CARBOHYDRATES $C_n(H_2O)_m$

Monosaccharides have ONE sugar: *eg.* **glucose, fructose, ribose**

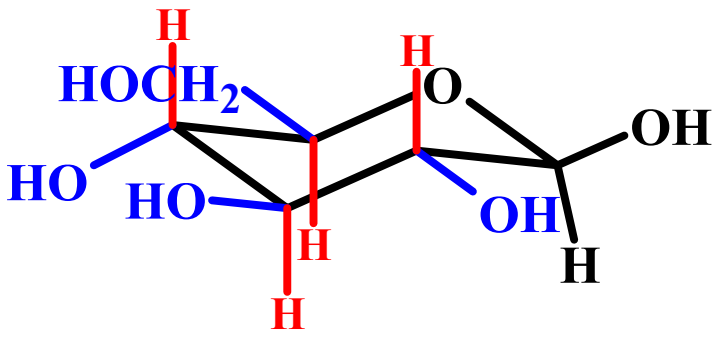
Disaccharides have TWO sugars: *eg.* **sucrose, maltose, lactose**

Oligosaccharides have a FEW sugars: *eg.* **raffinose**

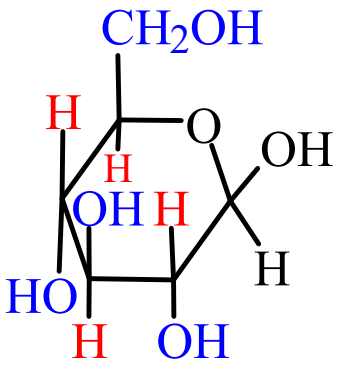
Polysaccharides have MANY sugars: *eg.* **starch, cellulose**

Carbohydrates store water as well as being an energy source

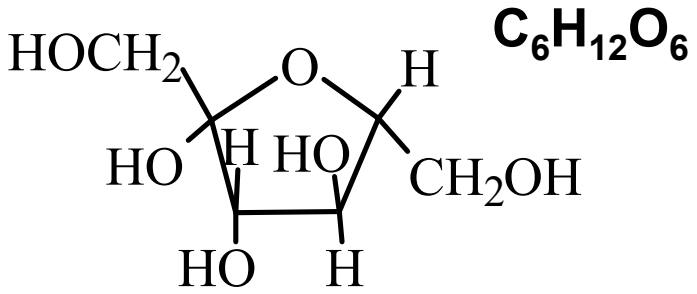
Glucose = blood sugar = dextrose: needs no digestion



or

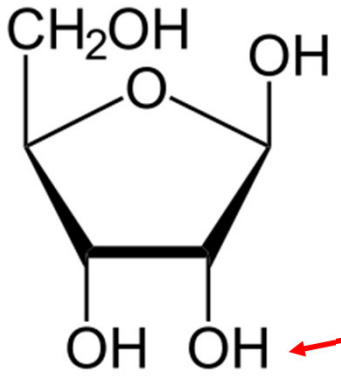


SOME SUGARS HAVE THE SAME FORMULA BUT MAKE 5-membered rings: *eg.* **FRUCTOSE**



$C_6H_{12}O_6$

Sweetest sugar: *'high fructose corn syrup'* need less to sweeten BUT fructose has been alleged *to lead to insulin resistance and promote type II diabetes (this is controversial)*

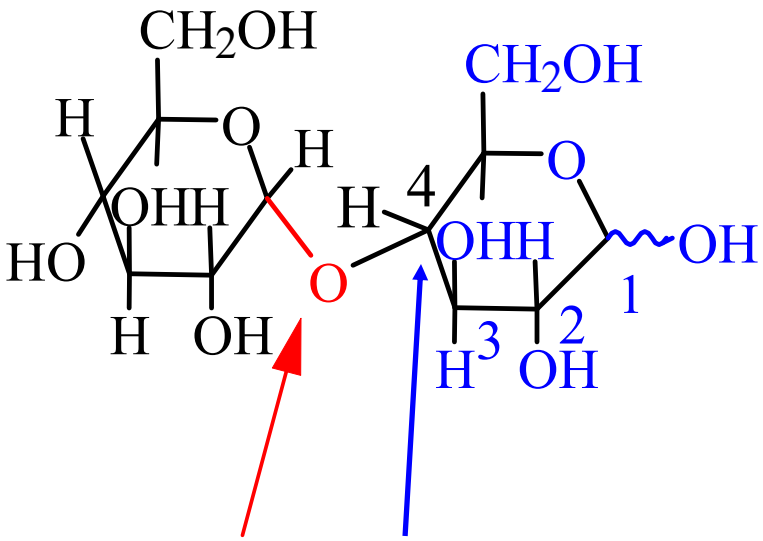


(-) - D- Ribose used in RNA

(deoxyribose, used in DNA, has H instead of OH)

DI-SACCHARIDES most important in foods

MALTOSE uses two glucose molecules, (+) sugar



α-Glu-4-Glu

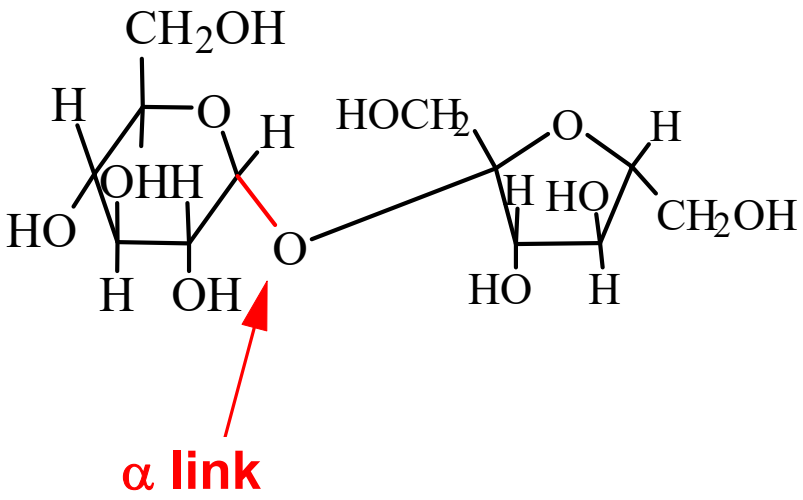
animals can easily cleave α links (eg. salivary enzymes) to (in this case) 2 glucoses

acetal α link 4-link

Other salivary enzymes cleave starch to maltose:
try chewing some bread: it gets sweeter as you chew

Note: this link is not interconvertible once formed,
i.e. α stays α, β stays β

SUCROSE: Table sugar (>80M tons/y)

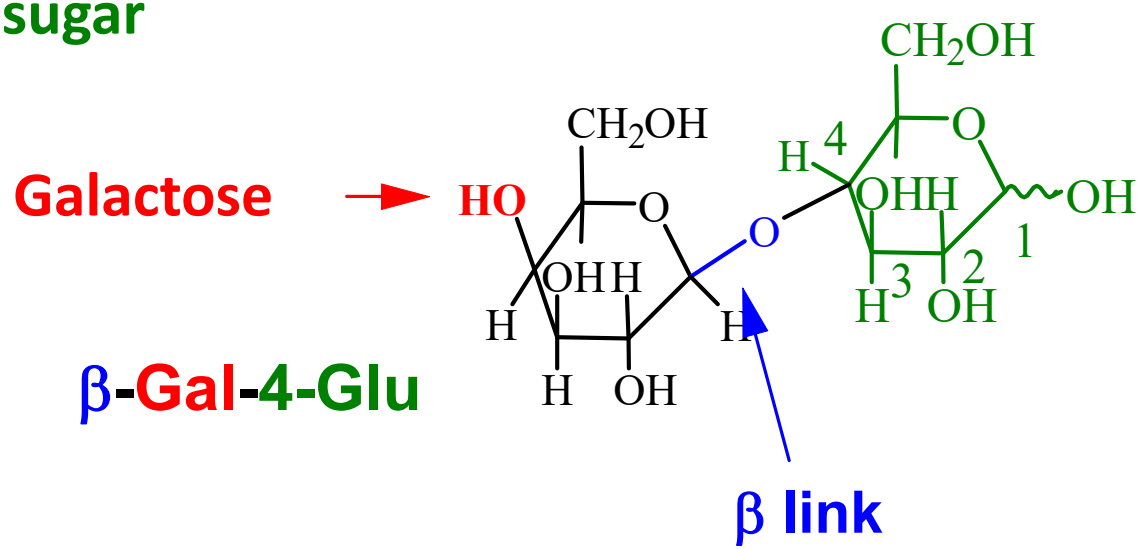


α-Glu-2-Fru

So we can split this to glucose and fructose – we can only directly metabolize monosaccharides

The liver can inter-convert glucose and fructose as needed but as before too much fructose is not good!

LACTOSE, Milk sugar



Babies have *lactase* which can cleave the β-link but many humans and all other animals LOSE this enzyme on weaning and so do not tolerate lactose well

Sweetness (relative): Fructose 1.7; Sucrose 1; Lactose 0.16

POLYSACCHARIDES

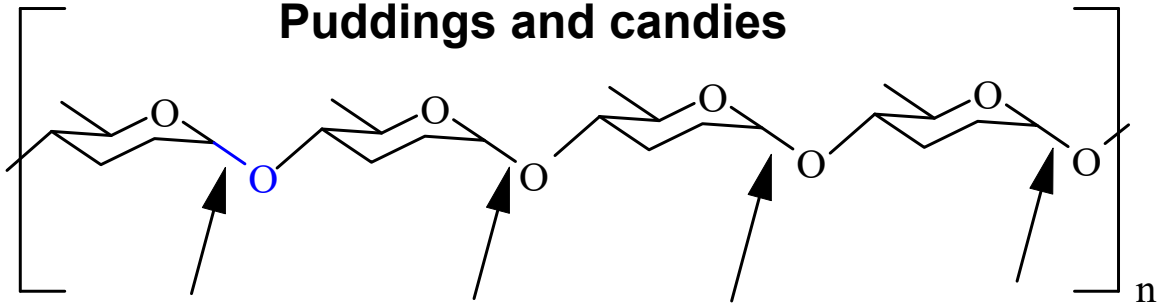
STARCH, Amylose = water soluble portion of starch (20-25%)

Plants store STARCH for energy usage (plus a lot of water!)

Animals use GLYCOGEN stored in liver and muscles:

branched/cross-linked but α-links for fast breakdown to glucose

Puddings and candies



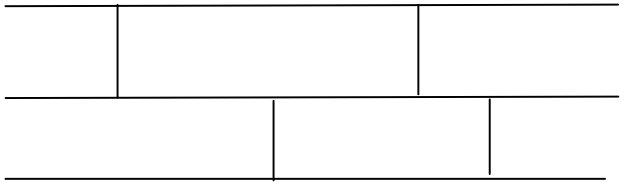
AMYLOSE

$-[\alpha\text{-Glu-4-Glu-}]_n-$

ALL α-links

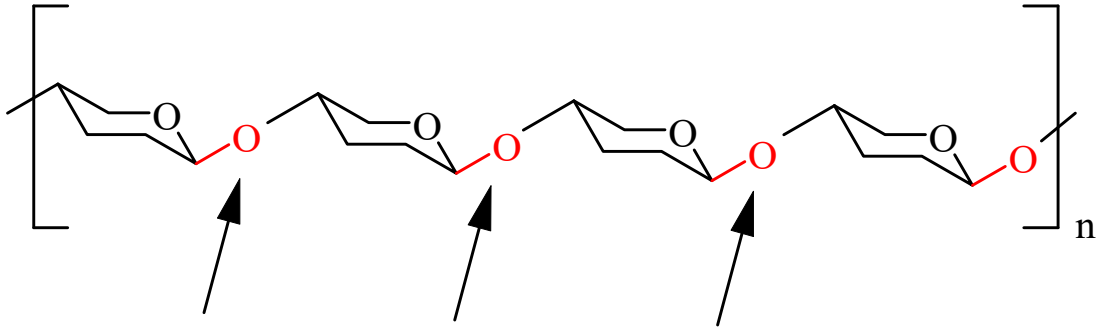
n = 15-250

rest is AMYLOPECTIN Gravies and sauces



1000-5000 Glu units (3D)
cross-linked using the CH_2OH

CELLULOSE



all β-links

-[-β-Glu-4-Glu-]$_n$-

Most animals lack cellobiase which can cleave the β-links

Cows, goats, horses, termites, etc. have bacteria in their rumens (2nd stomach) which have the enzymes to cleave cellulose

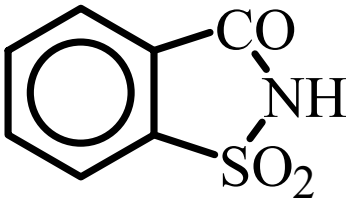
SWEETENERS

Lead acetate is sweet but toxic!! $Pb(OCOCH_3)_2$ - *sugar of lead*

Not much logic as to why things taste sweet

SACCHARIN **discovered 1879!** **300x sweeter than sucrose**

Banned in Canada in 1977



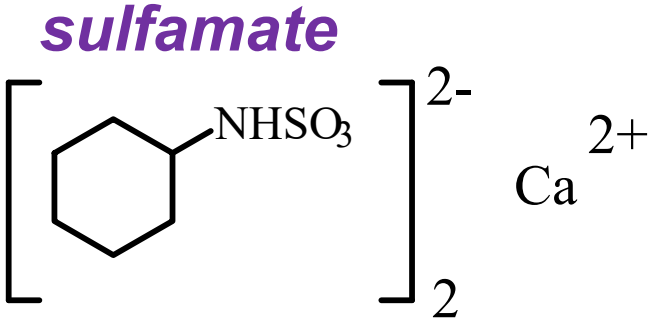
sulphonamide

Some experience a *very bitter aftertaste*

CYCLAMATE (1930)

30x sweeter than sucrose,

but no after-taste



Reached peak in 1969 with 7 Mkg /y (US) soft drinks

Banned in US (1969) but not in Canada

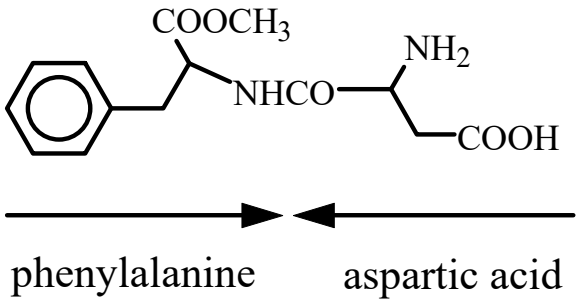
Still approved in Canada, though not used in soft drinks

Sugar Twin = sodium cyclamate in Canada BUT saccharin in US

ASPARTAME (1965)

180x sweeter than sucrose,

texture of sugar



Peptide of amino acids phenylalanine and aspartic acid:
Use ~ 100mg (4 kcal/g) so about 0.4 kcal

Some (1 in 10,000) cannot metabolise phenylalanine:
(phenylketonuria) high levels of neurotransmitters, headaches

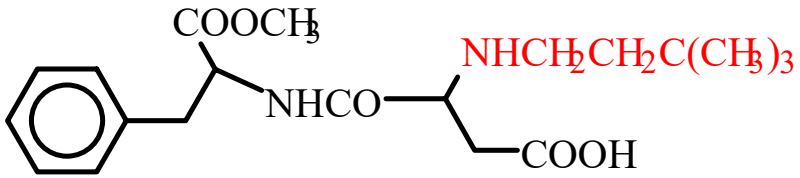
Use: 10 Mkg/yr in NA, 80% of NA market (70% in soft drinks)

Not so useful in cooked goods

100's of web sites with 'information'!

BEWARE SOURCES!!!

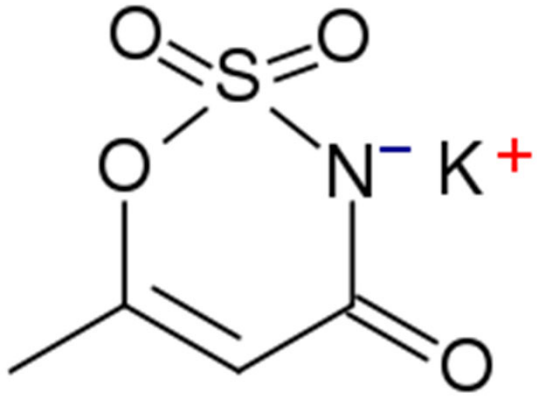
NEOTAME (made by NutraSweet, 2002) ~10^4 x sweeter than sugar



HEAT STABLE:
useful in baking
http://www.cfsan.fda.gov/~lrd/tpneotam.html

ACESULFAME-K (1967) 200 x sweeter than sugar (Sunett)

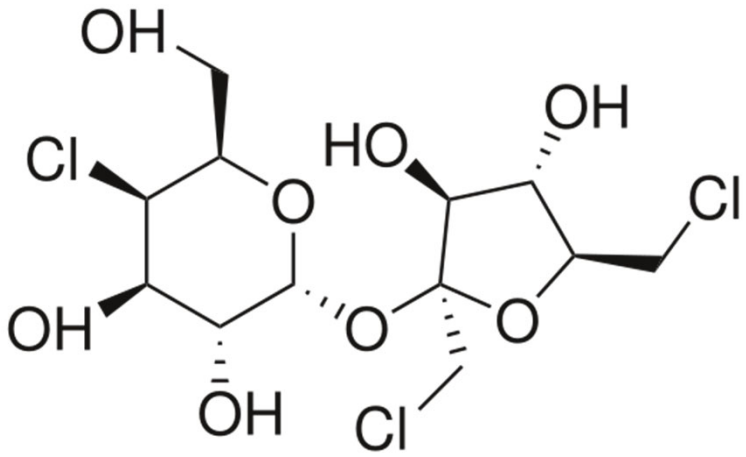
Used in drugs, toothpaste, mouthwashes...
approved for foods, HEAT STABLE



popular in Europe for decades but only
approved for general use in US in 2003
http://www.caloriecontrol.org/acesulf.html

SUCRALOSE 600 x sweeter than sugar

Can (91) FDA (98) WHO (91)



'Chlorinated galacto-sucrose' *i.e.* **Gal-Fru**

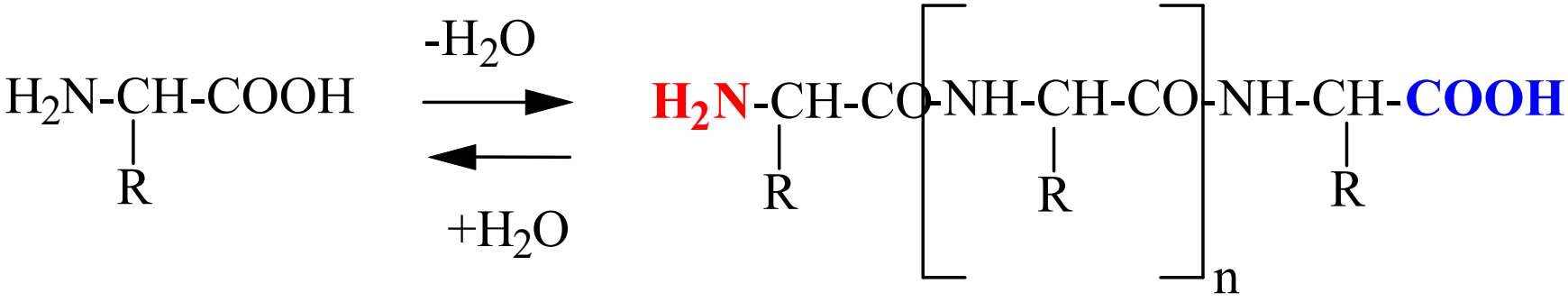
More than 100 studies indicate no adverse affects:

Can. Diabetes Assoc. guidelines 1.65 g/d for life with no adverse effects *(equivalent to 1 kg sugar/d)*

Fat insoluble: does not bio-accumulate

PROTEINS

Proteins are polyamides (like nylon below) are made from amino acids:

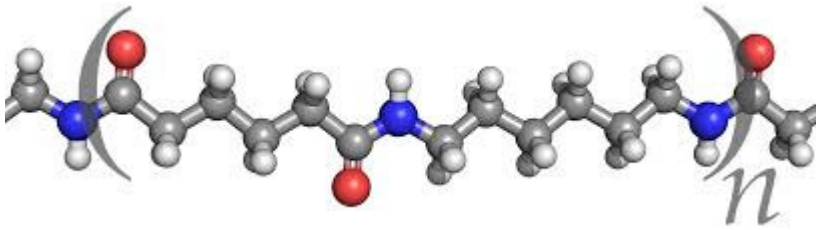


aminoacid

protein (n=large), peptide (n=small); R's are different

proteins and peptides have an AMINE END **ACID END**

Nylon-6,6



Proteins are not stored like fat and carbohydrates: constant breakdown and synthesis

PROTEINS IN THE DIET

Humans have about 10 kg protein,
need to replace about 300 g daily;
recycle ~230 g
so need to eat ~30 g meat/fish/egg protein
and ~40 g grain protein per day

Most of us >100g/day

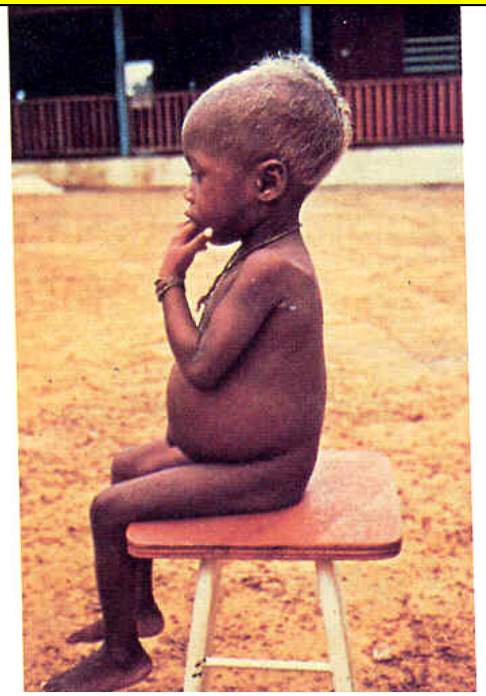
CONTENT OF FOODS

FOOD	WATER	PROTEIN	FAT	CARBs.	kcal/100g
Meats					
Beef, broiled	62	32	5	0	180
Lamb, broiled	61	28	9	0	200
Chicken, broiled	71	24	4	0	140
Salmon, broiled	64	27	7	0	180
Oysters, raw	85	8	2	3	66

Some grains lack some aminoacids

CORN	**lacks**	**lysine and tryptophan**
RICE		**lacks lysine and threonine**
WHEAT		**lacks lysine**
SOY		**lacks methionine (need 2g/day of this one)**

KWASHIORKOR (= red boy) is common in Africa where corn is major food. Bloated, swollen belly, scaly skin, retarded growth, mental apathy



High protein – low carb diets (Atkins, Paleo, Protein Power…)

Result in *quick weight loss* because eliminating carbohydrates results in loss of body fluids, but…

according to the American Heart Association, are not effective long term:

- **impede fat metabolism**
- **generally substitute carbohydrates with fats**
- **restricts mineral intake**
- **causes ketosis (and nausea):**
- **uremia (ammonia on breath)**
- **some cannot metabolize excess: liver/kidney disorders**

Keto diets: same idea but replace carbs with fats, similar concerns

Force body to burn fat as fuel and produce ketones in liver:
a ketotic state

Plenty of controversy here:

USC longitudinal study over 18 years found high protein-low carb diet equivalent to smoking a pack of cigarettes/day and increased likelihood of early death 74%

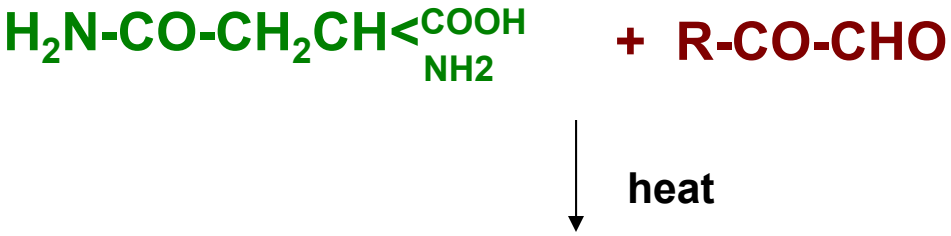
but…

Proponents claim no account was taken to control lifestyle or starting fitness level

2002: Acrylamide, a potent carcinogen, identified in many popular foods such as fries, potato chips, cakes, bread, coffee, cookies *See: http://www.who.int/foodsafety/publications/chem/en/acrylamide_summary.pdf*

Comes from carb rich foods that are fried or baked

Source identified from amino acid asparagine + dicarbonyl compound from browned sugars



Is this a risk? $H_2N\text{-}CO\text{-}CH{=}CH_2$

Maybe not: NOAEL *(no observed adverse affect limit)* is 500x higher at 0.5 mg/kg body weight than the amount in a normal portion of the worst offender, french fries (*ca.* 1.3 mg/kg or 25 mcg/server)