounds like fruit, plant parts, edible flowers, seeds, and bee products were commonly used. However, the current trend is to explore more unconventional functional compounds such as microalgae, fungi, mushrooms, exotic fruit, and spices to enhance the functional value of products [13]. Additionally, there is a growing interest in high-protein products, as people increasingly adopt a healthy lifestyle focused on sports and a balanced diet [14]. Particularly the use of bee products in fortifying yoghurt is high. Various studies have been conducted to highlight how these ingredients influence yoghurt as the final product with functional properties in various regions of the world [13].

Damage resulting from oxidative stress can contribute to the development of human diseases such as cardiovascular diseases, cancers, and aging [15]. Antioxidants play a crucial role in preventing and treating these chronic conditions. Functional foods, rich in phytochemicals, act as bioactive pharmaceuticals with positive effects on organs [16]. Phytochemicals, synthesised by plants, are commonly found in fruit, vegetables, grains, beans, and other plant-based sources, encompassing tannins, alkaloids, steroids, saponins, flavones, and various other groups. Among approximately 10,000 phytochemicals, those with antioxidant activity, including phenolics, carotenoids, flavonoids, and compounds like vitamin C, have been reported to prevent chronic diseases by reducing reactive oxygen and nitrogen species, thereby safeguarding organs and cells from damage [15].

The ongoing research seeks to elucidate the nuanced advancements in innovation within the realm of acidic dairy products, delving into its multifaceted evolution from various scientific and industrial perspectives. Therefore, recognising this consumer trend, this paper aims to highlight classical functional compounds already used on an industrial scale and new trends that have not yet reached an industrial scale but hold genuine potential. This review examines both the traditional aspects and contemporary innovations of yoghurt. In addition to its conventional form, fortified yoghurt is highlighted for its nutritional enhancement, incorporating additional micronutrients to address specific dietary needs. The emergence of functional yoghurt is also explored, with ongoing research investigating potential health benefits associated with bioactive compounds and probiotics.

2. Industrial Preparation Process of Yoghurt

Yoghurt production begins with the milking of mammals, followed by a series of carefully executed procedures that end with the packaging of the resulting yoghurt product [17]. The pre-treatment phase involves the manipulation of milk composition prior to processing.

In the production of set or stirred yoghurt, this manipulation may involve the incorporation of milk solids to attain a specific viscosity [18]. The pre-treatment process includes the regulation of the fat content in the milk. This involves standardising the milk through various methods, such as extracting a portion of the fat content, mixing whole milk with skimmed milk, adding cream into full-fat or skimmed milk, or employing a combination of these techniques with the aid of standardisation centrifuges [18]. Homogenisation is the next step in the process of obtaining yoghurt, which impacts the chemical and physical aspect of the milk. In this process, the large fat globules are divided in smaller ones [19]. The purpose of this process is to prevent the separation of the cream layer and to ensure uniform mixing of any dairy ingredients added to the milk [18].

Traditional heat treatment methods encompass thermalisation, low-temperature and high-temperature pasteurisation, ultra-heat treatment, and sterilisation. The utilisation of heat treatment in milk exerts influence on its flavour, microbial composition, and milk proteins. The degree of heat treatment intensity correlates with the magnitude of alterations. Furthermore, heat treatment impacts the texture of the resultant yoghurt, augmenting the value of its textural attributes and viscosity [17]. Following heat treatment, the milk undergoes cooling to attain the specified inoculation temperature, typically ranging between 40 and 45 °C, before the introduction of the starter culture [20]. The classical yoghurt starter culture is a mixture of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*, with a ratio of usually 1:1 [21].

The outcomes of the final product can be influenced by the conditions during incubation. In general, thermophilic lactic acid bacteria exhibit an optimal temperature range of 40 to 43 °C. The consensus has been that lower fermentation temperatures prolong the time required to reach a specific pH and, consequently, firmness, resulting in a firmer final product [22]. Upon reaching a pH of 4.3–4.7, yoghurt is cooled to approximately 5 °C to suppress the growth and metabolic activity of the starter culture, preventing further acidity. Cooling can occur in one or two phases. One-phase cooling involves rapid cooling to below 10 °C, resulting in yoghurt with low viscosity. Two-phase cooling involves a swift drop to less than 20 °C, followed by a gradual decrease to the storage temperature of 5 °C, yielding yoghurt with increased viscosity and limited syneresis, a common practice, especially when incorporating fruit in the manufacturing process [23].

Modern dairy science and nutrition have suggested the involvement of probiotic cultures and prebiotic ingredients in order to increase the nutritional value of dairy products, while minimising detrimental effects on the sensory characteristics [17].

The detailed procedure explored by Nagaoka [24] outlines the production of three types of yoghurt: set yoghurt, stirred yoghurt, and drinking yoghurt (Figure 1). These steps highlight variations in production, from the traditional set yoghurt to the less firm stirred yoghurt, and finally, the liquid drinking yoghurt enriched with stabilisers, sugars, and flavours.

At the technological level, there have been innovations described a decade ago, as presented by Sfakianakis et al. [17]; however, in his review, the focus was on the addition of bioactive substances.

Consumers have a variety of flavour options to suit their preferences, including traditional fruit flavours such as strawberry and blueberry [25]. Currently, strawberry stands out as the most popular flavour in the market [26]. In response to the growing demand for healthier choices, manufacturers are producing low-fat and non-fat versions of their top-selling flavours [13]. The functional food market, especially in the yoghurt segment, has experienced significant growth in recent decades, largely due to the seamless integration of pre- and probiotics. However, the introduction of prebiotics to yoghurt has been found to adversely affect its sensory characteristics, which may deter consumers [27]. Despite its popularity, yoghurt still has a relatively short shelf life compared to other fermented products. To address this limitation, novel manufacturing techniques like made-in-transit (MIT) are under consideration as a means to extend the shelf life of yoghurt [27].

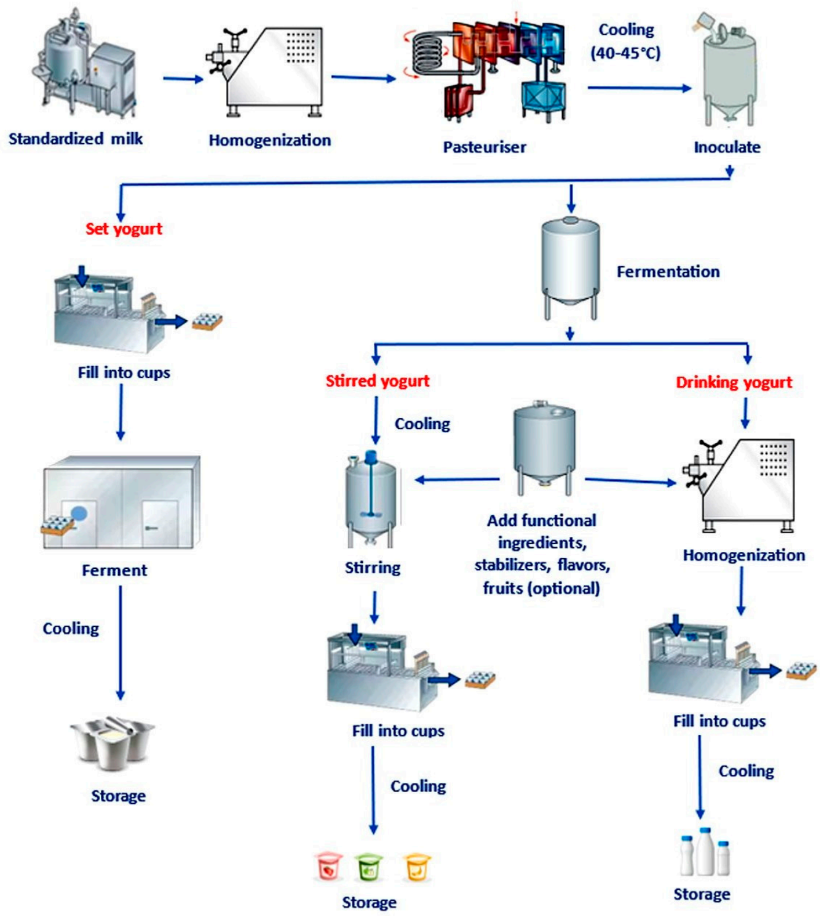

Figure 1. Yoghurt types and their industrial preparation processes.

3. Functional Ingredients and Their Biological Activity

3.1. Ingredients Used to Increase Functional Properties of Yoghurts

Natural functional ingredients, including bee products (honey, propolis, pollen, and royal jelly), fruits (strawberry, banana, blueberry, aronia, papaya, mango, watermelon, cantaloupe, kaki, and apple), and hibiscus, are recognised for their abundant reserves of bioactive compounds with potential health benefits. These ingredients already serve as common valuable components for food fortification and the development of functional foods.

In the following, there will be information provided on the biological active potential of the most common ingredients used in yoghurt, like honey and other bee products, cassava, cantaloupes, high protein ingredients like quinoa, oyster mushroom, chickpea flour, spirulina, moringa, and the latest trends of functional ingredients: aloe vera, kombucha, *Auricularia auricula*, saffron, turmeric, mushrooms, nutmeg, okara, cumin oil, green banana flour, carob, coffee, and *Artemisia absinthium* L.

3.1.1. Fruit

Similar to yoghurt, fruit has long been recognised as a valuable nutritional resource, linked to various health advantages. Combining these nutritional elements, the integration of fruit and yoghurt can result in a highly nutritious food product. Moreover, there is a proposition that plant-based foods possess the capacity to influence microbiota, similar to the effects of probiotics and prebiotics, thereby enhancing cardiovascular health [26]. Fruit are rich in numerous compounds with a positive effect on human health, serving as an excellent source of dietary fibre, antioxidants, phenolic compounds, and carotenoids, as reported in the scientific literature (Table 1).

Researchers have explored the production of enriched yoghurt by incorporating various fruit pulps or extracts, including but not limited to grapes and berries as explored by

Dimitrellou et al. [28] and Karnopp et al. [29], papaya and cactus pear after Amal et al.'s [30] research, apple pomace and sea buckthorn after Selvamuthukumaran et al.'s [31] research, a combination of orange, pineapple, grape, banana, and rutub date (*Phoenix dactylifera* L.) as found by Ismail et al. [32], and pomegranate [33].

The incorporation of fruit flavours into yoghurt is a nuanced process. Beyond enhancing the yoghurt's nutritional profile, these alterations also have a significant impact on various physical and chemical attributes, including texture, pH, acidity, syneresis, and water-holding capacity. Furthermore, the stability of the yoghurt can either increase or decrease in comparison to plain yoghurt. The magnitude of these changes is contingent upon the concentration of the fruit flavour utilised. For instance, Amal et al. [30] observed that the addition of 15% cactus pear resulted in an increase in yoghurt acidity over a 5-day storage period, along with an augmentation in its water-holding capacity. Conversely, syneresis decreased in the yoghurt with 15% cactus pear compared to plain yoghurt. Similarly, Wang et al. [34] investigated the addition of apple pomace to yoghurt at various concentrations, reporting comparable outcomes where the physicochemical properties of the yoghurt were influenced.

Banana stands among the most consumed fruits globally and is nutritionally rich, boasting diverse minerals. It exhibits elevated concentrations of calcium, magnesium, and potassium, along with an array of antioxidants, including vitamins A, C, and E [35]. In addition to minerals, the banana fruit is abundant in amylose, starch, and dietary fibre, serving as a source of proteins. Notably, bananas also contain substantial amounts of β-carotene, lycopene, and phenols, all of which are crucial for human health [35]. Nevertheless, alternative forms of banana products, such as pulp, powder, and flour, are also employed in yoghurt preparation, yielding varied outcomes in the final product. For example, Çakmakçi et al. [36] utilised banana puree in the production of probiotic yoghurt, investigating its effects on acidity, pH, bacterial counts, and sensory attributes across different storage durations. The bacteria count of probiotics decreased throughout the storage period of 7 days, whereas mould and yeast count increased over time. [36]

The majority of experiments involving apples in yoghurt production primarily employ apple pomace due to its nutritional features and the fact that it is often discarded as waste. Consequently, to repurpose the waste and extract nutritional benefits from it, experiments were focused on utilising pomace and its derivatives [37]. The extensive use of apple pomace in the dairy industry is attributed to its stabilising properties and its role as a texturiser [38].

Comparable results were documented by Wang et al. [34], indicating that the inclusion of apple pomace powder led to heightened cohesiveness and firmness in yoghurt. The study observed that the introduction of apple pomace powder strengthened the casein gel structure. Notably, this effect was significant with a 1% concentration of apple pomace powder, whereas it was not observed with a 0.5% concentration. The authors attributed this phenomenon to the gelling properties of the apple pomace particles, which facilitated the formation of a consistent gel structure [39].

Strawberry-flavoured yoghurt is the predominant choice among consumers, representing approximately 70–80% of sales in Brazil [40]. Despite their presence in small quantities, strawberries contain essential fatty acids, including unsaturated ones, as documented by the USDA in 2010. Additionally, strawberries serve as a source of manganese, with a 144 g serving supplying over 20% of the recommended daily intake for this mineral. Moreover, the same amount provides approximately 5% of the recommended daily intake for potassium [41]. The composition of the sample reveals a delicate balance: moisture levels gently oscillate around the high seventies, while fat content exhibits a subtle decline. Ash content and acidity maintain a gradual descent, suggesting a harmonious progression. Total solids, in their steadfast consistency, hint at stability amidst this symphony of components. pH levels whisper a tale of nuanced acidity, weaving a narrative of subtlety and refinement [40].

Cantaloupe has therapeutic effects which are of great interest for the development of functional foods such as yoghurt. Melons (*Cucumis melo* L.) belong to a species of plant belonging to the Cucurbitaceae family, subdivided into botanical groups, among them Reticulatus, which is considered noble, because of its better-quality fruits, with characteristic aroma and flavour [42]. The cantaloupe melon is a fruit rich in bioactive compounds that contribute to improve health. In addition to containing phenolic compounds, it is considered a source of β-carotene, which contributes to the orange coloration of the pulp [43]. The addition of cantaloupe in natural yoghurt ameliorates the load of lactic flora and modifies the rheological property of the new products [44]. The results of Kermiche et al.'s [44] study showed that the addition of cantaloupe to yoghurt significantly improved its quality.

These natural functional ingredients offer a diverse array of bioactive compounds, contributing to their health-promoting properties. All these ingredients have an important biological activity in common: antioxidant properties. The consumption of antioxidant-rich foods can lower the risk of chronic diseases. The antioxidant potential is inherent in plain yoghurt, with the fermentation process generating amino acids and small peptides that contribute to antioxidant effects. Additionally, the presence of reducing sugars, fatty acids, oligosaccharides, and lactic acid bacteria in yoghurt serves as reducing agents with antioxidant properties [45]. However, the incorporation of natural functional ingredients into yoghurts is pivotal for enhancing antioxidant activity, given their rich content of antioxidant components such as polysaccharides, phenolics, flavonoids, anthocyanins, and more [46,47].

Table 1. The addition of fruits to yoghurt and their functional roles.

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Strawberry	0%, 5%, 10%, 15%	Moisture (%): 71.79, 71.83, 71.85, 71.93 Fat (%): 4.72, 4.35, 4.11, 4.07 Ash (%): 0.78, 0.75, 0.72, 0.69 Acidity (%): 0.7, 0.8, 0.8, 0.9 Total solids (%): 28.21, 28.17, 28.15, 28.07 pH (%): 4.48, 4.00, 3.98, 3.97	Anthocyanins, saturated monounsaturated, polyunsaturated acids	Anti-inflammatory, antioxidant activity	[40]
Watermelon	0%, 5%, 10%, 15%	Protein (%): 3.80, 3.72, 3.61, 3.53 Fat (%): 3.75, 3.63, 3.49, 3.37 Acidity (%): 0.67, 0.72, 0.75, 0.79 Total solids (%): 25.40, 25.15, 24.87, 24.65 Carbohydrates (%): 17.13, 17.19, 17.26, 17.37 Syneresis decreases with the addition of watermelon but increases with storage period	Lycopene, vitamin C, B1, B6, potassium, magnesium, zinc	Anti-inflammatory properties	[35]
Banana puree	15 g banana marmalade in 100 g yoghurt	The count of bacteria decreased throughout the 7 days of storage, whereas mould and yeast counts increase	Amylose, starch, dietary fibre, protein, vitamins, minerals	Probiotic effect	[36]

Table 1. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Strawberry tree and hawthorn	8 mg/mL, 12 mg/mL	Proteins (g/100 g extract) 1.40 ± 0.06 Reducing sugar (g/100 g extract) 48.50 ± 5.10 TPC (mg GAE/g extract) 17.93 ± 4.17 α-Amylase inhibition (%): 5.46 ± 0.65 α-Glucosidase inhibition (%) 54.07 ± 9.90	Phenolic acids, flavanols, anthocyanins	Antioxidant, antidiabetic properties	[48]
Aronia	0%, 5%	pH: decreases during storage period Acidity (%): no significant difference during storage period Reducing sugars (%): significantly higher when compared to the control but decreases during the storage period Syneresis (%): increases with the addition of aronia juice and during the storage period Total phenolic content (μg GAE g^{-1}): 56.5	Phenolic compounds	Antioxidant activity	[28]
Papaya	0%, 5%, 10%, 15%	Fat (%): 3.75, 3.68, 3.57, 3.44 Acidity (%): 0.67, 0.70, 0.73, 0.77 Total solids (%): 25.40, 25.20, 25.02, 24.87 Carbohydrates (%): 17.13, 17.11, 17.17, 17.26	Enzymes, carotenoids, alkaloids, phenolics, glucosinolates	Anti-inflammatory, antioxidant activity	[30]
Goldenberry	10%, 20%	Moisture: 88.40% Protein: 1.06% Fat: 0.16% Ash: 0.80% Total phenol (mg GAE/100 mL): 112.40% Ascorbic acid: (mg/100 mL) 52.68 Carotenoids (μg mL^{-1}): 86.54 % DPPH Inhibition 78.34	Phenolics, carotenoids, ascorbic acid	Antioxidant activity, antihepatotoxic effect	[49]
Mango peel	2%	Moisture: 69–76% Fat: 0.01–2.97% Ash: 2.7–6.39% Protein: 1.52–3.57% WHC: 55.3–63.23%	Carotenoids, flavonoids, phenolic compounds	Antidiabetic, antibacterial, antioxidant activity	[50]

Table 1. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Apple pulp	5%, 10%, 15%	Acidity increases and pH decreases during the storage period Moisture decreases while fats, proteins, and total solids increase over the storage period with the addition of apple pulp Viscosity increases for the first 5 days and subsequently decreases while syneresis increases with the storage period	Polyphenols, minerals, vitamins	Antioxidant, anti-inflammatory activity	[51]
Apple pomace powder	0.1%, 0.5%, 1.0%	Syneresis values varies irregularly during the storage period Firmness, cohesiveness, and consistency increase with the concentration and during the storage period	Dietary fibre, polyphenols, high-methoxyl pectin	Antioxidant activity	[39]
Apple pomace powder	0%, 3%, 6%, 9%	Total phenolic content (mg GAE/g): 3.39, 3.67, 3.99, 4.12 Total flavonoid content (CE mg/g): 1.21, 1.24, 135, 1.46 Syneresis (%): 9.17, 9.77, 10.13, 10.34 Fat (%): 4.11, 4.03, 3.91, 3.84 Protein (%): 15.27, 15.09, 14.57, 14.17	Polyphenols, minerals, vitamins	Antioxidant activity	[47]
Sour orange, sweet orange, lemon	0.5%, 1%, 2%	The addition up to 0.5% of different types of citrus (SO, SWO, and LO) peel powders in milk does not change the overall acceptability scores of the synbiotic yoghurt statistically significantly ($p < 0.05$)	Pigments, antioxidant compounds	Antioxidant acidity, antibacterial activity	[52]
Bael fruit pulp	0%, 5%, 10%	Slight increase in the pH/acidity of the product LGG significantly reduces the degree of syneresis; bael fruit extract further reduces syneresis when combined with LGG Enhance probiotic viability up to 14 days of storage	Carotenoids, phenolics, alkaloids, flavonoids	Antioxidant activity	[53]
Cantaloupe powder and puree	0%, 5%, 10%	Ameliorates the load of lactic flora and modifies its rheological properties	β-carotene, vitamin A, vitamin C	Decreasing antioxidant activity	[44]

Table 1. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Kaki	0.0002%	Supplementation of plant extracts do not affect the initial pH and titratable acidity, which ranged from 6.51 to 6.66 and from 0.10 to 0.13%, respectively Supplementation of plant extracts, as prebiotics, decreases fermentation time and increases the viability of yoghurt starter cultures	Carotenoids, flavonoids	Antioxidant, anti-inflammatory activity	[54]
Kaki	5%, 10%, 15% 20%	Yoghurt sample with 20% persimmon fruit has the highest Fe and Zn contents both when fresh and after storage Microbial population decreases with the increase in fresh persimmon fruit levels and after a storage period	Phenols, flavonoids, carotenoids	Antioxidant, antimicrobial activity	[55]
Sea buckthorn	1%, 2%	Enhanced the texture of the yoghurt Protein (%): 3.25 ± 0.06 Total solids (%): 16.01 ± 0.02 Ash (%): 0.75 ± 0.09 Fat (%): 3.38 ± 0.033 pH: 4.51 ± 0.05	Polyphenols, tocopherols, carotenoids	Antioxidant, cytoprotective, antibacterial effect	[56]

TPC = total phenolic content; mg GAE/g = milligrams of gallic acid equivalents per gram of extract; WHC = water-holding capacity; DPPH = 2,2-Diphenyl-1-picrylhydrazyl; SO = sour orange; SWO = sweet orange; LO = lemon; LGG = *Lactobacillus rhamnosus* GG.

3.1.2. Honey and Bee Products

Natural sweeteners like honey are considered superior choices for enhancing the flavour of yoghurt compared to artificial alternatives (Table 2). Honey, a well-regarded product, is distinguished by its elevated levels of antioxidants, encompassing phenolics, flavonoids, and carotenoids. Furthermore, honey possesses distinctive sensory attributes, encompassing taste and aroma, contributing to its popularity among consumers [57].

Honey is a complex food substance. The major components in honey, on average, are water (17.2%), fructose (31.3%), sucrose (1.3%), maltose (7.3%), polysaccharides (1.5%), free acids (0.43%) such as gluconic, formic, oxalic acids, etc., ash (0.169%), and nitrogen (0.041%). Minor substances, minerals, vitamins, hormones, enzymes, antioxidants, and other unidentified components are responsible for the most important honey properties [58].

As shown by Machado et al. [57], goat milk supplemented with stingless bee honey in yoghurt production has improved properties, with improvements observed at different honey concentrations. The acceptability and overall willingness to purchase shows an upward trend with increasing honey concentration. Challenges encountered included a marginal rise in syneresis and a decrease in water-holding capacity during storage. Similarly, Coskun et al. [59] utilised pine honey in the preparation of functional yoghurt, yielding comparable outcomes. However, a nutrient analysis of the resultant yoghurt was not conducted. Studies involving ingredients like moringa, honey, and aloe vera have yielded diverse outcomes, potentially attributed to variations in products, species, or experimental conditions. The sensory properties of the yoghurt with added honey were the same for 2% and 4% added honey, while the brightness of the yoghurt decreased during the storage period [59]. There exists a necessity for further research in this domain of food production to achieve yoghurt with heightened stability, improved flavour, enriched nutrition, and enhanced bioactive compounds.

Propolis is a resinous substance obtained from different parts of the plants by honeybees. Propolis is a natural mixture with a strong odour, is not very soluble in water, and has a viscous and sticky texture. In terms of biological activity, it is well known for its antioxidant, antimicrobial, anti-inflammatory, and antitumor activities, thanks to the high presence of phenolic and volatile compounds [60]. In Gunhan et al.'s [61] research, they tested the effect of the antioxidant and antimicrobial features of powdered propolis encapsulated in the characteristics of yoghurt. The addition of encapsulated propolis with different encapsulants significantly affected ($p < 0.05$) the dry matter, protein, and ash of yoghurt samples [61].

Bee pollen, a product formed by the aggregation of pollen particles by worker honeybees into pellets, exhibits a dynamic chemical profile influenced by the diverse plant sources foraged by the bees. While lacking a precisely defined chemical formula, the general constitution is characterised by an average distribution comprising 40–60% simple sugars, specifically fructose and glucose, 20–60% proteins, 3% minerals and vitamins, 1–32% fatty acids, and 5% miscellaneous components, such as significant quantities of vitamins, flavonoids, and phenolic acids, among others [62]. Bee pollen has exhibited a multitude of health-promoting effects, including but not limited to antifungal, antimicrobial, antiviral, anti-inflammatory, hepatoprotective, anticancer, immune-stimulating, and localised analgesic properties [63]. The titratable acidity ranges from 90.00 to 110 °T, while the active acidity, measured by pH, falls between 4.40 and 4.48. The dry matter content is within the range of 12.6% to 12.8%. The vitamin C content varies from 0.08 to 0.85 mg/100 g. The electrical conductivity levels range from 12.83 to 13.79 mS/cm [64].

Royal jelly is another important bee product. Royal jelly, a glandular secretion synthesised by worker bees for the nourishment of young larvae and queens, falls within the category of "dietary supplements". Its utilisation is not primarily attributed to its rich composition of noble substances, but rather to its presumed stimulating and therapeutic properties [65]. Designating it as a medicinal product would entail a dependency on medical prescriptions, confining the production and distribution of royal jelly-based products exclusively to the pharmaceutical industry. These findings augment the role of honeybee products as inhibitors for micro-organisms in stored foods [66].

Table 2. The addition of honey and bee products to yoghurt and their functional roles.

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Honey and spirulina powder	8.5%	With an increase in the enrichment level from 0 to 1.5 percent, there is a significant increase in protein from 3.803 to 7.090 percent and total solids from 19.64 to 24.32 percent	Phenolic acids, flavonoids	Antimicrobial	[67]
Black cumin honey	0%, 2.5%, 5%, 10%, 15%	Antioxidant activity ranges from 14.33 to 17.41 mM TE, while total phenolic compound content varies between 202.50 and 1415.00 mg GAE/kg Significant differences in phenolic content are observed between yoghurt containing black cumin honey and the control during storage ($p < 0.05$)	Polyphenols	Antioxidant activity	[68]

Table 2. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Honey and vitamin C	2% honey 50 mg/kg vitamin C	The initial pH values of the fresh fermented milk products are similar across all samples (4.29–4.32), showing a slight but significant decrease ($p < 0.05$) after 24 h (4.22–4.24), which remains stable until the end of the storage period (4.15–4.16)	Polyphenols	Enhance the viability of yoghurt culture and bifidobacteria	[69]
Manuka honey	5%	The addition of manuka honey maintains a high probiotic survival (7.0 log CFU/mL) after the three-week refrigerated storage (4 °C) The pH values significantly ($p < 0.05$) decrease during the storage period for all the yoghurt types from day 7 onwards	Oligosaccharides, methylglyoxal	Antibacterial activity	[70]
Pine honey	0%, 2%, 4%, 6%	Bacterial count, pH, water-holding capacity, and bacterial count (*L. delbrueckii* and *L. acidophilus*) decrease during the storage period The sensory properties of the honey-added yoghurt are similar for 2% and 4% added honey, while the brightness of the yoghurt decreases during the storage period	Ascorbic acid, peptides, enzymes	Antimutagenic, antibacterial antioxidant activity	[59]
Honey and bee pollen	5%, 10%, 15% honey, 0.4%, 0.6%, 0.8% bee pollen	Titratable acidity: 90.00–110 °T Active acidity, pH: 4.40–4.48 Dry matter: 12.6–12.8% Vitamin C: 0.08–0.85 mg/100 g Electrical conductivity: 12.83–13.79 mS/cm	Polyphenols, carbo-hydrates	Reduces the risk of contamination of the product with unwanted microflora	[64]
Rape honey	1%, 3%, 5%	Dry matter content increases with higher additions of honey, while fat content decreases pH values of yoghurt decrease during storage The sample with the highest addition of rape honey shows the lowest firmness and cohesiveness	Carbohydrates, glucose, fructose, phenolic compounds	Antioxidant, bacteriostatic, anti-inflammatory, antimicrobial	[71]
Royal jelly and bee pollen	0.1% to 0.5%	The present findings augment the role of honeybee products as inhibitors for micro-organisms in stored foods	Amino acids, glucose oxidase, phenolic compounds	Antibacterial, antioxidant activity	[66]
Honey and royal jelly	4% bee honey (BH) 4% bee honey + 0.2% royal jelly (RY) 0.6% royal jelly	The presence of BH or RJ has an insignificant influence on fat content, while cold storage significantly increases the mean values of fat and total nitrogen and ash contents, as a result of water loss	Minerals, vitamins	Antibacterial activity	[72]

Table 2. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Propolis	5%, 10%, 20%	The addition of 2% water extract of propolis (20% extract) to raw milk resulted in acceptability of the yoghurt up to 12 and 48 h at 30 °C and 5 ± 1 °C, respectively	Phenolic compounds, flavonoids	Antioxidant activity	[73]
Propolis	0%, 0.5%, 1.0%, 1.5%, and 2.0%	Compared to the control, the best organoleptic test results are obtained for market milk, yoghurt, and kefir supplemented with 0.5% propolis	Phenolic compounds, flavonoids, esters, terpenes	Antiseptic, anti-inflammatory, antioxidant, antibacterial, antifungal, antiulcer, anticancer, antitumoral	[74]
Propolis	0.05 and 0.1%	The addition of encapsulated propolis with different encapsulant affects significantly ($p < 0.05$) dry matter, protein and ash of yoghurt samples.	Volatiles, phenolic compounds	Antioxidant, antimicrobial, anti-inflammatory activity	[61]

CFU = colony forming unit.

3.1.3. Legumes, Root Vegetables, Flowers, and Spices

Several root vegetables (carrots and cassava), flowers (roselle, jasmine, and lavandula) or spices (cinnamon) have been used to enrich the yoghurt's biologically active compounds (Table 3).

Cassava (*Manihot esculenta*) is a high-carbohydrate tropical root crop, and the starch-rich thickened roots or tubers are the parts used as human foods and starch-based industrial raw material [75]. Additionally, cassava contains phytochemicals like flavonoids, saponins, and tannins, contributing to its antioxidant and anti-inflammatory properties. The resistant starch content in cassava can positively impact gut health by serving as a prebiotic, supporting the growth of beneficial gut bacteria [76]. The study showed that the titratable acidity of cassava yoghurt increased gradually from 0.64% in the beginning to 0.78% at 15 days of storage. Yeast and mould populations in all the yoghurts were less than 10^3 CFU/mL and *E. coli* was not detected throughout the storage period [75].

Cinnamon essential oil exhibits a wide range of applications in the pharmaceutical and food industries, attributable to its diverse bioactive properties encompassing antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hypolipidemic, cardioprotective, neuroprotective, anticancer, immunomodulatory, and various other effects [77]. The fortification of stirred yoghurt with an aqueous extract produced from waste cinnamon leaves (CLE) led to significant improvements in total phenolics, total flavonoids, 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity, ferric reducing antioxidant power, and albumin denaturation inhibition activity [78].

Roselle flower exhibits diverse biological properties, functioning as an antioxidant, cholesterol regulator, blood pressure modulator, antimicrobial, anti-inflammatory, and anticancer agent, as well as contributing to diabetes management [79]. These effects are attributed to the presence of polyphenols and flavonoids in hibiscus flowers, specifically flavanols in both simple and polymerised forms [80]. This study concluded that alcoholic roselle flower extract exhibited antioxidant activity. Furthermore, the alcoholic roselle flower extract at a concentration of 3.0% notably increased free radical scavenging by 392.8% in yoghurt [81].

Carrots are notably abundant in β-carotene, ascorbic acid, and tocopherol, and are categorised as a vitaminised food [82]. Combining carrot juice with yoghurt enhances the nutritional and functional characteristics of the yoghurt. Salwa et al. [83] investigated the impact of different carrot juice blending ratios on the shelf life and sensory properties of yoghurt, finding that the addition of 15% carrot juice improved both the shelf life and consumer acceptance.

The incorporation of plant-derived colorants might deliver value-added benefits to the consumers, apart from their colouring effect. The use of natural plant pigments like the ones from spinach into the probiotic stirred yoghurts will have colour stability throughout the storage without adverse impacts on the physicochemical and sensory properties of the yoghurt. The pH level measures 4.98. At the onset of storage, the total phenolic content (TPC) was noted as 42.7 mg GAE/L in both the spinach variant and the control [84].

Table 3. The addition of legumes, flowers, spices to yoghurt and their functional roles.

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Hibiscus sabdariffa L.	0%, 15%, 20%	An increase in the antioxidant properties of the yoghurt The samples containing 20% hibiscus generally received higher scores than the samples containing 15% hibiscus	Phenolic acids, organic acids, flavonoids, anthocyans	Antioxidant activity	[85]
Roselle flower	0.3%	Alcoholic roselle flower extract exhibits antioxidant activity	Phenols, flavonoids	Antioxidant, anti-growth agent	[81]
Cinnamon leaves	0.2%	DPPH scavenging activity, ferric reducing antioxidant power, and albumin denaturation inhibition activity increase	Phenolics, flavonoids	Anti-inflammatory, antioxidant activity	[78]
Night-flowering jasmine (*Nyctanthes arbor-tristis* L.)	3%, 3.5%, 6%	An improvement of texture profile values is observed in the sample with 3.5% extract compared to the control with 3.00 ± 0.1% fat, 3.88 ± 0.23% crude protein, 77.94 ± 0.09 moisture, 14.97 ± 0.27 total soluble solids, and 0.7637 ± 0.03 ash	Phenolic compounds	Antioxidant, antidiabetic, antiglycation activity	[86]
Lavandula sp.	0.14, 0.21, 0.29, and 0.36 g/L	pH: 4.52–4.61 Titratable acidity: 112 °T Total solids: 15.42%	Tannins, flavonoids, terpenes	Antiviral, anti-inflammatory activity	[87]
Carrot	0%, 10%, 15%, 20%	The inclusion of carrot juice significantly increases pH and syneresis, while titratable acidity and total viable counts decrease	Carotenoids, tocopherols, fibres	Antioxidant, anti-inflammatory activity	[88]

Table 3. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Cassava	12.71%, 12.61% 12.52%	The titratable acidity of cassava yoghurt increases gradually from 0.64% in the beginning to 0.78% at 15 days of storage Yeast and mould populations in all the yoghurts are less than 10^3 CFU/mL and *E. coli* was not detected throughout the storage period	Carbohydrates	Antioxidant activity	[75]
Pumpkin	15%, 20%	Moisture: 86.68% Protein: 3.72–3.77% The fortified yoghurt exhibits higher levels of β-carotene, protein, fibre, and ash, while showing lower levels of carbohydrates, fat, and energy compared to its non-fortified counterpart	β-carotene	Antioxidant activity	[89]
Grape seed	0.1, 0.25, and 0.5 g/100 g yoghurt	Significant increments ($p \leq 0.05$) are observed in total solids, ash contents, pH, water-holding capacity, and viscosity values, especially when 0.5% grape seed extract was added	Polyphenols	Antioxidant activity, antibacterial, anticancer activities	[90]
Red grape skin	0.3%, 0.6%	Yoghurt with 0.6% tannic acid powder had the highest levels of anthocyanins, phenolic compounds, and antioxidants compared to the control yoghurt	Gallic acid, anthocyanins, phenolic compounds	Antioxidant activity	[91]
Purple sweet potato	30%	0.3 mL of purple sweet potato yoghurt per 20 g of mice improves lactic acid bacteria counts, decreases lipid levels (cholesterol, triglycerides, LDL), and reduces visceral fat and liver weight on a high-fat diet	Anthocyanins, flavonoids, phenolic compounds	Anti-obesity, cardioprotective effect	[92]
Spinach leaves	6%	pH: 4.98 At the start of storage, the total phenolic content is recorded as 42.7 mg GAE/L in the spinach variant and in the control	Phenolics, chlorophyll, peptides	Antioxidant, anti-inflammatory, anticarcinogenic activity	[84]

Table 3. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Sweet potato	15%	The yoghurts exhibit comparable ash contents, but differed in other component levels and pH High firmness, consistency, viscosity, and cohesiveness Throughout refrigerated storage, probiotic culture counts remained above 10^7 CFU/mL	Alkaloids, terpenoids, phenolics, peptides	Anti-inflammatory, antioxidant activity, immune system support	[76]

3.1.4. High Protein Ingredients

Beyond their nutritional value, high-protein dairy products contribute to satiety, aiding in weight management, and promote a balanced diet. The addition of different mushrooms, plants (*Sacha ichi*), oysters (*Crassostrea gigas*), beans, and peas are such examples of high-protein products (Table 4).

Similar to lentils and peas, *dry beans* offer a rich supply of phytochemicals, particularly polyphenols, along with essential proteins and dietary fibres. The presence of vital nutrients and bioactive compounds can vary among different market classes and bean varieties due to their distinct phenotypes and genotypes. For instance, the total phenolic content in beans ranged from 19.1 to 48.3 mg per 100 g, as reported by Luthria et al. [93].

Quinoa boasts a wealth of high-biological-value proteins, low-glycemic-index carbohydrates, phytosteroids, ω-3 and ω-6 fatty acids, and dietary fibre. Its nutritional excellence positions quinoa as a valuable contender for integration into functional food applications. The use of quinoa flour at percentages ranging from 20 to 50% corresponded to viscosity values of the mixtures (after gelatinisation) from 0.113 to 1.20 Pa·s [94].

Among the mushrooms, Li et al. [95] reported that oyster is an excellent source of high-quality nutrition, including protein, minerals, and particularly taurine. The bioactive peptides of oyster hydrolysate can exert beneficial effects on human health in addition to basic nutritional effects [96].

Oyster mushroom (*Pleurotus ostreatus*) is rich in β-glucan that can be used as natural food stabiliser. β-glucan is one of the dietary fibres that offers health benefits such as acting as an immunomodulator, reducing plasma cholesterol, and preventing hypertension, diabetes, obesity, and colorectal cancer [97]. Incorporating the extract led to elevated viscosity and total acid levels, which intensified with higher extract concentrations. Conversely, the addition of the extract resulted in reduced syneresis. Moreover, the protein and reducing sugar content in the yoghurt increased, with higher concentrations of the extract further enhancing these levels [97].

Agaricus blazei is another mushroom rich in bioactive compounds. Corrêa et al. [98] studied the use of commercially discarded *A. blazei* fruiting bodies for obtaining an extract rich in ergosterol as a fortifier ingredient for yoghurts. When added to the yoghurts, it significantly enhanced their antioxidant properties. Furthermore, it did not significantly alter the nutritional or the individual fatty acid profiles of the yoghurt.

Chickpea flour is highly digestible and contains a high amino acid content including high levels of lysine and arginine. Due to its high fibre and protein content, pea flour is also considered to be a potential prebiotic for probiotic species of *Lactobacillus*. Chickpea (*Cicer arietinum* L.) is rich in protein, fibre and other prebiotic substances. As a food ingredient, it may enhance the nutritional and functional qualities of food products. Hence, chickpea flour may be a highly attractive substance to incorporate into the formulation of yoghurt. Recent studies have demonstrated successful incorporation of chickpea flour into yoghurt [99]. Throughout five weeks of storage, the viable count of probiotics remained above the minimum therapeutic level. Meanwhile, the pH, titratable acidity, ash content, and total solids increased as the concentration of chickpea flour in the yoghurt increased [99].

Spirulina stands out as a natural food with the highest protein content at 62%. It encompasses the complete range of flavonoids and serves as the most abundant source of vitamin E, phycocyanin, and carotene. The inclusion of spirulina in diets contributes to overall wellness, promoting a balanced alkaline state. Its unique chemical composition yields numerous health benefits, potentially slowing down the progression of various ailments like cancer, kidney failure, and high blood pressure. According to the results, increasing the amount of spirulina from 0.5% to 1.5% led to a decrease in pH from 4.785 to 3.60 and from 4.785 to 3.195. The spirulina platensis powder (SPP) is renowned for its potent antioxidant properties. During storage, the levels of antioxidants, total phenolics, and total flavonoids exhibited a gradual increase over a period of 15 days in both the control group and all the treatment groups [67].

The incorporation of *Moringa oleifera* into yoghurt introduces notable biological activity. Moringa, rich in protein, antioxidants, vitamins, and minerals, enhances the nutritional profile of yoghurt. Its bioactive compounds may contribute anti-inflammatory and antimicrobial properties, potentially promoting digestive health [100]. During the storage period, there was a notable increase in syneresis, viscosity, firmness, and consistency of the product. The total phenolic content (GAE/100 g) was 280.65 in the extract and 18.31 in the yoghurt. The DPPH radical scavenging activity reached 78% [100].

Table 4. High protein ingredients used for yoghurt fortification.

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Navy bean	ratio 1:10 (*w*/*v*)	The protein concentration in the digestates of glycemic index is 154.90 ± 7.52 Increases protein content Maintains acceptable sensory attributes	Phenolics, peptides	Anti-inflammatory, antioxidant activity	[101]
Brown seaweeds	0.25% and 0.5% (*w*/*w*)	No effect on yoghurt pH, microbiology and whey separation by seaweed extract addition Moisture: 84.9–88.2% Fat: 2.4–2.7% Protein: 2.8–3.1%	Phenolics, flavonoids	Antioxidant activity	[102]
Chickpea	0%, 1%, 2.5%, 5%	Throughout 5 weeks of storage, the viable count of probiotics remains above the minimum therapeutic level The pH, titratable acidity, ash content, and total solids increase as the concentration of chickpea flour in the yoghurt increases	Amino acids, lysine, arginine	Probiotic effects	[99]

Table 4. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Crassostrea gigas	8%, *w*/*v*	Peptides derived from oyster goat yoghurt digestion with a molecular weight (MW) less than 10 kDa (at 500 μg/mL concentration) demonstrate the ability to mitigate intestinal inflammation in Caco-2 and HT-29 cell lines	Omega-3 fatty acids, peptides, vitamin B12	Anti-inflammatory, antioxidant activity	[96]
Moringa leaf	0%, 9%	During the storage period, there is a notable increase in syneresis, viscosity, firmness, and consistency of the product The TPC (GAE/100 g) is 280.65 in the extract and 18.31 in the yoghurt The DPPH radical scavenging activity reaches 78%	Phenolic compounds	Antioxidant activity	[100]
Pleurotus ostreatus	1%, 2%, and 3% (*v*/*v*)	The addition increases viscosity and total acid levels, especially with higher concentrations, and reduces syneresis Protein and reducing sugar content in the yoghurt increases, with higher extract concentrations further enhancing these levels	Fibres, peptides	Antioxidant, anticancer, antimicrobial proprieties	[97]
Quinoa	20 to 50% *wt/wt*	Incorporating quinoa flour results in mixture viscosities ranging from 0.113 to 1.20 Pa·s after gelatinisation Due to ongoing proteolysis, nutritional indexes are highest after 20 days of storage	Free amino acids, γ-Aminobutyric acid, polyphenols	Antidiabetic, antioxidant activity	[94,103]
Rice berry	0.125–0.5% (*w*/*w*)	Significant increase in total phenolic content (TPC), as well as in cyanidin-3-glucoside (C3G) and peonidin-3-glucoside (P3G) levels It enhances DPPH radical scavenging activity and ferric reducing antioxidant power (FRAP)	Free amino acids, γ-Aminobutyric acid, polyphenols	Antidiabetic, antioxidant activity	[104]

Table 4. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Sacha inchi (*Plukenetia volubilis*)	1 g/100 g	The results indicate that the properties of the wall materials used in the microcapsules, particularly their hydrophobicity, has a significant impact on the physicochemical and quality attributes of the yoghurt	Polyunsaturated fatty acids	Antioxidant activity	[105]
Tartary buckwheat (*Fagopyrum tataricum)*	0 g, 4 g, 6 g, 8 g, 10 g, or 12 g	The pH values of all yoghurt groups show a consistent decreasing trend throughout the fermentation period The acidity increases across all groups throughout the fermentation process Increase in apparent viscosity	Amino acids, dietary fibre, minerals, flavonoids	Antioxidation, anti-aging effects	[106]
Agaricus blazei	1.4%	The ergosterol extracted displays antioxidant and antimicrobial properties There are no significant alterations observed in the moisture, fat, protein, carbohydrates, ash, energy, galactose, and lactose contents No notable differences in the physicochemical properties	Ergosterols	Antioxidant, antimicrobial properties	[98]
Auricularia auricula	0.05%, 0.1%	Small differences for pH, but there is a notable alteration in titratable acidity TPC and antioxidant activity are found to be highest in the yoghurt supplemented with 0.1% AA extract throughout the storage period An increase in the viability of *Lactobacillus acidophilus* is observed during the storage period	Phenolics, peptides	Antitumor, antimicrobial, antioxidant activity	[107]

Analysing the biologically active compounds in the above tables of fruits, honey, bee products, legumes, flowers, spices, and high-protein foods, a connection was made between their properties (Figure 2). The analysis revealed that all the products shared active biological compounds with the following properties: antioxidant, antibacterial, anti-inflammatory, and anticancer activity.

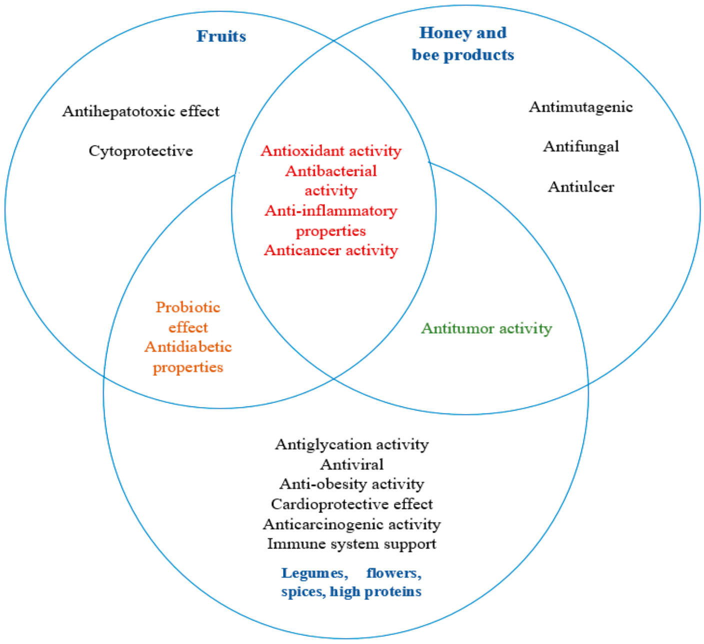

Figure 2. The connection between the biological activity of fruit, honey, bee products, legumes, flowers, spices, and high protein ingredients.

3.2. Latest Trends in Functional Yoghurt Development

During the very recent years, different research teams have incorporated new ingredients in the yoghurt formulas, from plant extracts (*Aloe* spp., *Artemisia* spp.) and flours, to fruit species or even kombucha (Table 5). These results, which are described below, have proven their added value from a functional perspective, especially from a prebiotic and probiotic point of view, as well as in terms of the nutrient and antioxidant profiles.

Aloe vera is a popular plant that has been traditionally used for its medicinal and therapeutic properties. It is currently being promoted as a valuable ingredient for the food, pharmaceutical, and cosmetic industries. It has also been reported that the addition of *Aloe vera*, which has a high concentration of aloin, to yoghurt increased bifidobacteria [108]. Incorporating aloe vera gel into yoghurt adversely affects its textural properties, with significant impacts observed across most attributes except for springiness and resilience [109]. pH decreased compared to the control group, while sensory attributes remained slightly lower. Incorporating aloe vera juice notably heightened syneresis and concurrently reduced bacterial count [110].

Artemisia absinthium L., commonly known as wormwood, is an important perennial shrubby medicinal plant native to North Africa, Middle East, Europe, and Asia. *Artemisia absinthium* contains many phytochemical compounds such as terpenoids, organic acids, lactones, tannins, resins, and phenols. It also contains flavonoids and phenolic acids (coumaric, syringic, salicylic, chlorogenic, and vanillic acids) which contribute to free radical scavenging mechanisms. In addition, the fortification of yoghurt with wormwood powder improved its antioxidant activity and rheological properties during the whole storage period. Also, the shelf life of fortified yoghurt was extended by about 4 days when compared to the control [111].

Green banana flour is an odourless rich source of dietary fibre, resistant starch, and minerals content. The incorporation of green banana flour up to 5% improved the physicochemical and sensory properties of yoghurt. Also, it increased the iron and fibre contents and enhanced the nutritional value of yoghurt [112].

Carob is a fruit that grow in Mediterranean climates with high natural sugar content and is rich in vitamin E and B, group vitamins, and calcium, magnesium, potassium, sodium, phosphorus, iron, zinc, manganese, and copper minerals. As the proportion of carob extract added to the yoghurt samples increases, the D-pinitol content, total dry matter, amount of phenolic compounds, and antioxidants also increase [113].

The research of Cerdá-Bernad et al. [114] aimed to stabilise saffron and its floral by-product extracts, rich in polyphenols, through their encapsulation in alginate beads, as well as to explore the possibility of developing fortified yoghurt by including them in a traditional recipe formulation. The finding illustrates that alginate microencapsulation effectively preserved the antioxidant properties of saffron flowers within the yoghurt matrix throughout the 21-day refrigerated storage period [114].

Turmeric contains a diverse array of vitamins and essential substances vital for the human organism. Furthermore, curcumin, a component of turmeric, exhibits antioxidant, anticarcinogenic, immunomodulatory, antifungal, and anti-inflammatory properties, rendering it well-suited for applications in both the medical and food industries [84]. Nevertheless, the incorporation of an aqueous curcumin extract into stirred-type yoghurt results in a decrease in the viable cell count of probiotics. This observed effect is likely attributed to the antimicrobial properties inherent in turmeric, thus negatively impacting the growth of the starter culture [84]. Additionally, curcumin's antioxidant-rich composition, featuring potent phytonutrients known as curcuminoids, aids in inhibiting cancer at various stages of development, supporting colon health, providing neuroprotective effects, and contributing to cardiovascular well-being [115].

Polyphenol compounds derived from nutmeg extracts could enrich yoghurt with antioxidant properties. Nutmeg seed is known for its medicinal value and is used in culinary practice to enhance the flavour and aroma of food. It contains α-pinene, β-pinene, p-cymene, β-caryophyllene, and carvacrol, which exhibit strong antioxidant properties. It is also used as an antifungal, antimicrobial, and anti-inflammatory, and even to reduce chronic liver disease [116]. The addition of nutmeg significantly affects ($p < 0.05$) the pH reduction (4.47 ± 2.7) as compared to control (4.56 ± 1.8) [116].

The principal traditional use of spice oils extracted from various spices lies in their role as natural flavouring agents, holding significant economic value [117]. There is a growing global demand for spice oils, especially those extracted from dried leaves. Considering consumer preferences, flavouring compounds play a crucial role in yoghurt. Consequently, oils from various spices and plants are incorporated into yoghurt in the form of nano emulsions, serving as functional components and flavouring agents. This creates a market for herbal yoghurt with spicy or leafy flavours, subject to quality and microbiological testing [116]. The addition of cumin oil to yoghurt introduces noteworthy biological activity. It exhibits antimicrobial, antioxidant, and anti-inflammatory properties. When incorporated into yoghurt, cumin oil may contribute to enhancing the overall nutritional profile and potential health-promoting effects of the product [118]. The bioactive compounds in cumin oil, such as cuminaldehyde and cuminol, can positively impact digestive health and may have a positive influence on the immune system [119]. Additionally, the aromatic and flavourful characteristics of cumin oil can enhance the sensory appeal of yoghurt, providing consumers with a unique and potentially beneficial culinary experience [118].

Coffee-flavoured yoghurt was developed to enrich the product with functional properties and help enhance local coffee consumption. Coffee-flavoured yoghurt, a probiotic as well as prebiotic product, has the potential to boost human nutrition in addition to enhancing calcium bioavailability from the yoghurt [109]. Based on the findings, the levels of lactic acid bacteria in coffee-flavoured yoghurt ranged between 3.7×10^7 and 1.09×10^8 CFU/mL. The yeast and mould ranged between 3.6×10^1 and 8.33×10^2 CFU/mL. Total phenolic content (TPC) ranged from 5.76 ± 0.4 to 97.89 ± 0.6 mg GAE/mL, while antioxidant properties varied from 15.82 ± 0.9 to $68.55 \pm 0.9\%$ DPPH [109].

Table 5. Trends in plants, fruits, vegetables, and spices used in functional yoghurt development.

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Aloe vera gel	0%, 1%, 2%, 3% with different (1%, 2%) fat contents	Increasing the concentration of gel led to a rise in pH, while acidity and syneresis decrease From a nutritional standpoint, protein, lactose, ash, and total solid contents decrease, while there was a slight, nonsignificant increase in total phenolic content	Polysaccharides	Antioxidant, anti-inflammatory activity	[108]
Aloe vera foliar gel	-	Incorporating *Aloe vera* gel into yoghurts adversely affects their textural properties, with significant impacts observed across most attributes except for springiness and resilience	Phenolic compounds, vitamin A, E, C	Antioxidant, aphrodisiac, antimicrobial, anti-inflammatory, antifungal, antiseptic proprieties	[120]
Aloe vera	16–20 g/100 g	pH decreases compared to the control group, while sensory attributes slightly lag behind Incorporating aloe vera juice notably heightens syneresis and concurrently reduced bacterial count	Amino acids, anthraquinones, saponins, phytosterols	Antitumour, antidiabetic, prebiotic properties	[121]
Carob	8, 10 and 12%	As more carob extract is added to yoghurt samples, significant increases are observed in D-pinitol content, total phenolic compounds, and antioxidant activity values based on analytical data	Gallic acid, minerals	Antioxidant, antibacterial activity	[113]
Argel leaf (*Solenostemma argel*)	(0.0, 0.1, and 0.2 g/100 mL	During storage, pH, LAB counts, syneresis, viscosity, colour values, total phenolic content, antioxidant activity, and sensory attributes decrease, while acidity and water-holding capacity (WHC) increase significantly ($p < 0.05$)	Phenolic compounds	Antioxidant activity	[110]
Basil seeds	0.5%, 1%	Adding basil seeds in yoghurt may enhance gel network formation, leading to higher viscosity and water-holding capacity (WHC), while reducing syneresis Moreover, it exerts a notable influence on antioxidant activity and sensory attributes	Polyphenols, flavonoids	Antioxidant activity	[122]

Table 5. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Bell pepper (*Capsicum annuum* L.)	5%	Results indicated a meaningful increase in starter bacteria counts, while sensory attributes, except for texture and appearance, show significant decreases in taste and colour scores ($p < 0.01$) Storage time also notably reduces LAB count and sensory scores Despite decreased taste and colour scores, all samples maintain acceptable sensory scores (mean scores > 7)	Fibres, vitamins, capsaicinoids	Antioxidant, antimicrobial, antiviral, anti-atherosclerotic, anti-inflammatory	[123]
Butterfly pea (*Clitoria ternatea*)	0–3%	The optimised butterfly pea flower-rich yoghurt exhibits an ash content of 0.74 ± 0.3% and total soluble solids of 16.12 ± 0.02, both of which are notably higher compared to the control yoghurt	Flavonoids, carotenoids, anthocyans	Anti-inflammatory, anticancerous, antimicrobial	[124]
Chavir (*Ferulago angulate*)	0.2% and 0.4%	The extract exhibits antimicrobial properties against *S. aureus*, *Bacillus subtilis*, *E. coli*, *L. buglaricus*, and *S. thermophilus* Initially, there is a significant decrease in pH with the addition of the extract, but after 21 days of storage, it reaches a level comparable to the control	Phenolics, flavonoids	Antiparasitic, antioxidant effect	[125]
Coconut (*Cocos nucifera*)	10, 20 and 30%	The pH of the yoghurt samples ranges from 3.61 to 5.74 for the freshly prepared samples and from 3.18 to 5.19 after 14 days of storage	Fibres, proteins, vitamins	Antioxidant activity	[126]
Coffee	0.0%, 0.1%, 0.2%, and 0.3%	The levels of lactic acid bacteria in coffee-flavoured yoghurt ranged between 3.7×10^7 and 1.09×10^8 CFU/mL The yeast and mould ranged between 3.6×10^1 and 8.33×10^2 CFU/mL Total phenolic content (TPC) ranged from 5.76 ± 0.4 to 97.89 ± 0.6 mg GAE/mL, while antioxidant properties varied from 15.82 ± 0.9 to 68.55 ± 0.9% DPPH	Polyphenolic compounds	Antioxidant activity	[109]

Table 5. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Corn	10%	Overall acceptability: 84% Moisture (%): 76.9 Protein (%): 3.8 Fat (%): 2.8 Ash (%): 0.9 Lactose (%): 3.6	Fibres, carotenoids, phytosterols	Antioxidant activity	[76]
Cumin oil (*Cuminum cyminum*)	20%	It is observed that the solids content and pH of the yoghurts experience minimal changes, while the stability of the yoghurt is significantly enhanced	Flavonoids, terpenes, phytosterols	Anti-inflammatory, antioxidant, antimicrobial properties	[118]
Eucalypt (*Eucalyptus camaldulensis*)	0.3%, 0.6%, and 0.9%	Increase in total phenolic content and antibacterial activity Despite minor differences in total solids and pH, significant variations are observed in syneresis, with pH rising and syneresis decreasing with increasing concentration	Phenolic compounds, terpenoids	Anti-inflammatory, antioxidant, antiseptic activity	[127]
Flaxseed (*Linum usitatissimum*)	–	Increase in the population of probiotic microbes within the gut Additionally, it produces metabolites that play a crucial role in lipid and glucose metabolism, as well as in homeostasis pathways	Dietary fibres, α-linolenic acid, phenolics, flavonoids	Prebiotic proprieties, anti-obesity, anticancerous activity	[128]
Garlic	1:4	Garlic oil exhibits the highest encapsulation efficiency among all microcapsules, demonstrating controlled release characteristics and effective antibacterial activity against both *E. coli* and *S. aureus*	Diallyl disulphide, diallyl sulphide	Antibacterial, antifungal activity	[129]
Ginger	0.5%, 1%, 1.5%, 2.5%	The addition of ginger powder to bovine milk at concentrations ranging from 0.5 to 2.5% (*w*/*v*) results in a significant reduction in the pH of the various yoghurt samples	Polyphenolic compounds, volatile oils	Antioxidant activity, therapeutic properties, antimicrobial properties	[130]
Green banana	3%, 5%, 10%	The addition leads to an increase in the probiotic population, proteins, lipids, and carbohydrates No observed effect on pH The firmness and consistency of the yoghurt increases	Fibre, resistant starch, minerals	Prebiotic proprieties, antioxidant activity	[131]

Table 5. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Holy basil (*Ocimum sanctum*)	0.1–2.0 µL mL^{-1}	Concentrations ranging from 0.4 to 0.6 µL mL^{-1} are found effective at inhibiting the growth of the aforementioned pathogenic micro-organisms A higher concentration, approximately 3 to 4 times greater, is necessary for bacteriostatic action against dairy starter cultures, suggesting its compatibility in broth	Flavonoids, tannins, volatile compounds	Anti-inflammatory, antioxidant, antimicrobial activity	[132]
Kecombrang flowers (*Etlingera elatior*)	2.5%, 5%, and 7.5%	The addition influences flavonoid levels, acidity, pH, fat and protein content, viscosity, and aroma, as well as organoleptic assessments However, it does not impact taste and colour	Flavonoids	Antioxidant, anticancer, antimicrobial activity	[133]
Marigold (*Tagetes species*)	0 to 1.5%	The study reveals elevated total phenolic content and antioxidant activity, measured using DPPH and total radical-trapping antioxidant capacity (TRC) assays Sensory analysis indicates an acceptance rate of 80.4% for the organic yoghurt	Phenols, flavonoids	Antioxidant, anti-inflammatory, antimicrobial	[134]
Nutmeg	10 g	The addition of nutmeg significantly affects ($p < 0.05$) the pH reduction (4.47 ± 2.7) as compared to control (4.56 ± 1.8) Total phenolic content (TPC; µg GAE/mL): 133.44 ± 0.7	α-pinene, β pinene, p-cymene	Antimicrobial, antioxidant, anti-inflammatory activity	[116]
Oregano (*Origanum vulgaris*)	5%, 10%, and 15%	As the levels of added plant extracts increases, there is an increase in antioxidant activity and phenolic compounds across all treatments	Carvacrol, flavonoids, terpenes	Antifungal, antibacterial activity	[135]
Radish	-	A stable cherry powder is obtained and successfully utilised as a yoghurt colorant, receiving high acceptance	Anthocyanins, phenolics, flavonoids	Antioxidative activity	[136]

Table 5. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Rosemary (*Rosmarinus officinalis* L.)	0, 1.5%, 2.0%, 2.5%, and 3.0% (*w*/*v*)	Fat, protein, and ash contents increase significantly with the addition of extracts Titratable acidity and moisture decrease Bacterial counts decrease over the storage period compared to the control Yoghurts prepared with extracts have lower sensory ratings compared to the control	Phenolics	Antioxidant, antimicrobial activity	[137]
Saffron	0.5 g/100 g, 1 g/100 g and 0.05 g/100 g, 0.1 g/100 g	Alginate microencapsulation effectively preserves the antioxidant properties of saffron flowers within the yoghurt matrix throughout the 21-day refrigerated storage period	Flavonoids, anthocyanins, volatile compounds	Antioxidant activity	[114]
Tiger nut (*Cyperus esculentus*)	10%, 20% and 30%	pH: 3.18–5.19 No significant differences are observed in the sensory properties of yoghurt	Fatty acids, minerals, fibres	Anticarcinogenic, antimicrobial antioxidant properties	[126]
Turmeric	10%	pH: 4.67 TPC (mg 100 g Gallic Acid Equivalents/100 g): 435	Curcumin	Antioxidant, anti-inflammatory activity	[115]
Walnut oil	-	The analysis confirms that the fortified yoghurts exhibit elevated levels of fat and dry matter, along with a higher pH compared to the control product	Polyunsaturated fatty acids	Increasing Omega-3 fatty acids	[138]
Wormwood (*Artemisia absinthium* L.)	2%, 4% and 6%	The addition does not alter the fermentation parameters or the viability of lactic acid bacteria starters	Terpenoids, organic acids, phenols, tannins	Antifungal, antioxidant activity	[111]
β-glucan from oat	0 to 0.3%	Adding 0.3% oat β-glucan (OG) decreases fermentation time by 16 min, resulting in a more liquid consistency The yoghurt's acidity is slightly higher	Fibres	Prebiotic properties, anti-inflammatory effects	[139]
Okara (Soybean dregs insoluble dietary fibre)	0.1%, 0.5%, 1%	Changes the pore network structure, enhances whey precipitation rate, improves rheological properties and texture, maintains a favourable pH for probiotic survival, prolongs shelf life, and imparts a yellowish hue, enhancing sensory appeal of yoghurt	Proteins, fibre, isoflavones	Antioxidant activity, prebiotic effects, immune system support	[140]

Table 5. *Cont.*

Natural Functional Ingredients	Concentration	Results	Functional Compounds	Biological Activity	References
Kombucha	60 mL/L	The lactic acid content in the product reaches the highest average level of 0.68 g/100 g These products exhibit characteristic pH values typical of yoghurt and demonstrates excellent microbiological quality	Organic acids, water-soluble vitamins, polyphenolic compounds	Probiotic effects, antioxidant activity, detoxification	[141]
Fish oil	0.25 g of fish oil per 100 mL	No significant differences are observed in pH, acidity, or syneresis during storage Yoghurt with fish oil nanoliposomes has higher concentrations of docosahexaenoic acid Sensory characteristics are similar to the control without significant differences.	ω-3 fatty acids	Antidiabetic activity	[142]

The research of Guadarrama-Flores et al. [142] studied two strategies: The first strategy could be to eliminate the cholesterol fraction of milk in order to reduce its impact on cardiovascular diseases. The second one would be to fortify milk with omega-3 fatty acids, especially since eicosapentaenoic acid (EPA; also, eicosapentaenoic acid) and docosahexaenoic acid (DHA) are the most well-known fatty acids for their properties as cardiovascular protection agents, for preventing rheumatic arthritis, and as antioxidants, among other properties. All of this can be achieved by adding microencapsulated ω-3 fatty acid powder from fish oil. No significant differences were observed in pH, acidity, or syneresis between the control and treatments during storage. The yoghurt with fish oil nanoliposomes had higher concentrations of DH compared to the control yoghurt but with sensory characteristics similar to the control [142].

The kombucha symbiotic culture of bacteria and yeast (SCOBY), also referred to as the tea mushroom due to its resemblance to the caps of macroscopic mushrooms, creates a cellulose-based biofilm through the polymerisation of monosaccharides. It encompasses acetic acid bacteria (AAB), yeast, lactic acid bacteria (LAB), and bifidobacteria, serving as a starter culture for crafting kombucha tea. This fermented beverage, described as slightly sweet and slightly sour, lacks established health-promoting properties for humans based on current knowledge. Nevertheless, numerous in vitro and in vivo animal studies hint at potential wholesome attributes [140]. Kombucha tea comprises bioactive compounds such as organic acids, water-soluble vitamins, and polyphenolic compounds that undergo metabolism by the SCOBY [143]. Featuring a diverse micro-organism composition, including LAB and bifidobacteria, the SCOBY presents an opportunity to identify potential probiotic strains [144]. The lactic acid content in the product reached the highest average level of 0.68 g/100 g. This product exhibited characteristic pH values typical of fermented milk beverages and demonstrated excellent microbiological quality [141].

The incorporation of modified okara insoluble dietary fibre into yoghurt introduces notable biological activity [140]. Okara, a by-product of soybean processing, boasts significant dietary fibre content, contributing to digestive health and promoting satiety. The modification process enhances its solubility and functional properties, ensuring better dispersion and integration within the yoghurt matrix. This addition enriches the yoghurt with beneficial insoluble fibre, potentially enhancing its prebiotic effects and overall nutritional value [140].

4. Conclusions

Nowadays, the idea of producing food without incorporating any additives is unimaginable, from both the practical and theoretical points of view. If in the past the emphasis was solely on improving the taste and aroma of yoghurts, based on the information presented in this work, it can be observed that currently, as well as in future trends, the functional aspect of yoghurt is becoming important.

The incorporation of prebiotic and probiotic functional ingredients in yoghurt production holds significant importance for both product quality and consumer health. Probiotics, comprising beneficial live micro-organisms like lactic acid bacteria, promote a balanced gut microbiota when consumed regularly. This not only enhances digestive health but also contributes to immune system modulation. This synergy between prebiotics and probiotics creates a product with improved functional and health-promoting properties.

Consumers often perceive yoghurt enriched with these functional ingredients as a healthier choice. The potential immunomodulatory effects, improved nutrient absorption, and the production of bioactive compounds further contribute to the appeal of these products. Additionally, the inclusion of prebiotics and probiotics allows yoghurt producers to diversify their offerings, tapping into the growing market for functional foods. Due to the rise in health issues, obesity, and nutritional problems, people are inclined to seek beneficial solutions to improve their diet by introducing innovative options and new combinations that bring an added element of health. The utilisation of kombucha, microalgae, mushrooms, fish oil, and spices represents a significant shift in trends, highlighting both the boundless development of technologies for obtaining these products and a keen interest in studying the synergy between these new combinations. The aim is to provide consumers with optimal options for fermented milks.

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