= Ramaria botrytis =

Ramaria botrytis , commonly known as the clustered coral , the pink @-@ tipped coral mushroom , or the cauliflower coral , is an edible species of coral fungus in the family Gomphaceae . Its robust fruit body can grow up to 15 cm (6 in) in diameter and 20 cm (8 in) tall , and resembles some marine coral . Its dense branches , which originate from a stout , massive base , are swollen at the tips and divided into several small branchlets . The branches are initially whitish but age to buff or tan , with tips that are pink to reddish . The flesh is thick and white . The spores , yellowish in deposit , are ellipsoid , feature longitudinal striations , and measure about 13 @.@ 8 by 4 @.@ 7 micrometers .

The type species of the genus Ramaria , R. botrytis was first described scientifically in 1797 by mycologist Christiaan Hendrik Persoon . A widely distributed species , it is found in North America , North Africa , central and eastern Europe , Australia , and Asia . The fungus is mycorrhizal with broadleaf trees , and fruits on the ground in wooded areas . There are several species of coral fungi that are superficially similar in appearance to R. botrytis , and although comparison of habitat or characteristics like color or branching morphology is often sufficient for identification , sometimes microscopy is required to definitively distinguish between them . Fruit bodies of Ramaria botrytis are edible , and young specimens have a mild , fruity taste . Some authors warn of laxative effects in susceptible individuals . The fungus contains several chemical compounds with in vitro biological activity , and fruit bodies have antimicrobial activity against several species and strains of drug @-@ resistant bacteria that cause disease in humans .

= = Taxonomy and classification = =

The species was first named as Clavaria botrytis in 1797 by Christian Hendrik Persoon . In 1821 , Elias Magnus Fries sanctioned the genus name Clavaria , and treated Ramaria as a section of Clavaria . It was given its current name in 1918 by Adalbert Ricken . Obsolete historical synonyms include Gotthold Hahn 's 1883 Corallium botrytis and A. A. Pearson 's variety Clavaria botrytis var. alba , which is no longer recognized as an independent taxon . Currie Marr and Daniel Stuntz described the variety R. botrytis var. aurantiiramosa in their 1973 monograph of western Washington Ramaria ; Edwin Schild and G. Ricci described variety compactospora from Italy in 1998 . In 1950 , E.J.H. Corner published George F. Atkinson 's 1908 Clavaria holorubella as R. botrytis var. holorubella , but this taxon is now known as the independent species Ramaria holorubella .

The specific epithet botrytis is derived from the Greek word ?????? (botrus) meaning " bunch of grapes " . The species is commonly known as the " cauliflower coral " , the " pink @-@ tipped coral mushroom " , or the " rosso coral " . In the Cofre de Perote region of Veracruz , Mexico , R. botrytis is known by the local names escobea , meaning " little broom " , or pechuga , meaning " breast meat of chicken " .

Ramaria botrytis was designated the type species of Ramaria in 1933 by Marinus Anton Donk . Modern molecular analysis indicates that Ramaria is a polyphyletic assemblage of species with clavarioid fruit bodies . According to the infrageneric classification scheme proposed by Marr and Stuntz , R. botrytis is included in the subgenus Ramaria , which includes species that have grooved spores , clamps present in the hyphae , and fruit bodies with a large , profusely branched cauliflower @-@ like appearance . Phylogenetic analysis of nuclear large subunit ribosomal DNA suggests that R. botrytis is closely related to R. rubripermanens and R. rubrievanescens , and that these species form a clade that is sister (sharing a recent common ancestor) to the false truffle genus Gautieria , the most derived group within the studied taxa .

= = Description = =

The fruit bodies produced by the fungus are 7 to 15 cm (2 @.@ 8 to 5 @.@ 9 in) wide and 6 to 20 cm (2 @.@ 4 to 7 @.@ 9 in) tall . They are fleshy cauliflower @-@ like masses with a stout central stem that splits into a few lower primary branches before branching densely above . The stem is

short and thick ? between 1 @.@ 5 and 6 cm (0 @.@ 6 and 2 @.@ 4 in) in diameter ? and tapers downward . Initially white , in age both the stem and branches turn pale yellow to buff to tan . Old fruit bodies can fade to become almost white , or may be ochre due to fallen spores . The branching pattern is irregular , with the primary branches few and thick ? typically 2 ? 3 cm (0 @.@ 8 ? 1 @.@ 2 in) ? and the final branches slender (2 ? 3 mm) , and usually terminated with five to seven branchlets . The branchlet tips are pink to purplish @-@ red . The flesh is solid and white , and has an odor described variously as indistinct or pleasant . A drop of Melzer 's reagent applied to the stem tissue reveals a weak amyloid staining reaction that often requires more than 30 minutes to develop . This reaction can be used to help distinguish R. botrytis from other similar fungi .

Spores are produced by basidia on the outer surface of the branches . Viewed in deposit , the spores are pale yellow . Microscopically , they have fine longitudinal or oblique striations that often fuse together in a vein @-@ like network . They range in shape from roughly cylindrical to sigmoid (curved like the letter " S ") , and their dimensions are 12 ? 16 by 4 ? 5 µm . Basidia are four @-@ spored (occasionally two @-@ spored) , and measure 59 ? 82 by 8 ? 11 µm . The sterigmata (slender projections of the basidia that attach to the spores) are 4 ? 8 µm long . The hymenium and subhymenium (the tissue layer immediately under the hymenium) combined are about 80 µm thick . Hyphae comprising the subhymenium are interwoven , 2 @.@ 5 ? 4 @.@ 5 µm in diameter , thin @-@ walled , and clamped .

The variety R. botrytis var. aurantiiramosa is distinguished from the more common variety by the orange color of the upper branches . Variety compactospora tends to show a more pronounced wine @-@ red , purple , or reddish color in the branch tips , and has smaller spores measuring 9 @.@ 2 ? 12 @.@ 8 by 4 ? 5 @.@ 4 µm .

= = = Similar species = = =

Distinctive features of Ramaria botrytis include its large size , the orange , reddish , or purplish branchlets , striate spores with dimensions averaging 13 @.@ 8 by 4 @.@ 7 µm , and a weak amyloid staining reaction of the stem tissue . R. rubripermanens has reddish terminal branches , a stout form , and striate spores , but may be distinguished from R. botrytis by its much shorter spores . Other species with which R. botrytis may be confused include : R. formosa , which has branches that are pinker than R. botrytis , and yellow @-@ tipped ; R. caulifloriformis , found in the Great Lakes region of the United States , whose branch tips darken with age ; R. strasseri , which has yellow to brown branch tips ; R. rubrievanescens , which has branches in which the pink color fades after picking or in mature fruit bodies ; and R. botrytoides , which is most reliably distinguished from R. botrytis by its smooth spores . The European species R. rielii , often confused with R. botrytis and sometimes considered synonymous , can be distinguished by microscopic characteristics : R. reilii lacks the clamped hyphae of R. botrytis , its spores are longer and wider , and they have warts instead of striations . The North American species R. araiospora , though superficially similar to R. botrytis , has several distinguishing characteristics : it grows under hemlock ; it has reddish to magenta branches with orange to yellowish tips ; it lacks any discernible odor ; it has warted , somewhat cylindrical spores averaging 9 @.@ 9 by 3 @.@ 7 µm ; and it has non @-@ amyloid stem tissue . Uniformly colored bright pink to reddish , R. subbotrytis has spores measuring 7 ? 9 by 3 ? 3 @.@ 5 µm .

= = Habitat and distribution = =

An ectomycorrhizal species , Ramaria botrytis forms mutualistic associations with broadleaf trees , particularly beech . In a study to determine the effectiveness of several edible ectomycorrhizal fungi in promoting growth and nutrient accumulation of large @-@ fruited red mahogany (Eucalyptus pellita) , R. botrytis was the best at improving root colonization and macronutrient uptake . Records of associations with conifers probably represent similar species . Fruit bodies grow on the ground singly , scattered , or in small groups among leaves in woods . They can also grow in fairy rings . Ramaria botrytis is a " snowbank fungus " , meaning it commonly fruits near the edges of melting

snowbanks in the spring . In Korea , it is prevalent at sites that also produce the choice edible species Tricholoma matsutake .

Ramaria botrytis is found in Africa (Tunisia) , Australia , Asia (including the eastern Himalayas of India , Nepal , Japan , Korea , Pakistan , China , the Far East of Russia , and Turkey) and Europe (including the Netherlands , France , Portugal , Italy , Bulgaria , and Spain) . It is also present in Mexico and in Guatemala . Widely distributed in North America , it is most common in the southeast and along the Pacific Coast . The variety R. botrytis var. aurantiiramosa , limited in distribution to Lewis County , Washington , associates with Douglas fir (Pseudotsuga menziesii) and western hemlock (Tsuga heterophylla) . Variety compactospora is known from Sardinia , Italy , where it has been found growing in sandy soil in forests comprising strawberry tree (Arbutus unedo) , tree heath (Erica arborea) , and holm oak (Quercus ilex) .

= = Uses = =

Ramaria botrytis is an edible species , and some rate it as choice . Its taste is " slight " , or " fruity " , and has been likened to sauerkraut , green peanuts (fresh harvested peanuts that have not been dehydrated) , or pea pods . Older fruit bodies develop an acidic flavor . It is sold in food markets in Japan as Nedzumi @-@ take , and harvested from the wild in Korea and Nepal . The thick base and main branches require longer cooking than the smaller branchlets . In the Garfagnana region of central Italy , the mushroom is stewed , or pickled in oil . Fruit bodies can be preserved by slicing thinly and drying . One field guide rates the edibility as " questionable " , warning of the possible danger of confusing specimens with the poisonous Ramaria formosa . Other authors warn that some individuals may experience laxative effects from consuming the mushroom . Caution is advised when collecting fruit bodies near polluted areas , as the species is known to bioaccumulate toxic arsenic .

Chemical analysis shows R. botrytis to have a food energy value of 154 kilojoules per 100 grams of fresh fruit bodies , which is comparable to the 120 ? 150 kJ range reported for commercially grown edible mushrooms . As a percentage of dry matter , the fruit bodies contain 39 @.@ 0 % crude protein , 1 @.@ 4 % lipids , 50 @.@ 8 % carbohydrates , and 8 @.@ 8 % ash . The majority of the lipid content comprises oleic (43 @.@ 9 %) , linoleic (38 @.@ 3 %) , and palmitic (9 @.@ 9 %) fatty acids .

= = = Chemistry = = =

Extracts of the fruit body of Ramaria botrytis have been shown to favorably influence the growth and development of HeLa cells grown in tissue culture . The mushroom contains nicotianamine , an ACE inhibitor (angiotensin @-@ converting enzyme) . Nicotianamine is a metal @-@ chelating compound essential in iron metabolism and utilization in plants . Several sterols have been isolated from the fruit bodies , 5? , 6? @-@ epoxy @-@ 3? @-@ hydroxy- (22E) -ergosta @-@ 8 (14) , 22 @-@ dien @-@ 7 @-@ one , ergosterol peroxide , cerevisterol , and 9? @-@ hydroxycerevisterol , in addition to the previously unknown ceramide (2S , 2'R , 3R , 4E , 8E) -N @-@ 2 ' -hydroxyoctadecanoyl @-@ 2 @-@ amino @-@ 9 @-@ methyl @-@ 4 @,@ 8 @-@ heptade @-@ cadiene @-@ 1 @,@ 3 @-@ diol .

Laboratory tests show that fruit bodies have antimicrobial activity against several strains of drug @-@ resistant bacteria that are pathogenic in humans . Extracts inhibit the growth of the Gram @-@ negative bacteria Enterococcus faecalis and Listeria monocytogenes , and kill the Gram @-@ positive species Pasteurella multocida , Streptococcus agalactiae and S. pyogenes . A separate study demonstrated growth inhibition against Proteus vulgaris .

In a 2009 study of 16 Portuguese edible wild mushroom species , R. botrytis was shown to have the highest concentration of phenolic acids (356 @.@ 7 mg per kg of fresh fruit body) , made up largely of protocatechuic acid ; it also had the highest antioxidant capacity . Phenolic compounds ? common in fruits and vegetables ? are being scientifically investigated for their potential health benefits associated with reduced risk of chronic and degenerative diseases .

= = = Cited literature = = =

Arora D. (1986) . Mushrooms Demystified : A Comprehensive Guide to the Fleshy Fungi . Berkeley , California : Ten Speed Press . ISBN 978 @-@ 0 @-@ 89815 @-@ 169 @-@ 5 .
Marr CD , Stuntz DE (1973) . " Ramaria of Western Washington " . Bibliotheca Mycologica 38 . Lehre , Germany : Von J. Cramer . ISBN 978 @-@ 3 @-@ 7682 @-@ 0902 @-@ 1 .