High intensive sweeteners

An overview of *non*-nutritive (artificial) sweeteners used to reduce calories

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Agenda

- Introduction
- Known artificial sweeteners (HIS).
- Their Chemicals structure.
- Their manufacture processes.
- Their benefits, Safety, applications, and regulatory status.
- Summary.

Introduction

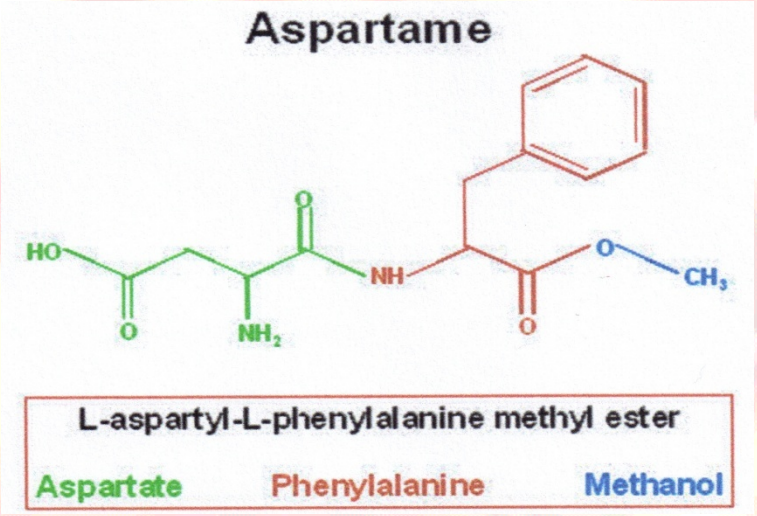
- High intensive sweeteners (HIS) are sweeter than sucrose with zero or low calories.
- Consumers are increasingly concerned with diabetes, weight gain, obesity-related disorder and dental caries.
- This is shaping the need for manufacturing something sweet that is low in calories .
- More than 12 million tons of sucrose produced per year.

Known artificial sweeteners (HIS)

- **Peptides**:
  - Aspartame.
  - Neotame.
  - Alitame.
- **Natural extracts**:
  - Stevia.
  - Monk fruit
  - Thaumatin.
  - Brazzein.

- **Synthetic chemistry**:
  - Sucralose.
  - Acesulfame-K
  - Saccharine.
  - Cyclamate.

Artificial sweeteners (Peptides)



[L-aspartyl-L-phenylalanine methyl ester]

- A low calorie sweetener.
- 200 times sweeter than sucrose.
- Digestible.
- Does <u>not</u> promote tooth decay.
- Enhance and intensified flavor (citrus and fruits)

Manufacturing process

- Aspartame is made through fermentation and synthesis process.

1) <u>Fermentation</u>:

B. flavus for L-aspartic acid production

C. glutamicum for L-phenylalanine production

Only <u>L</u> form of phenylalanine is used in manufacturing.

- <u>Separation of L phenylalanine</u>:

A) - ***Chemical separation***: Separated from D-phenyl alanine by adding acetic anhydride and sodium hydroxide. Extraction of L-phenyl alanine from aqueous layer.

B) - ***Enzymes separation***: using amino acylase enzymes from *Aspergillus oryzae*..

Manufacturing process Cont.

2) Synthesis:

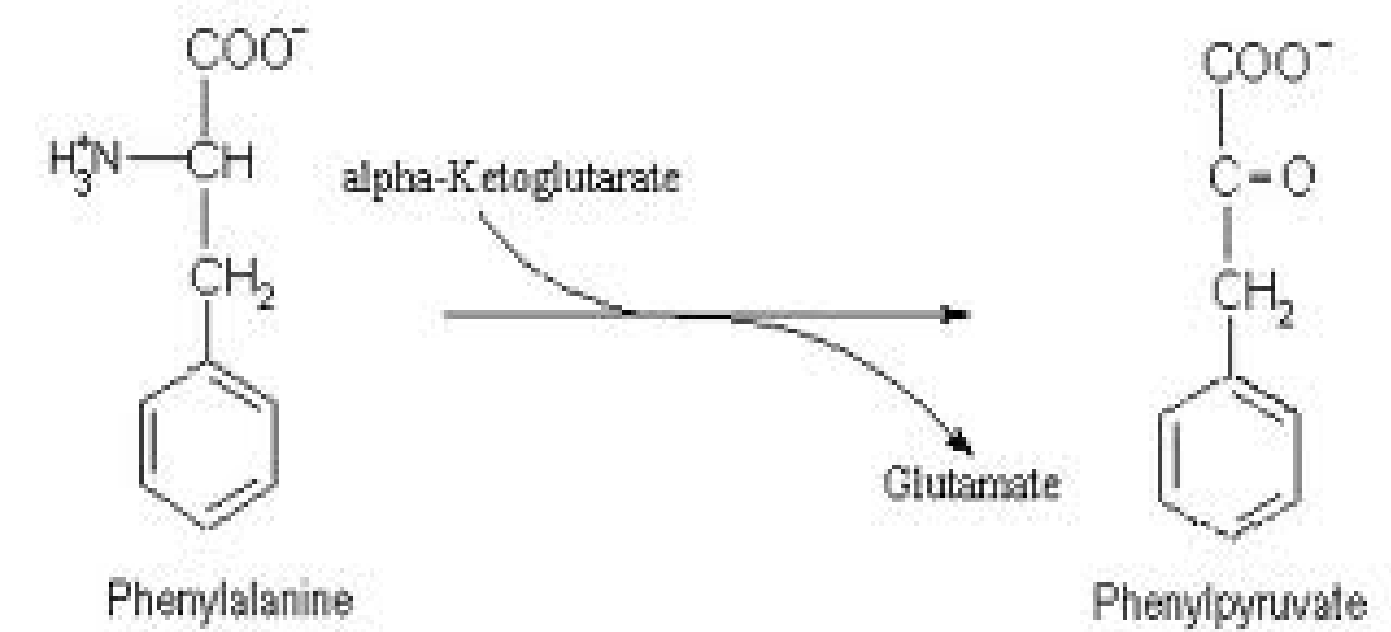
The two amino acids derived from fermentation process are modified to produce aspartame.

- L-Phenylaalanine is reacted with methanol to form methyl ester.
- L-aspartic acid is reacted with benzyl rings to shield specific sites.
- The two modified amino acids are mixed in acetic acid solution at 65^0C for 24 hrs.
- Aspartame recovery

Safety

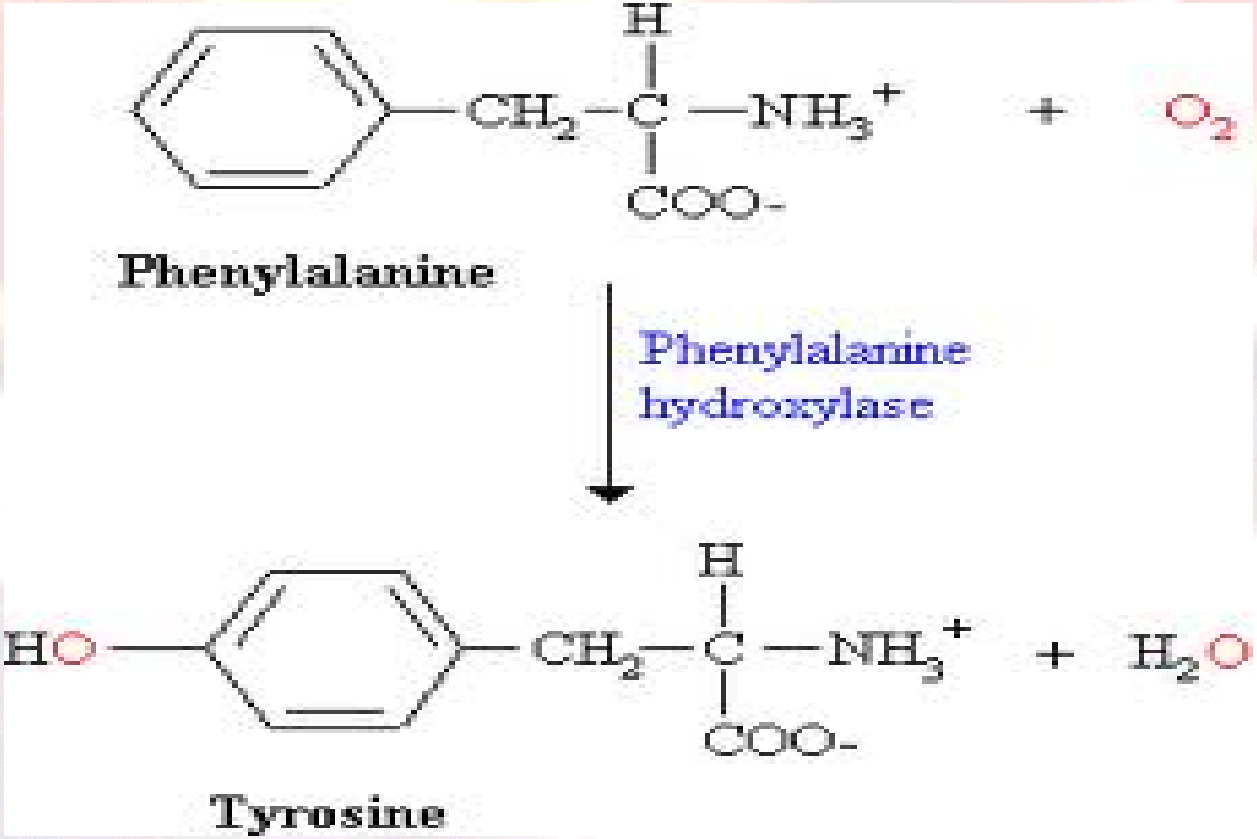
- It is safe and approved for people with diabetes, pregnant and nursing women.
- Acceptable daily intake (ADI) is 40mg/kg body weight.
- Restriction:
  - People with phenyl-ketonuria (PKU) disease.
  - PKU is a rare inherited disease that prevent the metabolism of essential amino acids.
  - Accumulation of phenyl-alanine in the body could cause health problems including mental retardation.
    * **A normal blood phenyl-alanine level is about 1mg/dl**
    * **In classic PKU , levels may range from 6 to 80 mg/dl**

Phenyl alanine metabolism

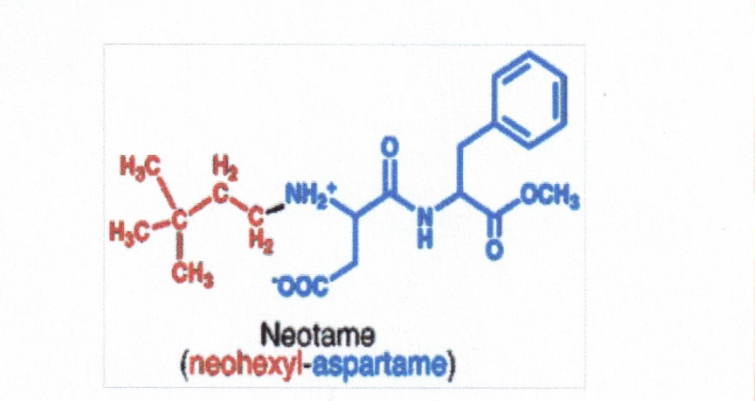


Transamination of Phenylalanine to Phenylpyruvate

Phenyl alanine metabolism



Neotame



(N-[N-(3,3-dimethylbutyl)-L- α-aspartyl]-L-phenylalanine 1-methyl ester)

- Peptide derivative of aspartic acid & Pheynl-alanine.
- Approved as a sweetener and flavor enhancer.
- 7,000-13,000 times sweeter than sucrose.
- 30—60 times sweeter than aspartame
- Rapidly metabolized by human.

Manufacturing process

- Neotame is also made through fermentation and synthesis process.

1) <u>Fermentation</u>:

Similar to Aspatame

2) <u>Synthesis</u>:

Similar to aspartame

plus

The addition of 3,3 dimethylbutyl to L-Aspartic acid.

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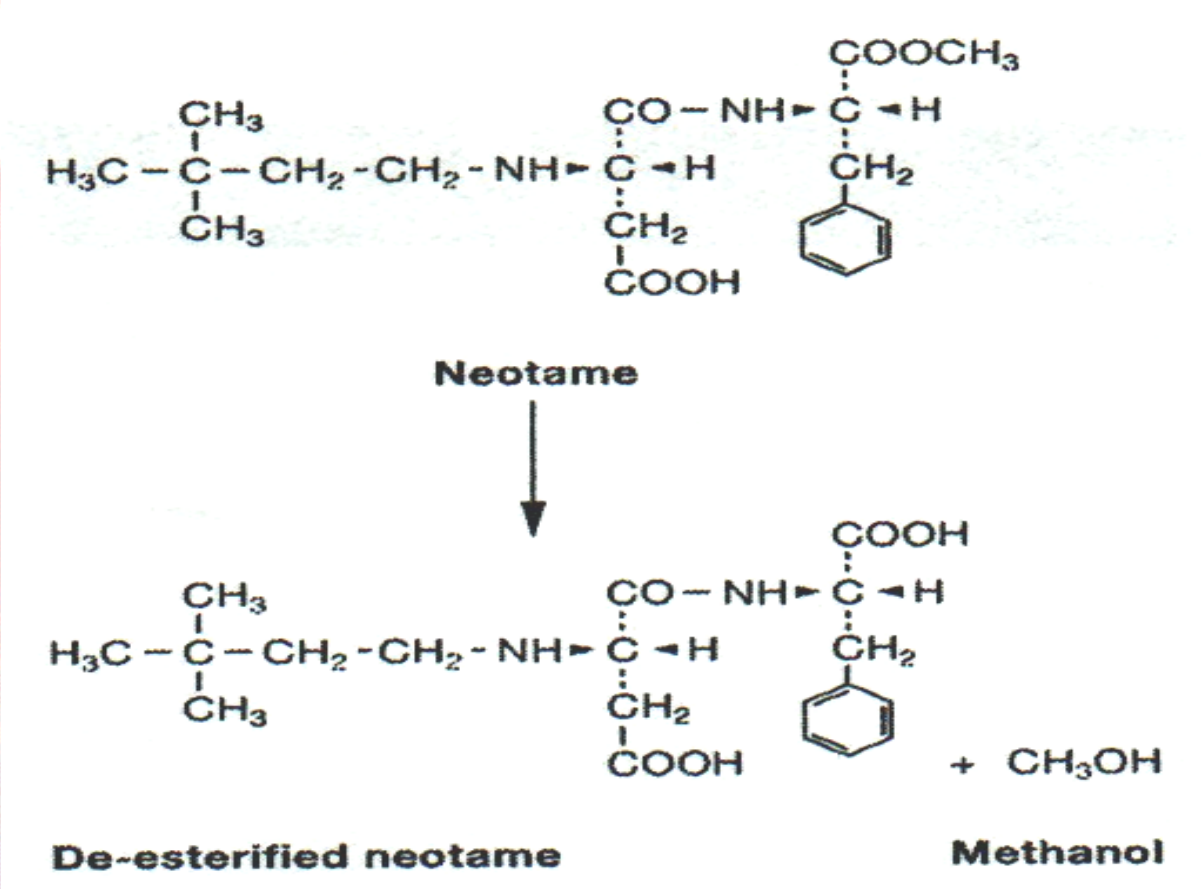
Advantages



- The major metabolic pathway is hydrolysis of the methyl ester by esterase enzymes.

Advantages (cont.)

- The presence of 3,3-dimethybutyl in the structure blocks peptidases enzymes in releasing the amino acid L-phenylalanine.
- No need to add special labeling for phenyketonuric (PKU) individual.

INGREDIENTS

Water, Liquid Soy Bean Oil, Plant Stanol Esters, Salt, Vegetable Mono and Diglycerides, Soy Lecithin, Polyglycerol Esters of Fatty Acids, Potasi... Acid a... EDTA... Artificic... Palmit... Carote...

A. B. C. D. E.

Nutrition Facts

Serving Size 1 box (19g)
Servings Per Container 2

Amount Per Serving	
Calories	70
Fat Calories	0
	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Cholesterol 0mg	0%
Sodium 200mg	8%
Total Carbohydrate 17g	6%
Dietary Fiber 1g	3%
Sugars 1g	
Protein 1g	

Vitamin A	8%	• Vitamin C	15%
Calcium	0%	• Iron	8%
Vitamin D	8%	• Thiamin	15%
Riboflavin	15%	• Niacin	15%
Vitamin B6	15%	• Folate	15%

* Percent Daily Values (DV) are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carb.		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Ingredients: Corn, sugar, salt, malt flavoring, corn syrup, niacinamide, ascorbic acid (C), iron, pyridoxine hydrochloride (B6), riboflavin (B2), vitamin A palmitate, thiamin hydrochloride (B1), folic acid and vitamin D. Quality protected with BHT.

Regulatory Status

- Approved for use as sweetener and flavor enhancers in foods and beverages in United States, Australia and New Zealand.
- Can be blended with nutritive sweeteners (HFCS, sucrose) to match the taste while providing significant cost savings.
- Applications:

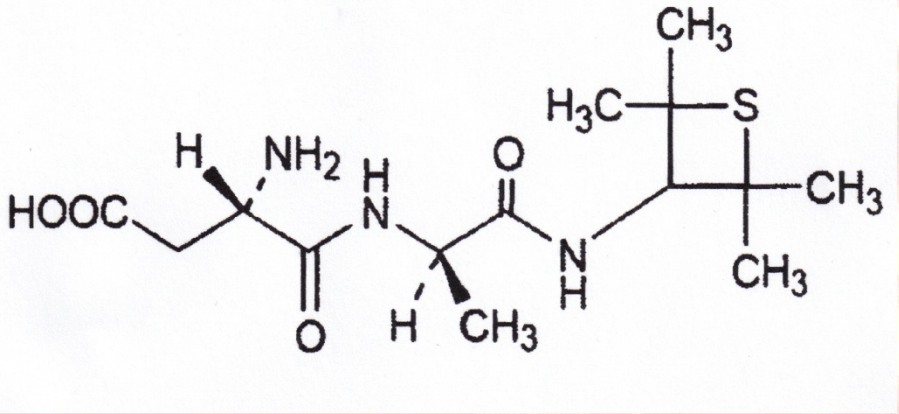
  Beverages and cereals.

  Tabletop sweeteners

  Chewing gums and confectionary.

  Frozen desserts, ice cream, yogurt.

Alitame



[L-alpha –Aspertyl-N-D-alaninamide]

- It is a dipeptides of L-aspartic acid and D-alanine, with a terminal *N*-substituted by tetramethyl-thietanly-amine.
- It is 200-300 times sweeter than sucrose and 10 times sweeter than aspartame.
- Soft drink with aspartame develop off taste after long storage.

Manufacturing process

- Alitame is prepared by a multistep synthesis involving the reaction between two intermediates.
  - (S)-[2,5-dioxo-(4-thiozolidine)]acetic acid.
  - (R)-2-amino-N-(2,2,4,4-tetramethyl-3-thietanyl)propanamide.
- The final product is isolated and purified by crystallization.

Benefits

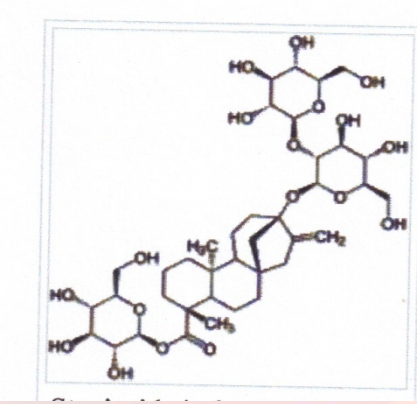
- Clean sweet taste.
- Excellent stability at high temperature.
- Suitable for diabetics.
- Safe for teeth.
- Synergetic when combined with other low calorie sweeteners.
- Its caloric contribution to the diet is negligible.

Safety

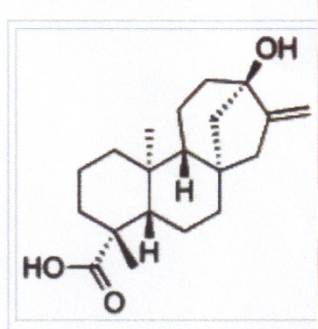
- Safe for human consumption.
- Acceptable daily intake (ADI) is 1mg/ kg. body weight.
- The aspartic acid is metabolized normally, but alanine amid does not further hydrolyze.
- Alitame has been approved under the brand name **Aclame** for use in a variety of food and beverage products in Australia, New Zealand, Mexico and China.
- In USA its petition as a sweetening agent or flavoring in foods has been withdrawn due to manufacturing cost.

Artificial sweeteners (Natural extracts)

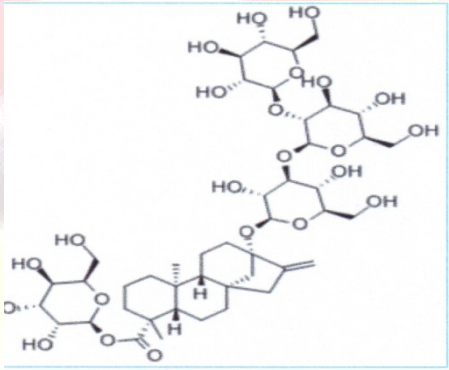
Stevia



Stevioside



Steviol glycosides



Rebaudioside-A

- It is an extract from the leaves of the plant *Stevia rebaudiana*.
- This plant is originated in south America, but is also grown in several Asian countries
- Non-cloric sweetener about up to 300 times sweet than sucrose.

Status

- **Stevioside** and **rebaudioside** are two of the sweet steviol glycosides in the stevia leaf.
- In the year 2008, the FDA approved the use of purified **rebaudioside-A** and classified it as Generally Recognized As Safe (GRAS).
- **Rebaudioside-A** is also called by the name **Reb-A** and **rebiana-A.**
- It is blended with erythritol and marketed under the name **Truvia** and **PureVia.**

Stevia Market

- Stevia manufacturer has predicted a global stevia products industry valued at $10 billion as soon as 2015.
- The World Health Organization (WHO) estimates stevia intake could eventually replace 20-30% of all dietary sweeteners.

Limitation

- Its sweetness accompanied by liquorices like after taste

Applications

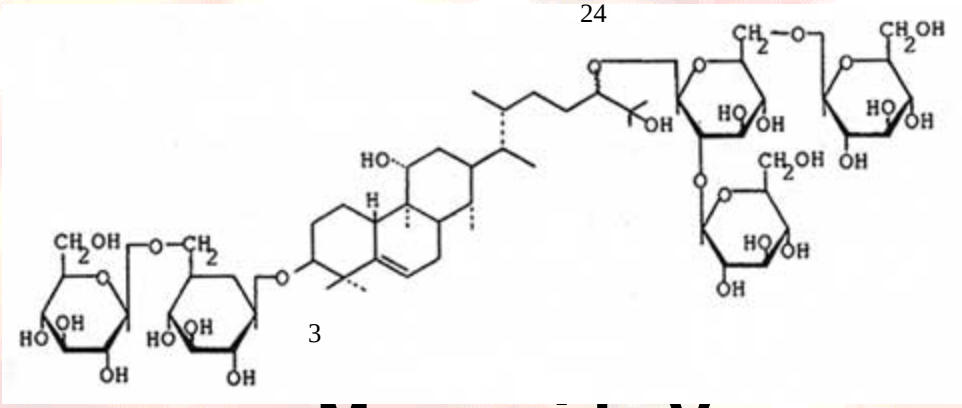
- Soft drink, Japanese -style vegetable products,

  table top sweeteners,

  confectionery, fruit products,

  and seafood's.

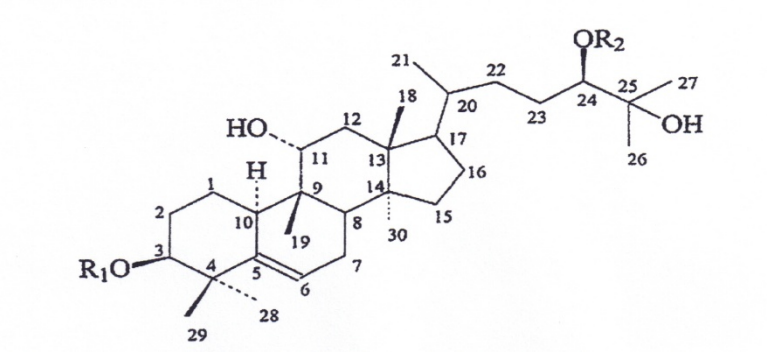
Monk Fruit



Mogroside V

- Natural powder or concentrate made from monk fruit (*Siraitia grasvenorii*).
- Zero calorie, 150-250 times sweeter than sucrose (the sweeter level is vary based on the application)
- Pure and clean sweet taste.
- Soluble in water.
- Heat stable up to 125^{0}C.

Mogrosides



Triterpene glycosides

- Mogrosides are formed of varying numbers of glucose units from 2 to 6.

- Mogroside II :	$R_1(G)$	$R_{24}(G)$
- Mogroside III :	$R_1(G)_{6\text{-}1}$	$R_{24}(G^{6\text{-}1}\text{---}G)_{2\text{-}1}$
- Mogroside IIII :	$R_1(G\text{---}G)^{6\text{-}1}$	$R_{24}(G\text{---}G)$
- Mogroside V :	$R_1(G\text{---}G)^{6\text{-}1}$	$R_{24}(G^{6\text{-}1}\langle{}^{G}_{2\text{-}1}G)$
- Mogroside VI :	$R_1(G\text{---}G)^{6\text{-}1}_{2\text{-}1}G$	$R_{24}(G^{6\text{-}1}\langle{}^{G}_{2\text{-}1}G)^{G}$

Applications

- It is Generally Recognized As Safe (GRAS).
- Available in the market under the trade name *Purefruit*.
- Its applications as sweetener and flavor for: food products, beverages, gums, backed goods, dietary supplements, powdered drinks, nutritional bars, and chocolates.

Thaumatin

Thaumatin I

- ***Thaumatin II***: a 1235 amino acid. It is a precursor for Thaumatin I.

- ***Thaumatin I*** **:** a 1207 amino acid (3kDa). It is the sweetener

Thaumatin

- A low calorie protein sweetener and flavor enhancer.
- It is an extract from West African fruit (katemfe fruit) *Thaumatococcus danielli.*
- 2000-3000 times sweeter than sucrose.
- Metabolized by the body as any other protein.
- It is a Generally Recognized as Safe (GRAS) by FDA in USA.
- Gained approval for over 30 countries around the world.

Benefits

- Natural sweetener in a dried form.
- Stable in freezing temperature, heat, and pH.
- Soluble in water.
- Does not promote tooth decay.
- Synergetic when combined with other low-calorie sweetener.
- Available in the market under the trade name **Talin.**

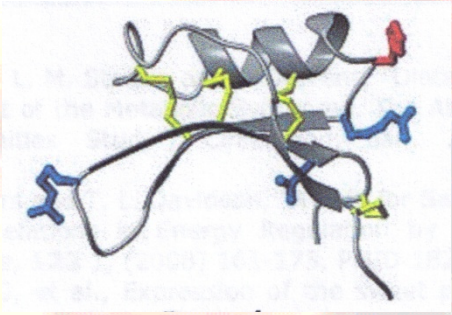
Applications

- Food and Beverages.
- Sweetener blends.
- Pharmaceutical and vitamin tablets.
- Oral care products.
- Animal feed and pet foods.

Limitation

- Delay perception of sweetness especially at high usage levels.
- Leaving a liquorices –like aftertaste at high usage levels

Brazzein



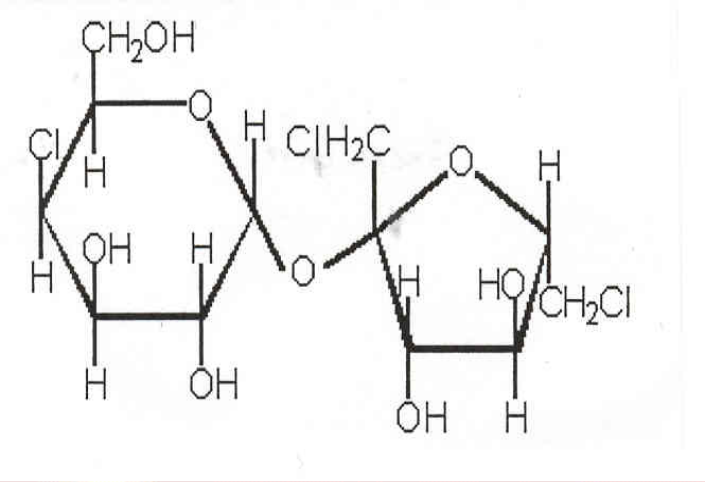
- Sweet tasting protein extracted from west African fruit *Pentadiplandra brazzeana*.
- Consist of 54 amino acid arranged in one alpha-helix and three strands betasheets.
- Its large scale extraction from the fruit is not feasible, but it has been genetically engineered in corn.
- The gluten protein from the modified corn contains 4% brazzein.

Brazzien (properties)

- Non-caloric sweetener.
- 1200 times sweeter than sucrose.
- Its taste is similar to sucrose with lingering sweet aftertaste.
- PH stable at the range of 2.5-8.0, and heat stable at 98^0C.
- These stability properties makes it practical for many commercial applications.
- It is commercially available in small packets under the brand name **Cweet**

Artificial sweeteners (Synthetic chemistry)

Sucralose



[Trichloro-galactosucrose]

- Sucralose is a common name for a new high intensity sweetener derived from sucrose.
- It is about 600 times sweeter than sucrose.
- Produced by the selective chlorination of sucrose

Benefits

- Non-cloric and does not breakdown in the body.
- Does not promote tooth decay.
- Soluble in water.
- Excellent stability in wide range of processed foods and beverages.
- Heat stable.

Safety

- Safe for human consumption.
- Approved by FDA and more than 35 countries.
- Acceptable daily intake (ADI) is 15mg/kg body weight.

Applications

Wide ranges of applications.

Acesulfame-K (Ace K)

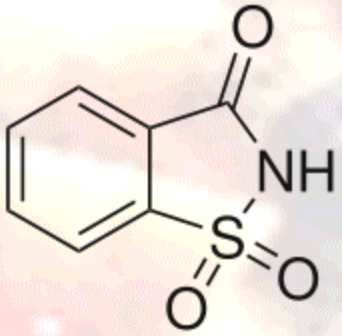
potassium 6-methyl-2,2-dioxo-2*H*-1,2λ6,3-oxathiazin-4-olate

- 180-200 times sweeter than sucrose.
- It is sweet as aspartame, about 1/2 as sweet as saccharine and about 1/4 as sweet as sucralose.
- It is usually used in combination with another sweetener, such as aspartame or sucralose.

Applications

- It is stable under heat and under moderately acidic or basic conditions.
- It is being used in baking, carbonated beverages, protein shakes, pharmaceutical products and in products that require a long shelf life.
- ADI is 15 mg./kg, body weight.
- Available under trade names **Sunett** and **Sweet One**.
- In Europe it is known by the name **E950**

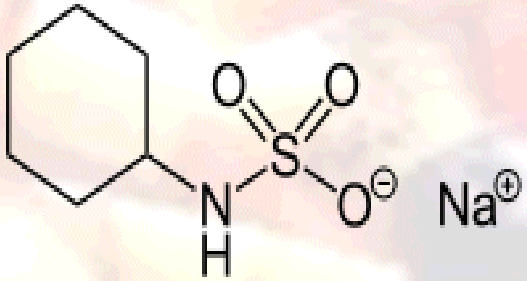
Saccharin



Benzoic sulfilmine

- 200-700 times sweeter than sucrose.
- Applied in both food and non-food products.

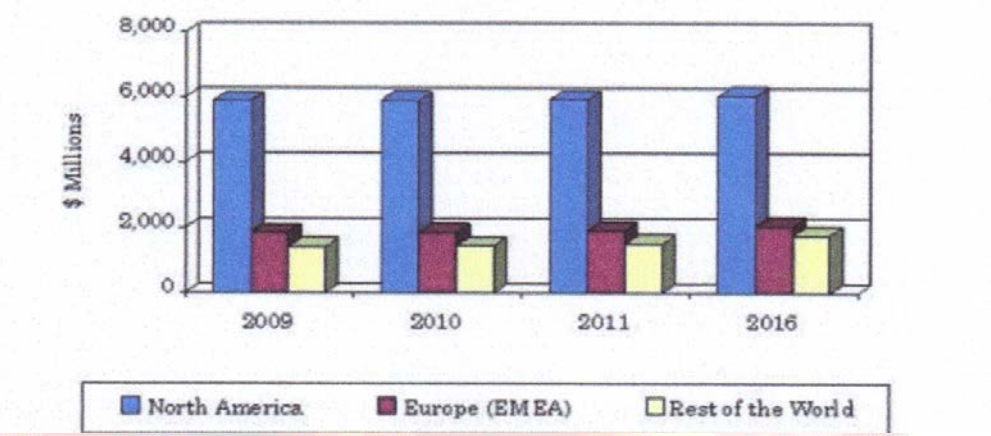
Cyclamate



Sodium N cyclohexilesulfamate

- 30-60 times sweeter than sucrose.
- Used in Canada and over 50 other countries.
- Its acceptable Daily Intake (ADI) is 11 mg/kg body weight.
- The Cancer Assessment Committee of the FDA decided that cyclamate is not carcinogenic.
- The FDA is currently reconsidering its ban.

Global food and beverages market of artificial sweeteners



- Global market for the year 2010 was $ 9.2 billions.
- Global market for the year 2011 is $ 9.3 billions.
- Global market for the year 2016 is expected to reach $ 9.9 billions.
- USA market in the year 2011 was $ 5.9 billions and is expected to reach 6 billions in the year 2016.
- European market in the year 2011 was $ 1.9 billions and is expected to reach $ 2 billions in the year 2016.

Summary

- Currently, aspartame is facing a strong competition from newly developed high intensive sweeteners (HIS).
- World Health Organization (WHO) estimates stevia intake could eventually replace 20-30% of all dietary sweeteners.
- The long used sweetener *saccharine* is continuing to decline.