Pinus

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The pine (Pinus L.) is the largest and most heteromorphic plant genus of the pine family (Pinaceae Lindl.), which grows almost exclusively in the northern hemisphere. The demand for plant-based remedies, supplements and functional food is growing worldwide.

Keywords: pine ; antioxidants ; functional food ; bioactive compounds

1. Introduction

Pinus (Pinaceae) is considered the largest genus of conifers, which includes more than 100 different species (**Table 1** and **Table 2**) [1].

Table 1. Taxonomic hierarchy of genus *Pinus* L. [2].

Kingdom	Plantae
Subkingdom	**Viridiplantae**
Infrakingdom	**Streptophyta**
Superdivision	**Embryophyta**
Division	**Tracheophyta**
Subdivision	**Spermatophytina**
Class	**Pinopsida**
Subclass	**Pinidae**
Order	**Pinales**
Family	***Pinaceae***
Genus	***Pinus* L.**

Table 2. Classification of subgenus *Pinus* [1].

Section *Pinus*		Section Trifoliae		
Subsection *Pinus*	**Subsection Pinaster**	**Subsection Contortae**	**Subsection Australes**	**Subsection Ponderosae**
P. densata, densiflora, hwangshanensis, kesiya, luchuensis, massoniana, merkusii, mugo, nigra, resinosa, sylvestris, tabuliformis, taiwanensis, thunbergii, tropicalis, uncinata, yunnanensis	***P. brutia, canariensis, halepensis, heldreichii, pinaster, pinea, roxburghii.***	***P. banksiana, clausa, contorta, virginiana;***	***P. attenuata, caribaea, cubensis, echinata, elliottii, glabra, greggii, herrerae, jaliscana, lawsonii, leiophylla, lumholtzii, muricata, occidentalis, oocarpa, palustris, patula, praetermissa, pringlei, pungens, radiata, rigida, serotina, taeda, tecunumanii, teocote***	***P. cooperi, coulteri, donnell-smithii, devoniana, douglasiana, durangensis, engelmannii, hartwegii, jeffreyi, maximinoi, montezumae, nubicola, ponderosa, pseudostrobus, sabineana, torreyana, washoensis.***

Pinus is a term first applied by Lineus in his work “Species Plantarum” for a group of 10 species, only five of which are currently included in this genus, i.e., P. cembra, P. pinea . P. strobus, P. taeda and P. sylvestris [3]. Because of the prevalence and morphological diversity of pines that can be found in many countries, many conflicting affiliations are known, particularly because many early affiliations to this genus were based on a very small number of morphological discriminants [3]. Pinus belongs to Pinaceae as a result of having shoot dimorphism, which includes short shoots (fascicles) that have one to eight narrow needles surrounded by bud scales at the base. Strong woody cone scales with the apical structure exposed after the first growing season (bump) and in the mature cone are also typical of the genus Pinus . Currently, Pinus is treated as a monophyletic taxon [1]. The subgenus Pinus (diploxylon or hard pines) has two fibrovascular bundles per needle, diverging pulvini at cataphyll bases ("fascicle breaks"), which usually have persistent sheaths. There are two to eight needles per fascicle and the position of the resin canals is polymorphic (septa; internal, medial external); the seed wings are articulated or oppressed [4]. In this subgenus, section Trifoliae , which is characterised by persistent fascicle sheaths, can be distinguished. Most species have cones with thick, woody scales that open at maturity; however, a few species have serotine pine cones. The section includes all North American hard pines, excluding P. tropicalis and P. resinosa [1]. The Pinus section has persistent fascicle sheaths. The number of needles ranges from one to three. External or medial resin canals are usually found [1]. Mature cones open at maturity (excluding P. pinea) and have thick scales. In most species, the seed wings are articulated; however, in P. canariensis and P. roxburghii , they have a decorative function. The section is widespread throughout Eurasia and the Mediterranean basin, as well as includes two species from the Americas: P. resinosa from eastern North America and P. tropicalis from western Cuba [1].

2. Nutritional Value and Mineral Content

Table 3 shows data on the nutritional value of different parts of trees of the genus Pinus . The nutritional value was identified in seeds, needles, bark and shoots.

Table 3. Nutritional value and mineral content.

Index	Species	Part of the Tree	Content	Reference
Energy value	***P. contorta* L.**	**needles**	**500 kcal/100 g**	[5]
Energy value	***P. pinea* L.**	**seeds**	**583 kcal/100 g**	[6]
Dry mass	***P. sylvestris* L.**	**shoots**	**13.98%**	[7]
	***P. taeda* L.**	**stem**	**30.74%**	[8]
		needles	**1.55%**	[8]
crude protein	***P. contorta* L.**	**needles**	**3.63%**	[5]
crude protein	***P. pinea* L.**	**seeds**	**31.6 g/100 g**	[6]
fat	***P. pinea* L.**	**seeds**	**44.9 g/100 g**	[6]

Index	Species	Part of the Tree	Content	Reference
triglycerides	*P. sylvestris* L.	inner bark	33.40 mg/g	[9]
	P. sylvestris L.	outer bark	1.71 mg/g	[9]
	P. sylvestris L.	conifer needles	10.3 µmol/g dry weight	[10]
Mono- and diglycerides of fatty acids	*P. sylvestris* L.	inner bark	2.26 mg/g	[9]
	P. sylvestris L.	outer bark	5.46 mg/g	[9]
	P. sylvestris L.	conifer needles	2.3 µmol/g dry weight	[10]
steryl esters	*P. sylvestris* L.	inner bark	1.54 mg/g	[9]
	P. sylvestris L.	outer bark	0.19 mg/g	[9]
free fatty acids	*P. sylvestris* L.	inner bark	0.63 mg/g	[9]
	P. sylvestris L.	outer bark	1.68 mg/g	[9]
	P. sylvestris L.	conifer needles	10.3 µmol/g	[10]
resin acids	*P. sylvestris* L.	inner bark	7.16 mg/g	[9]
	P. sylvestris L.	outer bark	2.39 mg/g	[9]
sterols and triterpenic alcohols	*P. sylvestris* L.	inner bark	4.50 mg/g	[9]
	P. sylvestris L.	outer bark	2.98 mg/g	[9]
fatty alcohols	*P. sylvestris* L.	inner bark	1.33 mg/g	[9]
	P. sylvestris L.	outer bark	1.25 mg/g	[9]
carbohydrates	*P. pinea* L.	seeds	13.3 g/100 g	[6]
total soluble sugar	*P. pinea* L.	seeds	5.15 g/100 g	[6]
reducing sugar	*P. pinea* L.	seeds	0.7 g/100 g	[6]
glucose	*P. sylvestris* L.	needles	121.8 µmol/g	[10]
fructose	*P. sylvestris* L.	needles	151.3 µmol/g	[10]
galactose/arabinose	*P. sylvestris* L.	needles	5.2 µmol/g	[10]
sucrose	*P. sylvestris* L.	needles	59.6 µmol/g	[10]
sucrose	*P. pinea* L.	seeds	4.3 g/100 g	[6]
raffinose/melibiose	*P. sylvestris* L.	needles	4.1 µmol/g	[10]
starch	*P. sylvestris* L.	needles	124.8 µmol/g	[10]
Na	*P. pinea* L.	seeds	11.7 g/100 g	[6]
Ca	*P. pinea* L.	seeds	13.8 mg/100 g	[6]
Ca	*P. sylvestris* L.	bark	0.38%	[11]
Ca	*P. sylvestris* L.	needles	0.53%	[12]
Ca	*P. taeda* L.	stem	0.09%	[8]
Ca	*P. taeda* L.	needles	0.31%	[8]
K	*P. pinea* L.	seeds	713 mg/100 g	[6]
K	*P. sylvestris* L.	Needles	0.54%	[12]
K	*P. sylvestris* L.	bark	0.172%	[11]
K	*P. taeda* L.	stem	0.08%	[8]
K	*P. taeda* L.	needles	0.54%	[8]

Index	Species	Part of the Tree	Content	Reference
Mg	*P. pinea* L.	seeds	325 mg/100 g	[6]
Mg	*P. sylvestris* L.	Needles	0.09%	[12]
Mg	*P. sylvestris* L.	bark	0.059	[11]
Mg	*P. taeda* L.	stem	0.14%	[8]
Mg	*P. taeda* L.	needles	0.18%	[8]
P	*P. pinea* L.	seeds	512 mg/100 g	[6]
S	*P. sylvestris* L.	Needles	0.095%	[12]
Fe	*P. pinea* L.	seeds	10.2 mg/100 g	[6]
Fe	*P. sylvestris* L.	Needles	61.7 µg/g	[12]
Mn	*P. pinea* L.	seeds	6.9 mg/100 g	[6]
Mn	*P. sylvestris* L.	Needles	275.6 µg/g.	[12]
Zn	*P. pinea* L.	seeds	6.4 mg/100 g	[6]
Zn	*P. sylvestris* L.	Needles	53.63 µg/g	[12]
Cu	*P. pinea* L.	seeds	1.5 mg/100 g	[6]
Cu	*P. sylvestris* L.	Needles	5.3 µg/g	[12]
Cu	*P. sylvestris* L.	bark	2.98 mg/kg	[11]
N	*P. sylvestris* L.	bark	0.49%	[11]
N	*P. taeda* L.	stem	0.35%	[8]
N	*P. taeda* L.	needles	1.39%	[8]
ascorbic acid	*P. pinea* L.	seeds	2.5 mg/100 g	[6]
ascorbic acid	*P. sylvestris* L.	shoots	29.3 mg/g	[7]
Thiamine	*P. pinea* L.	seeds	1.5%	[6]
Riboflavin	*P. pinea* L.	seeds	0.28%	[6]

The seeds have the highest energy value due to a high fat content [6]. The seeds also generally have the highest content of the tested nutrients, excluding vitamin C, which is higher in the conifer needles. The seeds of P. pinea can be a good source of Mg, P and especially Zn [6]. These seeds have higher zinc content than sesame seeds (approx. 4.5 mg/100 g) and seeds of some pumpkin species (0.54–1.31 mg/100 g), which are considered to be good dietary sources of zinc [13][14] . It is well known that different parts of plants have different nutritional content [15]. Seeds are generally lower in vitamins than the green parts of plants; however, they are higher in macronutrients, especially fats [16]. The uptake of mineral nutrients and their content in a plant depends not only on their content in the soil in the form available for plants, but also on the mutual quantitative ratio of individual mineral nutrients in the environment and on the afforestation level [17][18][19][20]. Other factors, such as soil pH, temperature, water supply, rainfall, access to sunlight, precipitation, weather and climate change, are also of great importance [21][22][23]. Nutrients, which can be categorized as macro- and micronutrients, have a nutritional role in plants [24]. Macronutrients affect biochemical processes, physiological responses and yield quantity [17][25]. When it comes to macronutrients, their role in plant organisms includes many life processes that determine plant functioning [24][26]. Therefore, it is very difficult to clearly indicate a specific role of elements because they act in a complex way. The role of micronutrients, on the other hand, is more specific, as it is related to specific, well-defined life processes in the plant and to plant growth [27][28]. Nutrient deficiency results in various disorders in terms of the normal growth and development of the plant [29][30]. Some nutrients, because of their specific functions in the plant, may limit the growth of certain pathogens [31]. Those constituents include zinc, sulphur, calcium and potassium [32]. Plant raw materials are a good source of minerals in the diet. This includes brews such as tea brews, coffee brews and herbal mixtures. As indicated by the results of many works, pine shoots can also be a valuable raw material for the preparation of brews in nutrition [33][34]. Pine seeds were found to be a good source of magnesium—an electrolyte essential for many metabolic and biological processes in the body, including acting as a cofactor in over 300 enzyme reactions [35]. Pine seeds were also found to be high in phosphorus and zinc, which are key minerals in terms of metabolic processes and energy metabolism [36]. Both the outer and inner bark is rich in resinous acids. These compounds may be toxic and allergenic; however, a positive effect has also been shown—abietic acid, which is found mainly in the inner bark, can act as an inhibitor of testosterone 5α-reductase [37]. Testosterone reductase inhibitors are used for treatment of benign prostatic hyperplasia, prostate cancer and pattern hair loss [38].

3. Polyphenol Content

Polyphenols are chemical compounds found in herbs, vegetables and fruit that have a wide range of uses. Currently, more than 8000 phenolic compounds are known. They include flavonoids, tannins, phenolic acids and their derivatives such as polymers [39]. Polyphenols are essential secondary metabolites that allow plants to grow and develop. They also protect plants from insects and other factors [38][40][41]. Polyphenols found in plants are involved in functions related to sensory properties such as colour, bitterness and sourness [42][43]. The presence of benzene rings and hydroxyl groups is common to all polyphenols. However, they are very diverse and can be divided into several subgroups. There are different ways to categorise these compounds based on their source of origin, biological function or chemical structure [39]. Polyphenols can be divided into different categories. Classifications are frequently used according to the number of present phenolic rings and structural components, which combine these rings, by differentiating the molecules into phenolic acids, flavonoids, stilbenes and lignans [44][45]. Simple phenols and flavonoids correspond to most natural phenolic substances. Moreover, flavonoids belong to the most common group of these compounds. Their common order is C6–C3–C6, which corresponds to two aromatic rings (rings A and B) bonded to three carbon atoms to produce an oxidised heterocycle (ring C). As a result of the type of hydroxylation and differences in the chromate ring (C ring), flavonoids can be further divided into distinct subgroups, including anthocyanins, flavan-3-ols, flavones, flavanones and flavonols [46][47][48]. The demand for phenolic acids is very high in many industries because they are used as precursors to other important bioactive molecules that are regularly needed for therapeutic and cosmetic purposes, as well as for food industry. Phenolic acids are also commercially available as dietary supplements [49].

Various parts of a pine (needles, seeds, bark and cones) and different solvents can be used to extract polyphenols. The pine bark is the best-examined part. Although all pine extracts have significant amounts of polyphenols, their content in the extract depends on the solvent type, extraction method, plant part used or pine species (**Table 4**). This results from natural variability, such as genotype, crop differences and harvesting conditions, climate, soil type, etc. [49][50]. Polyphenols were found to reduce morbidity and slow the progression of cardiovascular, neurodegenerative and cancer diseases. The mechanism of action of polyphenols is strongly associated with their antioxidant activity and reduction of reactive oxygen species in the human body [51][52]. Furthermore, the health-promoting properties of plant polyphenols include anti-inflammatory, anti-allergic, anti-atherosclerotic, anticoagulant and antimutagenic effects [53]. There are now pine tree preparations on the market, which are concentrated sources of polyphenols. The most popular pine tree preparation is an extract from P. pinaster— Pycnogenol ® (Horphag Research Ltd., Geneva, Switzerland). The quality of this extract is defined in the United States Pharmacopeia (USP 28). Between 65% and 75% of Pycnogenol are procyanidins comprising catechin and epicatechin subunits with varying chain lengths. Other constituents include polyphenolic monomers, phenolic or cinnamic acids and their glycosides. According to many studies, the constituents of Pycnogenol are highly bioavailable [54]. The daily intake of polyphenols among the general population ranges from 0.1 to 1.0 g per day. Fruit, vegetables, herbs, spices, coffee, tea and wine are the main source of polyphenols [55][56].

Table 4. Polyphenol content.

Compound	Species	Part of the Tree	Content	Reference
gallic acid	*P. sylvestris* L.	shoots	208.38 ± 069 μg/g dw	[7]
2,5-dihydroxybenzoic acid			16.63 ± 0.54 μg/g dw	[7]
4-hydroxybenzoic acid			1084.92 ± 39.04 μg/g dw	[7]
caffeic acid			1502.03 ± 52.53 μg/g dw	[7]
syringic acid			145.44 ± 3.28 μg/g dw	[7]
p-coumaric acid			387.89 ± 15.83 μg/g dw	[7]
ferulic acid			2088.89 ± 56.89 μg/g dw	[7]
chlorogenic acid			518.25 ± 4.90 μg/g dw	[7]
sinapic acid			54.09 ± 2.06 μg/g dw	[7]
t-cinnamic acid			111.44 ± 3.4 μg/g dw	[7]
vanillic acid			0.46 ± 0.01 μg/g dw	[7]
salicylic acid			0.36 ± 0.00 μg/g dw	[7]
naringenin			1.59 ± 0.02 μg/g dw	[7]
vitexin			0.61 ± 0.01 μg/g dw	[7]
rutin			0.63 ± 0.02 μg/g dw	[7]
quercetin			0.98 ± 0.03 μg/g dw	[7]
apigenin			0.30 ± 0.01 μg/g dw	[7]
kaempferol			0.38 ± 0.01 μg/g dw	[7]
luteolin			0.30 ± 0.01 μg/g dw	[7]

Compound	Species	Part of the Tree	Content	Reference
protocatechuic acid	*P. radiata*	bark	46.2 ± 1.1 μg/mg	[57]
	P. sibirica	seeds	49.2 ± 0.5 mg/100 g dw	[58]
(+)-Catechin			52.5 ± 0.6 mg/100 g dw	[58]
vanillic acid			85.5 ± 1.0 mg/100 g dw	[58]
epigallocatechin gallate			47.0 ± 1.4 mg/100 g dw	[58]
syringic acid			101 ± 0.3 mg/100 g dw	[58]
()-epicatechin;			125 ± 3.1 mg/100 g dw	[58]
taxifolin			172 ± 3.1 mg/100 g dw	[58]
eriodictyol			383 ± 1.0 mg/100 g dw	[58]
(E)-cinnamic acid			12.2 ± 1.2 mg/100 g dw	[58]
naringenin			37.0 ± 2.1 mg/100 g dw	[58]

Compound	Species	Part of the Tree	Content	Reference
catechin	P. sinaster	bark	117.0 ± 8.0 mg/L	[59]
gallocatechin			16.8 ± 4.9 mg/L	[59]
taxifolin			447.7 ± 32.5 mg/L	[59]
quercetin			105.5 ± 2.7 mg/L	[59]
3,4 hydroxybenzoic acid			17.3 ± 2.4 mg/L	[59]
gallic acid			3.6 ± 0.7 mg/L	[59]
caffeic acid			20.6 ± 1.1 mg/L	[59]
o-coumaric acid			47.5 ± 25.3 mg/L	[59]
ferulic acid			47.2 ± 0.8 mg/L	[59]
rosmarinic acid			72.5 ± 4.0 mg/L	[59]
ellagic acid			402.2 ± 51.4 mg/L	[59]
naringin			173.4 ± 55.5 mg/L	[59]
apigenin			53.9 ± 0.1 mg/L	[59]
resveratrol			40.0 ± 0.4 mg/L	[59]
trans-ferulic acid	P. radiata	bark	5.9 ± 0.1 µg/mg	[57]
trans-caffeic acid			2.6 ± 0.1 µg/mg	[57]
()-epicatechin;			21.6 ± 1.7 µg/mg	[57]
(+)-Catechin			198.5 ± 6.4 µg/mg	[57]
cis-taxifolin			73.6 ± 2.7 µg/mg	[57]
trans-taxifolin			382.5 ± 12.1 µg/mg	[57]
quercetin			15.2 ± 1.0 µg/mg	[57]
quercetin, resin acid (abietic acid, neoabietic acid), taxifolin, catechin, quercetin derivative, taxifolin derivative, catechin and gallocatechin, kaempferol, rhamnetin isorhamnetin, myricetin, 3,4-dihydroxybenzoic acid, 3,4-dihydroxycinnamic acid, pinosylvin 3-methyl ether, dihydromonomethyl pinosylvin, resveratrol, glycoside, pinoresinol, secoisolariciresinol	*P. wallichiana and P. roxburghii, P. gerardiana*	stem and needle extract	presence found	[60][61]

Compound	Species	Part of the Tree	Content	Reference
1,5-diliydroxy-3,6,7-triniethoxy-8-allyloxyxanthone, 1-hydroxy-3,6-diinethoxy-2-β glucopyranoxanthone, friedelin, ceryl alcohol, b-sitosterol, taxifolin, quercetin, catechin, kaempferol, rhamnetin, 3,4-dihydroxybenzoic acid, 3,4-dihydroxycinnamic acid, pinosylvin, pinoresinol, resin acid, sterols, gallocatechin and tannins was found. hexacosyl ferulate	*P. roxburghii*	bark	presence found	[62][63]
12-hydroxydodecanoic acid, 14-hydroxytetradecanoic acid and 16-hydroxy-hexadecanoic acid		needle wax	presence found	[64]

Abbreviation dw—dry weight.

4. Food Application of Pinus

There is an increasing demand for health-promoting plant products all over the world [65]. Today, conifer shoots are virtually unused as a food ingredient, despite their common availability in many parts of the world. An exception is a common juniper, whose berry-like cones are a valued seasoning in Europe [66]. Pine shoot products, such as pine shoot syrup, pine shoot-based beer and herbal teas are available on the market. Despite its many potential applications, currently, the shoot products are not very popular [67].

To date, there has been little research on the use of pine tree elements in food products (**Table 5**). However, current literature indicates a possible application of such ingredients in beverages, dairy products, meat products or even bread. The addition of P. pinaster extracts increases the antioxidant potential of juices and dairy products. With regard to juices, polyphenols derived from pine extracts may also have a negative, inhibitory effect on the microflora [67][68][69][70]. Moreover, in terms of sensory experience, kefir enriched with pine bud syrup was assessed higher than the control sample, which indicates that it may also serve as an ingredient providing flavour and aroma [67]. In the case of the addition of pine extract to bread and meat, the substance acted as a shelf life extender by inhibiting the growth of bacteria and oxidisation of fats [71][72]. Moreover, pine extracts can be possibly applied in the future as additives and preservatives, as they are commercially sold as dietary supplements. Many of these extracts are listed on the Everything Added to Food in the United States (EAFUS) database that the Food and Drug Administration (FDA) approved as food additives or affirmed as Generally Recognised as Safe (GRAS) [73].

Table 5. Application of *Pinus* in food products.

Food Application	Material Used	Application Result	References
Fruit juices supplementation	*P. pinaster* Ait bark extract	Fresh fruit juices enriched with PBE exhibited the highest inhibitory effect on the growth of pathogenic intestinal bacteria, primarily *E. coli* and *Enterococcus faecalis*. The in vitro digestion process reduced the antibacterial effect of juices on the majority of pathogenic bacteria by approx. 10%.	[68]
		ROS production increased in the inflamed cells exposed to digested commercial red fruit juice (86.8 ± 1.3%) in comparison with the fresh juice (77.4 ± 0.8%) and increased in the inflamed cells exposed to digested enriched red fruit juice (82.6 ± 1.6%) in comparison with the fresh enriched juice (55.8 ± 6%)	[74]
		Following the in vitro digestion, the level of detectable phenolic compounds (expressed as gallic acid equivalent) was higher in both pineapple and red fruit juices enriched with Pycnogenol than non-enriched commercial juices (155.6 mg/100 mL vs 94.6 mg/100 mL and 478.5 mg/100 mL vs 406.9 mg/100 mL respectively). Increased antioxidant activity (measured by 2,2’-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) and oxygen radical absorbance capacity (ORAC) methods) was observed in digested enriched juices, contrary to the same samples before digestion. Undigested, enriched with Pycnogenol pineapple juice displayed a higher antiproliferative effect between the 24th and 72nd hour of incubation in comparison with the non-enriched juice.	[69]

Food Application	Material Used	Application Result	References
	***P. brutia*, *P. pinea* bark extracts, Pycnogenol®.**	**The paper shows that juices enriched with pine bark extracts exhibit higher antioxidant capacities and ascorbic acid contents compared to the control group, thereby providing improved functionality.**	[70]
Yoghurt supplementation	**French marine bark extract**	**Addition of Pycnogenol neither significantly affected the growth of microorganisms nor caused any modifications in nutritional parameters during the storage of yoghurt. Data indicate that neither the content of total polyphenol nor selected phenolic substances (catechin, epicatechins, chlorogenic acid and caffeic acid) was affected during the shelf life. In conclusion, these results indicate Pycnogenol as a valuable ingredient for the enrichment of yoghurt preparations.**	[75]
	***P. nigra* cones**	**This study used yoghurt samples to identify the LAB strains generated by the pine cone addition and determined the physicochemical properties of these samples. The genotypic identification revealed that in yoghurt samples, *Streptococcus* thermophilus strains were the main force conducting the fermentation process, while Lactobacillus plantarum strains appeared in three yoghurt samples as an adjunct culture. The time of pine cones collection significantly affected the physicochemical properties of yoghurt.**	[76]
Kefir	**Pine bud syrup**	**The pine bud syrup used to enrich kefir contains a lot of polyphenols and terpenes, as well as exhibiting a high antioxidant activity. The addition of pine bud syrup resulted in an increase in total solids, as well as a decrease in the content of fat, proteins and pH levels. The kefir sample containing 10% pine bud syrup was the most appreciated by the sensory panel. Its overall acceptability score was higher (6.71 points) than that of the regular kefir (5.57 points). The addition of 10% pine bud syrup improved the texture and consistency of regular kefir.**	[67]
Meat	**Pine bark extract (Pycnogenol)**	**The pine bark extract (Pycnogenol®) significantly improved the oxidative stability of cooked beef and reduced the hexanal content by 73% after 3 days of refrigerated storage.**	[71]
Tea	**Pine needles**	**Supplementation of pine needle extract at 1, 2, 4 and 8% in the control diet and mixed groups significantly decreased the weight gain and visceral fat mass in comparison with the corresponding values of the control group.**	[34]
Beer	***P. sylvestris* needles**	**The addition of needles increases the beer gustatory properties and decreases the methanol content. The content of ascorbic acid in ready-made drinks amounts to 3.52 mg/100 g. The antioxidant activity of elaborated beer is 178.1 C/100 g and determines its high biological value. In the study, the influence of beer enriched with needle extract was evaluated concerning the antioxidant system of organisms of biological objects. Under acute pathological conditions, a beer with needle extract decreases its oxidative influence on brains of the biological objects.**	[77]
Bread	**Fermented pine needle extract syrup**	**Bread with a higher content of pine needle extract syrup demonstrated a slower increase of bread hardening during the storage period, suggesting a slowdown of bread retrogradation. The addition of pine needle extract syrup in bread dough also inhibited the growth of aerobic bacteria and moulds on the bread surface (by 0.8~24 in log (CFU/g) during the 4-day storage). The use of concentration higher than 11% initially gave the bread a strong, fine needle flavour, which disappeared after 2 days. Generally, the addition of pine needle extract syrup had no negative effect on the quality (including sensory) of bread. Therefore, the addition of needle extract syrup could improve storage stability and extend the shelf life of bread.**	[72]

Abbreviations: PBE—pine bark extract; ABTS—2,2′-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid; ORAC—oxygen radical absorbance capacity; LAB—lactic acid bacteria; CFU—colony-forming unit.

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