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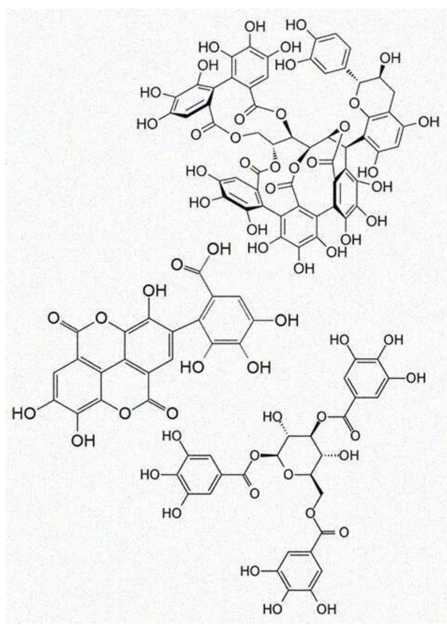
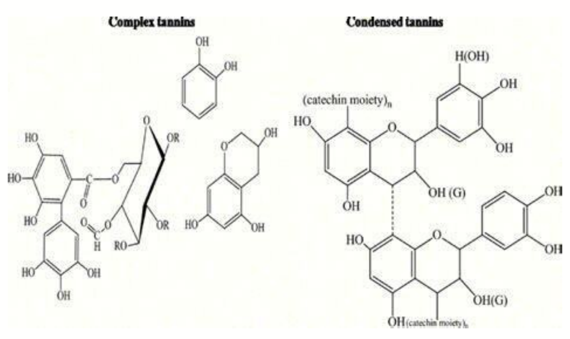
Non-hydrolyzable tannins examples

Difference between hydrolysable and non hydrolysable tannins. Difference between hydrolysable tannins and non hydrolysable tannins.

Hydrolysable tannins (HTs) are an important group of secondary plant metabolites that include simple gallic acid derivatives, gallotannins (GTs), and ellagitannins (ETs).From: Encyclopedia of Food Chemistry, 2019 Plant tannins are polyphenols that are widely found in terrestrial plants and in some marine plants (phloroglucinol). Plant tannins have been used as additives in animal production for many years (1). They may affect metabolism or the gut microbiota (2, 3), with the aim of improving performance or meat quality (4). Patra and Saxena (5) showed that plant tannins can improve feed efficiency and animal health. Aboagye et al. (6) found that plant tannins have a strong affinity for protein, and the appropriate addition of plant tannins to ruminant has nutritional value. yuvuside



It can be concluded that plant tannins have enormous potential as feed additives (10–12). However, plant tannins are complex substances whose beneficial and harmful properties depend on their chemical structure, the concentration and other factors. Therefore, this paper reviewed the classification, extraction sources and biological functions of plant tannins, as well as the factors influencing the additive effect, providing a reference for further research. Classification and Sources of Plant Tannins Classification of Plant Tannins The chemical structures of plant tannins are diverse, and systematic classification of tannins based on specific structural characteristics and chemical properties can provide a convenient framework for related research. Plant tannins can be broadly divided into hydrolyzed tannins and condensed tannins. Hydrolyzed tannins consist of polyphenol nuclei with molecular weights ranging from 500 to 3,000 Daltons (Da) (13). Condensed tannins are oligomeric or polymeric flavonoids composed of flavane-3-ols, including catechin, epicatechin, gallocatechin, and epigallocatechin. Their molecular weights vary from 1,000 to 20,000 Da, they depolymerize only with strong oxidation and acid, and they are not easily degraded by anaerobic enzymes (14). Plant tannins can be broadly divided into two categories, which are relatively general. There are ellagic tannins and polyol residues that cannot be completely hydrolyzed in hydrolyzed tannins (15), but they are divided into hydrolyzed tannins. Hydrolyzed tannins were first described as containing the C-glycoside catechin in addition to the characteristic structure of monomer ellagins in 1985 (16). At first, it was unscientific to classify these plant tannins into hydrolyzed tannins because C-C-coupled catechin structures contained some glycosides, and only some structures could be hydrolyzed (17). Therefore, tannins were further classified into four major categories according to their chemical structure: gallotannins refer to the combination of galloyl groups or their derivatives with polyols, catechins or triterpenoids; ellagitannins refer to at least two gallic C-Cs conjugated to each other and catechins conjugated without glycoside; compound tannins refer to glucogenated catechins in addition to gallic tannins or ellagic tannins and condensed tannins mean that C-4 of catechin is linked to C-8 or C-6 of another catechin unit to form oligomer procyanidins and polymeric procyanidins (18). Extraction Sources of Plant Tannin Plant tannins are widely distributed in the plant kingdom, especially in herbages, shrubs, cereals and medicinal materials (19). They are also found in many fruits, such as bananas, blackberries, apples and grapes (20–23). zibiki Complex tannins and condensed tannins are the most common and easy to extract from legumes, trees and shrubs; Gallic tannins are commonly found in gallnuts, lacquer leaves and cotinus leaves, while ellagic tannins are commonly found in oaks, blackberries and pomegranates. Plant tannins are more abundant in vulnerable parts of plants, such as new leaves and flowers (24). Because the chemical structure and content of plant tannins vary greatly among different plant species, growth stages and growth conditions (such as temperature, light, and nutrients), the biological functions of different extraction sources vary (25, 26). Biological Functions and Influencing Factors of Plant Tannins Antioxidant Activity The antioxidant properties of tannins are widely utilized in the food and medical fields. In recent years, many studies have been conducted to identify the relevant antioxidant activity of tannins. vahihuxu Owing to its antioxidant capacity, such as preventing cardiovascular disease, cancer or osteoporosis, tannins have attracted much attention (27, 28). In a study by Phung et al., the extracts of Japanese chestnut exhibited the most remarkable DPPH-scavenging capacity.



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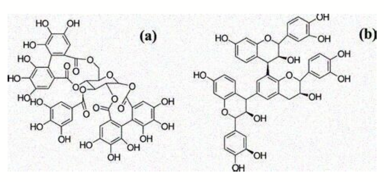

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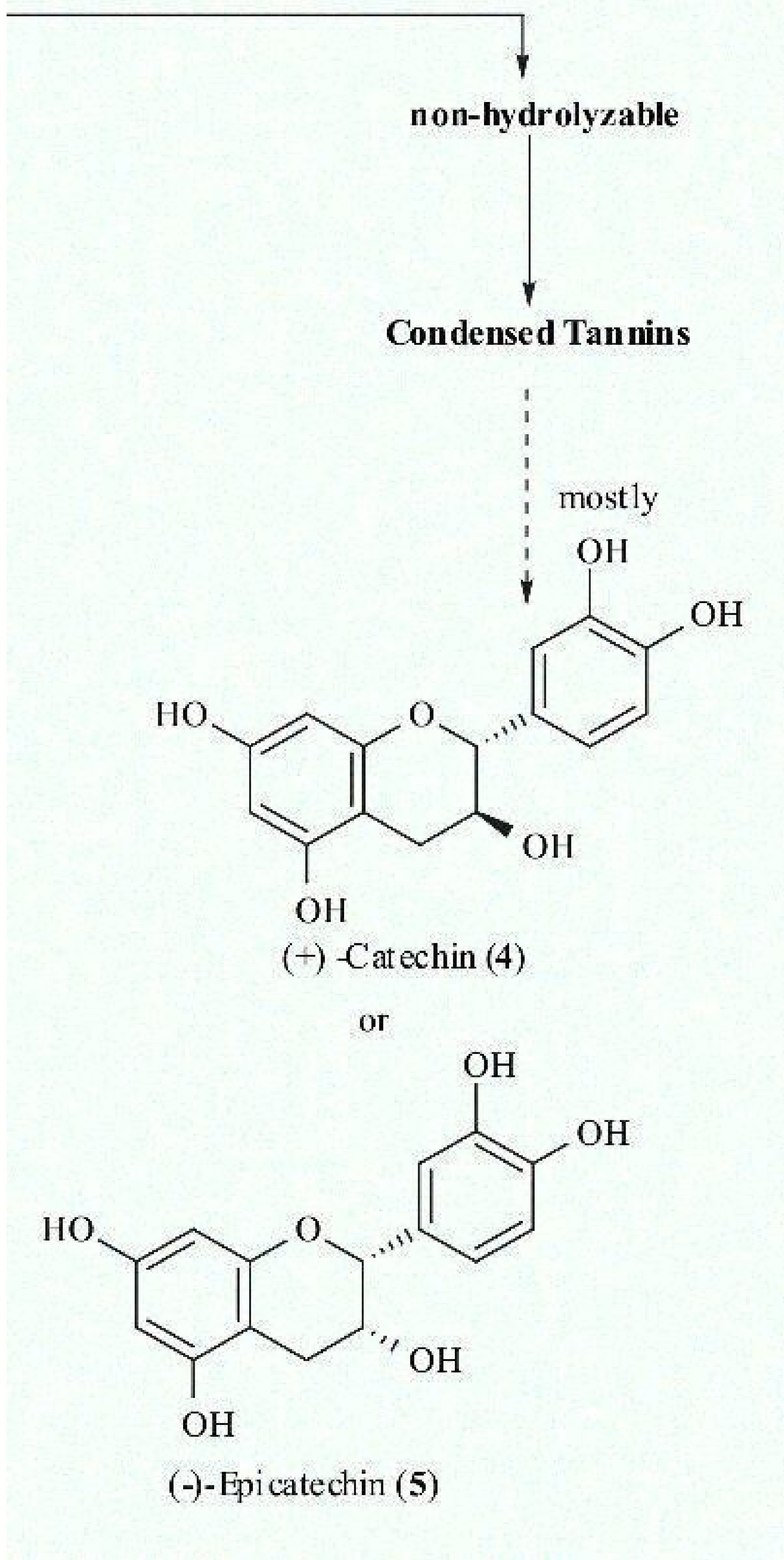

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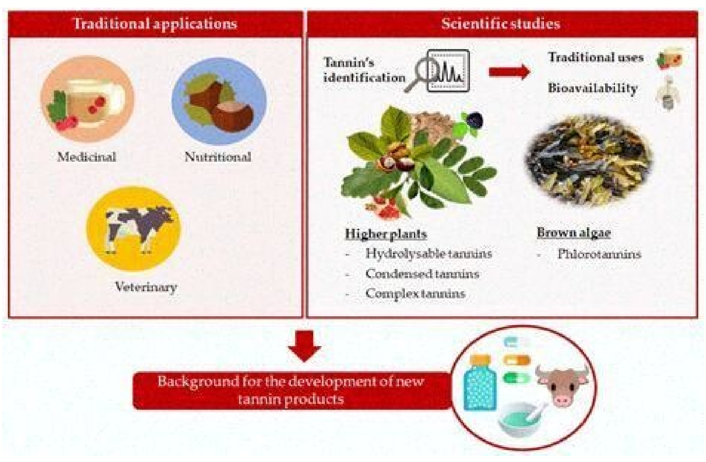

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Literature reviewed so far tends to demonstrate that the antioxidant function of plant tannins are mainly linked to their chemical structure rather than the extraction source (plant spp.). In addition, the specific antioxidant mechanism of plant tannins in animal tissues has not completely clarified, and further research is needed. Antibacterial Activity As natural polyphenolic compounds, tannins display antibacterial effects. Research has investigated the effects of different levels of tannins on growth performance, intestinal microorganisms and morphology in piglets. A study found that tannins at 0.13, 2.25, and 0.45% significantly improved the feed conversion rate, reduced the concentrations of ammonia, isobutyric, and isovaleric acid in the cecum, decreased the depth of ileal crypts and reduced intestinal bacterial proteolysis (40). Studies showed that compared to the control, 250 or 500 mg/kg sweet chestnut tannin had no obvious effects on body weight and feed conversion in 41-day-old chickens. However, in 28-day-old chickens, 1,000 mg/kg tannins reduced the numbers of E. coli and other harmful bacteria in the small intestine. It has also been observed that tannins change the microorganism population quantity in the small intestine and colon in chickens (41). An experiment based on broilers investigated the effect of different concentrations of phenolic compounds from grape pomace (GP). The work showed that grape pomace might delay meat lipid oxidation, which was linked to an increase in the meat polyunsaturated fatty acid (PUFA) concentration (42).

A hydrolyzable tannin extracted from chestnut was tested for efficacy in regulating the proliferation of Clostridium perfringens in the gut. The results showed that even at low concentrations (1.5–3.0 g/kg), chestnut tannins had a remarkable effect on controlling necrotic enteritis (NE). Compared to the control group, proliferation of Clostridium perfringens and gut damage were reduced by tannins in the treatment groups (11). Experimental studies on pigs demonstrated the effects of two compounds containing tannins. The gastrointestinal absorption of mycotoxins was reduced by grape pomace, which would be considered an alternative to commercial products. Gold grape seed extract (GSE) caused an ecological shift in the microbiome, significantly increasing the numbers of Lachnospiraceae, Clostridales, Lactobacillus, and Ruminococcaceae. This might be due to the bacterial populations or the structures of the compounds in the colon (43, 44).

Based on the above results, tannins represent a potential alternative strategy to antibiotics in animal production. However, suppression of intracellular bacteria is also important (45) and needs to be further studied in plant tannins. Further investigation is necessary to determine the effects of tannins on bacterial conditions in vitro (46).

A bacteriostatic model was used to study the mechanism of tannins. Condensed tannins (CT) from purple prairie clover (Dalea purpurea Vent; PPC) were screened for anti-Escherichia coli O157:H7 activity against E. coli O157:H7 strain 3,081. After 24 h, optical density was measured to assess the growth of the bacteria at 600 nm.

CT increased the lag time and reduced the growth rate of E. coli O157:H7. At the same time, CT decreased the proportions of unsaturated fatty acids in the total fatty acids and disrupted the outer membrane structure. The results showed that the possible mechanism was associated with fatty acid composition and the outer membrane of the cell (47).

Synthesizing each index showed that tannins exert bacteria by inhibiting extracellular microbial enzymes and oxidative phosphorylation, which directly affects microbial metabolism, depriving microorganisms of substrates needed for growth and increasing membrane permeability (48). It has been reported that the amount of hydroxyl groups in tannins and the release of hydrogen peroxide are important indicators to evaluate the antibacterial properties, which are positively correlated with antioxidant properties. For instance, trihydroxy b-cycloflavonol (gallic catechin) has stronger effects on Streptococcus, Clostridium, and Staphylococcus than dihydroxy b-cyclocatechin (43, 49). Because tannins come from a wide range of sources and have diverse antibacterial effects, screening and identifying tannins that are effective and specific to target microorganisms will be the work of ongoing research. Antiviral Activity Some papers have reported that tannins have the ability to prevent viral infection such as HIV, bovine adeno-associated virus (BAAV) and norovirus.

An herb screening model based on saliva-based binding/blocking assays using the NoV P protein was developed, and tannic acid was identified as a strong inhibitor in the binding of NoV to HBGA receptors. The data suggested that tannic acid (TA) is a promising antiviral agent against NoVs (50). Another study on TA and BAAV found that treatment with TA reduced BAAV transcytosis and increased lung transduction. The sorting and activity of the BAAV-expressed cystic fibrosis transmembrane regulator membrane protein were not impaired by TA (51). The inhibitory activity of tannins on HIV-1 was tested, and the results indicated that tannins inhibited syncytia formation, lytic effects, viral p24 antigen production and the activity of the HIV-1 reverse transcriptase (RT) enzyme (52). Another study on HIV-I integrase activity showed that some herb extracts display strong inhibition of integrase activity. The effect was most likely due to tannins in herb extracts (53). According to data from these studies, tannins are an effective compound against HIV-1 with high potential for further studies (54). In addition to the above viruses, tannins also inhibited other types of viruses, such as enterovirus. Research in mice demonstrated that chebulagic acid, as a hydrolyzable tannin, reduced the viral cytopathic effect on rhabdomyosarcoma cells. By inhibiting viral replication, chebulagic acid may reduce the mortality induced by a lethal dose of enterovirus 71 and relieve clinical symptoms (55). The beneficial effect was also reflected in the inhibition of hepatitis virus. In vitro, the results showed that (2)-epigallocatechin-3-gallate (EGCG) from green tea acted directly on hepatitis C virus (HCV) and prevented the virus from entering the cell surface (56). The same results were obtained in Huh7.5 cells, in which tannic acid, a polymer of gallic acid and glucose molecules, blocked cell-to-cell spread in infectious HCV cell cultures but did not inhibit HCV replication after infection (57).

Hepatitis B virus (HBV) infection remains a major global health problem. In this study, hydrolyzable tannins such as punicalagin, punicalin, and geraniin reduced the production of HBeAg and the accumulation of cccDNA in HepDES19 and HepG2.117 cells. These hydrolyzable tannins may serve as new agents or strategies to block HBV infection (58).

A study investigated the antiviral effects of tannins on 12 different viruses (enveloped and non-enveloped viruses). Extracts from persimmon showed strong antiviral effects against various viruses. Other tannins derived from green tea, acacia and gallnuts were effective against some viruses. Tannins interact with virion proteins, and restricted virus adsorption to the cells may be the possible mechanism of the inhibitory effect of tannins (59). In summary, the antiviral function of tannins is realized through inhibiting the invasion of cells and nuclei by viruses, the activity of virus reverse transcriptase, and the transmission to other cells and promoting viral protein denaturation. However, due to their different sources and chemical structures, tannins have different antiviral properties. Antiparasitic Activity Parasitic infections represent a major pathological threat to livestock and poultry production. Tannins represent a valuable option as an alternative to drugs for the control of parasites.

In vitro bioassays evaluated the effects of condensed tannins (CTs) obtained from Lotus pedunculatus (LP), Lotus corniculatus (LC), Dorycnium pentaphyllum (DP), Dorycnium rectum (DR), and Rumex obtusifolius (RO) on egg hatching, larval development and the viability of Teladorsagia circumcincta (Stadelmann, 1894) (Ostertagia circumcincta) and the L3 larvae of Trichostrongylus colubriformis (Giles, 1892). These studies showed that CTs were able to inhibit egg hatching, slow larval development, kill undeveloped larvae and disrupt the life cycle of nematodes (60–62).

Some experiments evaluated the anthelmintic effects of extracts from tropical tanniniferous plants (TTPs), such as Acacia pennatula, Lysiloma latisiliquum, Piscidia piscipula and Leucaena leucocephala, on Haemonchus contortus. These results suggested that tannins may be used as anthelmintics for gastrointestinal nematodes by interfering with the process of L (3) exsheathment (63, 64). In addition, condensed tannins showed activity against free-living larvae and parasitic adults, confirming the potential role of tannins in the control of parasites at different growth phases (65, 66). In summary, the direct mechanisms involve restricting larval development to reduce the establishment of infected third-stage larvae in the host and decreasing spawning to inhibit the motion performance of the parasite, and the indirect mechanisms involve improving human immune function and resistance to infection. However, many factors influence the impact of tannins, such as plant sources of different varieties, the growth stage of parasites and the different host species. Anti-inflammatory Activity Recently, some studies found that plant tannins have anti-inflammatory effects by inhibiting NO and prostaglandin-E2 (PGE2) (67). Most tannin extracted from different plants display anti-inflammatory functions. An in vitro assay using obese Zucker rats applied grape seed procyanidin extract to demonstrate that it can reduce obesity-induced inflammation by mediating the expression of cytokines (68). In addition, the tannin fraction of the extract from black raspberry seeds has anti-inflammatory activity to reduce nitric oxide (NO) induced by lipopolysaccharide (LPS) in RAW 264.7 cells (69). The anti-inflammatory function has also been demonstrated in croton oil-induced ear edema mice. In this study, hydrolyzable tannins from Myricaria bracteata showed a significant anti-inflammatory effect on mice (70). Tannins can form a gastroprotective barrier to improve gastritis symptoms based on their antioxidant activity (39). Therefore, it is speculated that the anti-inflammatory properties of tannins from different sources may be caused by regulating cytokine expression, reducing the production of inflammatory substances and enhancing complexation with other molecules.

However, the mechanism remains to be explored because animal experiments are still lacking. Antidiarrheal Activity Plant tannins have shown antidiarrheal potential in animal models. A study performed by Bonelli et al. (71) shown that administration of tannins in calves with diarrhea may shorten the duration of the diarrheic episode (DDE). This research shows that some plant tannins have anti-diarrhea effects. In a mouse model of diarrhea induced by castor oil, Galla Chinensis oral solution (GOS) showed significant antidiarrheal activity, suggesting that GOS can be used to complement other therapies because it is an effective and stable antidiarrheal drug (72). In piglets, an experimental model for post-weaning diarrhea with enterotoxigenic Escherichia coli F4 (ETEC F4) was established, and then the effect of chestnut-tannin (1%) in preventing diarrhea was assessed. Tannins reduced the diarrhea rate and the duration of diarrhea (73). A study examined the effects of a hydrolyzable tannin extracted from Chinese gallnut (penta-m-digalloyl-glucose, PDG) on mouse diarrhea. The results showed that intraluminal injection of PDG reduced cholera toxin-induced intestinal fluid secretion (74). Overall, tannins are effective antidiarrhea compounds, and they may provide a new therapeutic intervention for diarrhea in animal production. Conclusion and Future Perspectives As a natural polyphenolic substance, plant tannins have been found to have a variety of biological functions. The potential utility of plant tannins as feed additives is enormous in animal production. However, the addition of high tannins in animal diet needs to be very cautious.it may adversely affect the growth and development of animals and induce metabolic disorders, which may depend on the type and chemical structure of tannins, intake, dietary composition and animal species. In addition, different extraction sources and concentrations of plant tannins, as well as different animal species and physiological statuses, will influence the additive effect. At present, studies on the structure and nutritional characteristics of plant tannins are not sufficient. Most of the research has focused on complex plant tannins, while there have been few studies on the effects of single plant tannins. Meanwhile, cross-disciplinary studies are also insufficient, resulting in some conclusions still being limited to speculation. The mechanism of action is not yet clear. More studies should focus on the main active components, structural characteristics and mechanisms of plant tannins from different sources to ensure the accurate application of plant tannins in animal production. Further research is needed in the future. Author Contributions ZT wrote this manuscript.

WH and XF collected literature. AG reviewed the manuscript and given critical suggestions and comments. All authors read and approved the final manuscript. Funding This work was supported by the Scientific and Technological Innovation Team Construction Project for Protection and Utilization of Under-Forest Biological Resources in Universities of Yunnan Province. Conflict of Interest The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. Publisher's Note All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers.

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Not to be confused with Tanin (disambiguation). Tannic acid, a type of tannin Tannin powder (mixture of compounds) A bottle of tannic acid solution in water Tannins (or tannoids) are a class of astringent, polyphenolic biomolecules that bind to and precipitate proteins and various other organic compounds including amino acids and alkaloids. The term tannin (from Anglo-Norman tanner, from Medieval Latin tannāre, from tannum, oak bark) refers to the use of oak and other bark in tanning animal hides into leather. By extension, the term tannin is widely applied to any large polyphenolic compound containing sufficient hydroxyls and other suitable groups (such as carboxyls) to form strong complexes with various macromolecules. The tannin compounds are widely distributed in many species of plants, where they play a role in protection from predation (acting as pesticides) and might help in regulating plant growth.[1] The astringency from the tannins is what causes the dry and puckery feeling in the mouth following the consumption of unripened fruit, red wine or tea.[2] Likewise, the destruction or modification of tannins with time plays an important role when determining harvesting times. Tannins have molecular weights ranging from 500 to over 3,000[3] (gallic acid esters) and up to 20,000 Daltons (proanthocyanidins). Structure and classes of tannins There are three major classes of tannins: Shown below are the base unit or monomer of the tannin. Particularly in the flavone-derived tannins, the base shown must be (additionally) heavily hydroxylated and polymerized in order to give the high molecular weight polyphenol motif that characterizes tannins. Typically, tannin molecules require at least 12 hydroxyl groups and at least five phenyl groups to function as protein binders.[4] Base unit / scaffold Gallic acid Phloroglucinol Flavan-3-ol Polymer class Hydrolyzable tannins Phlorotannins Condensed tannins[5] Phlobatannins (C-ring isomerized condensed tannins)[5] Sources Plants Brown algae Plants Tree heartwood Oligostilbenoids (oligo- or polystilbenes) are oligomeric forms of stilbenoids and constitute a minor class of tannins.[6] Pseudo-tannins Pseudo-tannins are low molecular weight compounds associated with other compounds.

They do not change color during the Goldbeater's skin test, unlike hydrolysable and condensed tannins, and cannot be used as tanning compounds.[4] Some examples of pseudo tannins and their sources are:[7] Pseudo tannin Source(s) Gallic acid Rhubarb Flavan-3-ols (Catechins) Tea, acacia, catechu, cocoa, guarana Chlorogenic acid Nux-vomica, coffee, mate Ipecacuanhic acid Carapichea ipecacuanha History Ellagic acid, gallic acid, and pyrogallic acid were first discovered by chemist Henri Braconnot in 1831.[8]:20 Julius Löwe was the first person to synthesize ellagic acid by heating gallic acid with arsenic acid or silver oxide.[8]:20[9] Maximilian Nierenstein studied natural phenols and tannins[10] found in different plant species.

Working with Arthur George Perkin, he prepared ellagic acid from algarobilla and certain other fruits in 1905.[11] He suggested its formation from galloyl-glycine by Penicillium in 1915.[12] Tannase is an enzyme that Nierenstein used to produce m-digallic acid from gallotannins.[13] He proved the presence of catechin in cocoa beans in 1931.[14] He showed in 1945 that luteic acid, a molecule present in the myrobalanitannin, a tannin found in the fruit of Terminalia chebula, is an intermediary compound in the synthesis of ellagic acid.[15] At these times, molecule formulas were determined through combustion analysis. The discovery in 1943 by Martin and Synge of paper chromatography provided for the first time the means of surveying the phenolic constituents of plants and for their separation and identification. There was an explosion of activity in this field after 1945, including prominent work by Edgar Charles Bate-Smith and Tony Swain at Cambridge University.[16] In 1966, Edwin Haslam proposed a first comprehensive definition of plant polyphenols based on the earlier proposals of Bate-Smith, Swain and Theodore White, which includes specific structural characteristics common to all phenolics having a tanning property. It is referred to as the White–Bate-Smith–Swain–Haslam (WBSSH) definition.[17][self-published source?] Occurrence Tannins are distributed in species throughout the plant kingdom. They are commonly found in both gymnosperms and angiosperms. Mole studied the distribution of tannin in 180 families of dicotyledons and 44 families of monocotyledons (Cronquist). Most families of dicot contain tannin-free species (tested by their ability to precipitate proteins). The best known families of which all species tested contain tannin are: Aceraceae, Actinidiaceae, Anacardiaceae, Bixaceae, Burseraceae, Combretaceae, Dipterocarpaceae, Ericaceae, Grossulariaceae, Myricaceae for dicot and Najadaceae and Typhaceae in Monocot. To the family of the oak, Fagaceae, 73% of the species tested contain tannin. For those of acacias, Mimosaceae, only 39% of the species tested contain tannin, among Solanaceae rate drops to 6% and 4% for the Asteraceae. Some families like the Boraginaceae, Cucurbitaceae, Papaveraceae contain no tannin-rich species.[18] The most abundant polyphenols are the condensed tannins, found in virtually all families of plants, and comprising up to 50% of the dry weight of leaves.[19][20] Cellular localization This section needs additional citations for verification. Please help improve this article by adding citations to reliable sources in this section. Unsourced material may be challenged and removed.Find sources: "Tannin" – news · newspapers · books · scholar · JSTOR (September 2021) (Learn how and when to remove this template message) In all vascular plants studied, tannins are manufactured by a chloroplast-derived organelle, the tannosome.[21] Tannins are mainly physically located in the vacuoles or surface wax of plants. These storage sites keep tannins active against plant predators, but also keep some tannins from affecting plant metabolism while the plant tissue is alive. Tannins are classified as ergastic substances, i.e., non-protoplasm materials found in cells. Tannins, by definition, precipitate proteins. In this condition, they must be stored in organelles able to withstand the protein precipitation process. Idioblasts are isolated plant cells which differ from neighboring tissues and contain non-living substances. They have various functions such as storage of reserves, excretory materials, pigments, and minerals. They could contain oil, latex, gum, resin or pigments etc. They also can contain tannins. In Japanese persimmon (Diospyros kaki) fruits, tannin is accumulated in the vacuole of tannin cells, which are idioblasts of parenchyma cells in the flesh.[22] Presence in soils See also: Soil pH The convergent evolution of tannin-rich plant communities has occurred on nutrient-poor acidic soils throughout the world. Tannins were once believed to function as anti-herbivore defenses, but more and more ecologists now recognize them as important controllers of decomposition and nitrogen cycling processes. As concern grows about global warming, there is great interest to better understand the role of polyphenols as regulators of carbon cycling, in particular in northern boreal forests.[23] Leaf litter and other decaying parts of kauri (Agathis australis), a tree species found in New Zealand, decompose much more slowly than those of most other species. Besides its acidity, the plant also bears substances such as waxes and phenols, most notably tannins, that are harmful to microorganisms.[24] Presence in water and wood The leaching of highly water soluble tannins from decaying vegetation and leaves along a stream may produce what is known as a blackwater river. Water flowing out of bogs has a characteristic brown color from dissolved peat tannins. The presence of tannins (or humic acid) in well water can make it smell bad or taste bitter, but this does not make it unsafe to drink.[25] Tannins leaching from an unprepared driftwood decoration in an aquarium can cause pH lowering and coloring of the water to a tea-like tinge. A way to avoid this is to boil the wood in water several times, discarding the water each time. Using peat as an aquarium substrate can have the same effect. Many hours of boiling the driftwood may need to be followed by many weeks or months of constant soaking and many water changes before the water will stay clear. Raising the water's pH level, e.g. by adding baking soda, will accelerate the process of leaching.[26] Softwoods, while in general much lower in tannins than hardwoods,[27] are usually not recommended for use in an aquarium[28] so using a hardwood with a very light color, indicating a low tannin content, can be an easy way to avoid tannins. Tannic acid is brown in color, so in general white woods have a low tannin content.

Woods with a lot of yellow, red, or brown coloration to them (like cedar, redwood, red oak, etc.) tend to contain a lot of tannin.[29] Tannin-rich fresh water draining into Cox Bight from Freney Lagoon, Southwest Conservation Area, Tasmania, Australia Bog-wood (similar to, but not, driftwood) in an aquarium, turning the water a tea-like brown Upper Tahquamenon falls Panoramic view The tannin-rich Oparara River in the West Coast region of New Zealand Extraction There is no single protocol for extracting tannins from all plant material. The procedures used for tannins are widely variable.[30] It may be that acetone in the extraction solvent increases the total yield by inhibiting interactions between tannins and proteins during extraction[30] or even by breaking hydrogen bonds between tannin-protein complexes.[31] Tests for tannins There are three groups of methods for the analysis of tannins: precipitation of proteins or alkaloids, reaction with phenolic rings, and depolymerization.[32] Alkaloid precipitation Alkaloids such as caffeine, cinchonine, quinine or strychnine, precipitates polyphenols and tannins. This property can be used in a quantitation method.[33] Goldbeater's skin test When goldbeater's skin or ox skin is dipped in HCl, rinsed in water, soaked in the tannin solution for 5 minutes, washed in water, and then treated with 1% $FeSO_4$ solution, it gives a blue black color if tannin was present.[34] Ferric chloride test Use of ferric chloride ($FeCl_3$) tests for phenolics in general. Powdered plant leaves of the test plant (1.0 g) are weighed into a beaker and 10 ml of distilled water are added. The mixture is boiled for five minutes. Two drops of 5% $FeCl_3$ are then added. Production of a greenish precipitate is an indication of the presence of tannins.[35] Alternatively, a portion of the water extract is diluted with distilled water in a ratio of 1:4 and few drops of 10% ferric chloride solution is added. A blue or green color indicates the presence of tannins (Evans, 1989).[36] Other methods The hide-powder method is used in tannin analysis for leather tannin and the Stiasny method for wood adhesives.[37][38] Statistical analysis reveals that there is no significant relationship between the results from the hide-powder and the Stiasny methods.[39][40] Hide-powder method 400 mg of sample tannins are dissolved in 100 ml of distilled water. 3 g of slightly chromated hide-powder previously dried in vacuum for 24h over $CaCl_2$ are added and the mixture stirred for 1 h at ambient temperature.

The suspension is filtered without vacuum through a sintered glass filter. The weight gain of the hide-powder expressed as a percentage of the weight of the starting material is equated to the percentage of tannin in the sample. Stiasny's method 100 mg of sample tannins are dissolved in 10 ml distilled water. 1 ml of 10M HCl and 2 ml of 37% formaldehyde are added and the mixture heated under reflux for 30 min. The reaction mixture is filtered while hot through a sintered glass filter. The precipitate is washed with hot water (5× 10 ml) and dried over $CaCl_2$. The yield of tannin is expressed as a percentage of the weight of the starting material. Reaction with phenolic rings The bark tannins of Commiphora angolensis have been revealed by the usual color and precipitation reactions and by quantitative determination by the methods of Löwenthal-Procter and of Deijs[41] (formalin-hydrochloric acid method).[42] Colorimetric methods have existed such as the Neubauer-Löwenthal method which uses potassium permanganate as an oxidizing agent and indigo sulfate as an indicator, originally proposed by Löwenthal in 1877.[43] The difficulty is that the establishing of a titer for tannin is not always convenient since it is extremely difficult to obtain the pure tannin. Neubauer proposed to remove this difficulty by establishing the titer not with regard to the tannin but with regard to crystallised oxalic acid, whereby he found that 83 g oxalic acid correspond to 41.20 g tannin. Löwenthal's method has been criticized. For instance, the amount of indigo used is not sufficient to retard noticeably the oxidation of the non-tannins substances. The results obtained by this method are therefore only comparative.[44][45] A modified method, proposed in 1903 for the quantification of tannins in wine, Feldmann's method, is making use of calcium hypochlorite, instead of potassium permanganate, and indigo sulfate.[46] Food items with tannins Pomegranates Main article: Pomegranate ellagitannin Accessory fruits Strawberries contain both hydrolyzable and condensed tannins.[47] Berries Strawberries in a bowl Most berries, such as cranberries,[48] and blueberries,[49] contain both hydrolyzable and condensed tannins. Nuts Nuts vary in the amount of tannins they contain. Some species of acorns of oak contain large amounts. For example, acorns of Quercus robur and Quercus petraea in Poland were found to contain 2.4–5.2% and 2.6–4.8% tannins as a proportion of dry matter,[50] but the tannins can be removed by leaching in water so that the acorns become edible.[51] Other nuts – such as hazelnuts, walnuts, pecans, and almonds – contain lower amounts. Tannin concentration in the crude extract of these nuts did not directly translate to the same relationships for the condensed fraction.[52] Herbs and spices Cloves, tarragon, cumin, thyme, vanilla, and cinnamon all contain tannins.[citation needed] Legumes Most legumes contain tannins. Red-colored beans contain the most tannins, and white-colored beans have the least. Peanuts without shells have a very low tannin content. Chickpeas (garbanzo beans) have a smaller amount of tannins.[53] Chocolate Chocolate liquor contains about 6% tannins.[54] Drinks with tannins Main articles: Tannins in tea and Tannins in wine Principal human dietary sources of tannins are tea and coffee.[55] Most wines aged in charred oak barrels possess tannins absorbed from the wood.[56] Soils high in clay also contribute to tannins in wine grapes.[57] This concentration gives wine its signature astringency.[58] Coffee pulp has been found to contain low to trace amounts of tannins.[59] Fruit juices Although citrus fruits do not contain tannins, orange-colored juices often contain tannins from food colouring. Apple, grape and berry juices all contain high amounts of tannins. Sometimes tannins are even added to juices and ciders to create a more astringent feel to the taste.[60] Beer In addition to the alpha acids extracted from hops to provide bitterness in beer, condensed tannins are also present. These originate both from malt and hops. Trained brewmasters, particularly those in Germany, consider the presence of tannins to be a flaw[citation needed].

However, in some styles, the presence of this astringency is acceptable or even desired, as, for example, in a Flanders red ale.[61] In lager type beers, the tannins can form a precipitate with specific haze-forming proteins in the beer resulting in turbidity at low temperature. This chill haze can be prevented by removing part of the tannins or part of the haze-forming proteins. Tannins are removed using PVPP, haze-forming proteins by using silica or tannic acid.[62] Properties for animal nutrition Tannins have traditionally been considered antinutritional, depending upon their chemical structure and dosage.[63] Many studies suggest that chestnut tannins have positive effects on silage quality in the round bale silages, in particular reducing NPNs (non-protein nitrogen) in the lowest wilting level.[64] Improved fermentability of soya meal nitrogen in the rumen may occur.[65] Condensed tannins inhibit herbivore digestion by binding to consumed plant proteins and making them more difficult for animals to digest, and by interfering with protein absorption and digestive enzymes (for more on that topic, see plant defense against herbivory). Histatins, another type of salivary proteins, also precipitate tannins from solution, thus preventing alimentary adsorption.[66] Legume fodders containing condensed tannins are a possible option for integrated sustainable control of gastrointestinal nematodes in ruminants, which may help address the worldwide development of resistance to synthetic anthelmintics. These include nuts, temperate and tropical barks, carob, coffee and cocoa.[67] Tannin uses and market Tannin in a plastic container Tannins have been used since antiquity in the processes of tanning hides for leather, and in helping preserve iron artefacts (as with Japanese iron teapots). Industrial tannin production began at the beginning of the 19th century with the industrial revolution, to produce tanning material for the need for more leather. Before that time, processes used plant material and were long (up to six months).[68] There was a collapse in the vegetable tannin market in the 1950s–1960s, due to the appearance of synthetic tannins, which were invented in response to a scarcity of vegetable tannins during World War II. At that time, many small tannin industry sites closed.[69] Vegetable tannins are estimated to be used for the production of 10–20% of the global leather production.[citation needed] The cost of the final product depends on the method used to extract the tannins, in particular the use of solvents, alkali and other chemicals used (for instance glycerin). For large quantities, the most cost-effective method is hot water extraction. Tannic acid is used worldwide as clarifying agent in alcoholic drinks and as aroma ingredient in both alcoholic and soft drinks or juices.

Tannins from different botanical origins also find extensive uses in the wine industry.[citation needed] Uses Tannins are an important ingredient in the process of tanning leather. Tanbark from oak, mimosa, chestnut and quebracho tree has traditionally been the primary source of tannery tannin, though inorganic tanning agents are also in use today and account for 90% of the world's leather production.[70] Tannins produce different colors with ferric chloride (either blue, blue black, or green to greenish-black) according to the type of tannin. Iron gall ink is produced by treating a solution of tannins with iron(II) sulfate.[71] Tannins can also be used as a mordant, and is especially useful in natural dyeing of cellulose fibers such as cotton.[72] The type of tannin used may or may not have an impact on the final color of the fiber. Tannin is a component in a type of industrial particleboard adhesive developed jointly by the Tanzania Industrial Research and Development Organization and Forintek Labs Canada.[73] Pinus radiata tannins has been investigated for the production of wood adhesives.[74] Condensed tannins, e.g., quebracho tannin, and Hydrolyzable tannins, e.g., chestnut tannin, appear to be able to substitute a high proportion of synthetic phenol in phenol-formaldehyde resins for wood particleboard.[citation needed] Tannins can be used for production of anti-corrosive primers for treating rusted steel surfaces prior to painting, converting rust to iron tannate and consolidating and sealing the surface. The use of resins made of tannins has been investigated to remove mercury and methylmercury from solution.[75] Immobilized tannins have been tested to recover uranium from seawater.[76] See also Polyphenol References ^ Ferrell, Katie E.; Thorington, Richard W. (2006). Squirrels: the animal answer guide. Baltimore: Johns Hopkins University Press. p. 91. ISBN 978-0-8018-8402-3. ^ McGee, Harold (2004). On food and cooking: the science and lore of the kitchen. New York: Scribner. p. 714. ISBN 978-0-684-80001-1. ^ Bate-Smith and Swain (1962). "Flavonoid compounds". In Florkin M.; Mason H. S (eds.).
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