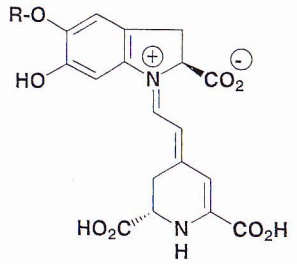
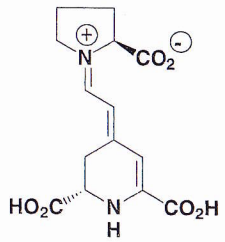
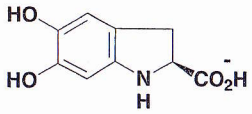
surfactants. It can also be converted to mucic acid, a tetrahydroxylated diacid capable of forming stable complexes with metal ions. This sequestering agent is sometimes described as a possible alternative to phosphates; it is biodegradable.



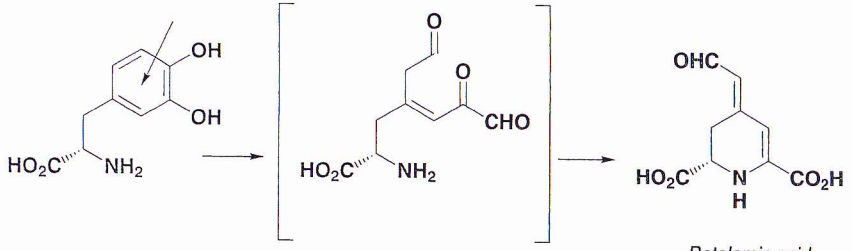
R = H : Betanidin
R = glc : Betanin



Indicaxanthin



Cclodopa



Betalamic acid

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Proteins

Protein Sweeteners

• THAUMATIN

Thaumatin was initially marketed in the United States and in Japan (Talin®), and it is now on the European Union list of approved additives (E957). It is a mixture of proteins isolated from the fruit of an African Marantaceae, *Thaumatococcus danielli* Benth.

The Plant. *T. danielli* is a species with large leaves on a long petiole, with purplish pink flower spikes, and a fleshy trigonal fruit, which ripens to a glowing red and contains 1-3 black seeds surrounded by a fleshy aril. The species is abundant in Ghana, the Ivory Coast, Togo, and Sierra Leone, and the sweetness of its arils has been described as early as the middle of the nineteenth century: it is due to proteins.

Composition. The frozen fruits undergo an aqueous extraction and the protein fraction is resolved by physical techniques (ultrafiltration). The extract contains two chief proteins (thaumatin I and II) which are each composed of 207 amino acids and differ from one another only in five positions; their structure includes eight disulfide bridges. Thaumatin is readily soluble in water and soluble in dilute alcohols. Its stability is maximal at pH 2.7-3 (the sweet taste turns acidic at pH<2) and the sweetening power does not disappear upon heating. Solutions may be pasteurized, but prolonged treatment (sterilization) destroys the sweet taste.

Properties. Thaumatin is a potent sweetener: its activity can be detected at a concentration of 10^{-8} M. The sweet sensation induced by thaumatin is slightly

applications in products such as chewing gums or breath fresheners. It is not toxic, not cariogenic, and it enhances aromas and flavors at low doses. At higher doses, it is an intense sweetener. Research efforts to come up with production methods that do not require using the plant (transgenic organisms) have not yet succeeded in achieving sufficient yields.

• Monellin

Monellin is found in the fruits of a Menispermaceae of tropical western Africa, *Dioscoreophyllum cuminsii* Diels. This tropical rain forest vine, with cordate leaves, bears tight bunches of up to a hundred little red berries. In spite of the fact that the seed is bitter (due to diterpenoids), the whitish mucilage that surrounds it is particularly "sweetening". This is due to monellin, a protein composed of two chains comprising 44 and 50 amino acids, respectively. Although it is particularly efficacious (2,000 times the sweetening potency of sucrose), monellin is unstable at extreme pHs, and does not resist heating, let alone the combination of the two (it is destroyed at 50°C at pH 3.2). Toxicological data are lacking, which seriously limits potential applications.

• Miraculin

This protein can be extracted from the fruit of a western African shrub: *Synsepalum dulcificum* Dan. (Sapotaceae). After about two and a half centuries in oblivion—since the first mention in 1725 of this fruit "which could mask the bitter taste of drugs"—the "miracle" fruit regained attention for its very curious properties: just about tasteless on its own, it transforms the acidic taste into a sweet taste and modifies the perception of numerous flavors. Its properties are linked to a glycoprotein, miraculin, composed of 473 amino acids. Its potential applications are of limited scope; moreover, it induces a risk for confusion due to the persistence (for two hours) of its ability to modify taste.

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Proteins

Lectins

Lectins, from the latin *lego, legere (lectum)* = to read, to choose, to se*lect*... are uninduced proteins or glycoproteins able to bind to saccharide residues on cell membranes, in a specific and reversible fashion, without displaying enzymatic activity. Most lectins of higher plants are located in the seeds: they form during ripening and disappear during germination. They are especially common in Fabaceae (peanut, soybean, lentil, *Canavalia*, green bean, and more).

Many lectins have the ability to agglutinate red blood cells—they are referred to as phytohemagglutinins—and several among them do so with blood group specificity. Some lectins are mitotic; a few can differentiate between normal and tumor cells; some are highly toxic.

Several lectins are currently available for numerous applications in the biological disciplines, but this aspect exceeds the scope of this text (see biochemistry, immunology, hematology texts).

VEGETABLES THAT ARE TOXIC DUE TO LECTINS

Although lectins are often toxic only by the parenteral route, some are not destroyed by the enzymes of the digestive tract: such is the case of abrin from jequirity seeds, phasin from green beans, and also ricin of castor seeds.

Intoxication by ingestion of this type of poison manifests itself 2-3 hours after consumption, by vomiting and hemorraghic diarrhea, loss of fluids, and a state of shock.

Lectins are in fact denatured by cooking: thus green beans are perfectly edible cooked, whereas ingesting raw seeds or pods results in severe gastric disturbances,