

Chemical Risks in Our Food in Perspective

JIFSAN May 2012

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Food Safety Risks in Perspective



- Pesticides and Environmental Contaminants
 - Pesticides in imported vs. domestic fruits and veggies
 - The “Dirty Dozen” list of fruits and vegetables consumers should avoid
 - Safety of organic food relative to conventional food
- Acrylamide
- Arsenic and other heavy metals
- BisPhenol A

Food Safety in Perspective

Food safety priorities of FDA and WHO

1. Microbiological contamination
2. Nutritional imbalance
3. Environmental contaminants
4. Naturally-occurring toxins
5. Pesticide residues
6. Food additives



Consumer Food Safety Ranking

1 Environmental contaminants – includes pesticides*

1 Food additives especially colors, sweeteners, chemical names that sound deadly*

1 Microbiological contamination by industry (not in the home or by your raw milk or cheese seller or farmer at the farmer's market)*

2 Perceived nutritional 'bad actors' - trans, fructose, gluten *

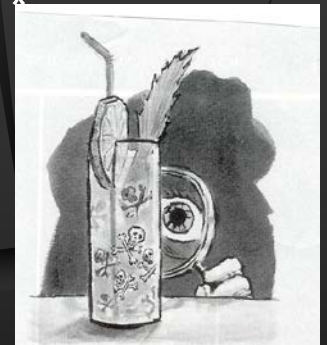
3 As and other things that are mention on Dr. Oz

7 Heavy metals - Hg, As - if pregnant

20 Obesity, diabetes, and diseases due to nutritional imbalance

59 Naturally-occurring toxins

*The ranking shifts with the current headlines



Definitions

- Safety
- Toxicity
- Hazard

- Vitamin A
- Vinegar - ~1 qt



Alle Ding' sind Gift, und nichts ohn' Gift; allein die Dosis macht, daß ein Ding kein Gift ist.

"All things are poison and nothing is without poison, only the dose permits something not to be poisonous." Paracelceus , 1533

Pesticides and Environmental Contaminants

Environmental Working Group

"Consumers can **lower their pesticide consumption** by nearly **four-fifths** by substituting **organic** forms of the commodities on the Dirty Dozen list"



EWG - F & V to Be Avoided



2012: Avoid conventional forms of

- | | |
|----------------------------|---------------------------|
| 1 Apple | 7 Grapes <i>import</i> |
| 2 Celery | 8 Red Peppers |
| 3 Strawberries | 9 Potatoes |
| 4 Peaches | 10 Blueberries <i>dom</i> |
| 5 Spinach | 11 Lettuce |
| 6 Nectarines <i>import</i> | 12 Kale/collard greens |

EWG “Clean 15” - Lowest in Pesticides

- 
- 1 Onions
 - 2 Sweet Corn
 - 3 Pineapples
 - 4 Avocado
 - 5 Asparagus
 - 6 Sweet peas
 - 7 Mangoes
 - 8 Eggplant
 - 9 Cantaloupe - domestic
 - 10 Kiwi
 - 11 Cabbage
 - 12 Watermelon
 - 13 Sweet potatoes
 - 14 grapefruit
 - 15 mushrooms

If organic forms are unavailable, consumers are urged to purchase fruits and vegetables from the **“Clean Fifteen”** as substitutes 2011: “dirtiest” = apple; “cleanest” = onion

Research Article

Dietary Exposure to Pesticide Residues from Commodities Alleged to Contain the Highest Contamination Levels

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Received 29 November 2010; Accepted 16 March 2011

Academic Editor: Ian Munro

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Probabilistic techniques were used to characterize dietary exposure of consumers to pesticides found in twelve commodities implicated as having the greatest potential for pesticide residue contamination by a United States-based environmental advocacy group. Estimates of exposures were derived for the ten most frequently detected pesticide residues on each of the twelve commodities based upon residue findings from the United States Department of Agriculture's Pesticide Data Program. All pesticide exposure estimates were well below established chronic reference doses (RfDs). Only one of the 120 exposure estimates exceeded 1% of the RfD (methamidophos on bell peppers at 2% of the RfD), and only seven exposure estimates (5.8 percent) exceeded 0.1% of the RfD. Three quarters of the pesticide/commodity combinations demonstrated exposure estimates below 0.01% of the RfD (corresponding to exposures one million times below chronic No Observable Adverse Effect Levels from animal toxicology studies), and 40.8% had exposure estimates below 0.001% of the RfD. It is concluded that (1) exposures to the most commonly detected pesticides on the twelve commodities pose negligible risks to consumers, (2) substitution of organic forms of the twelve commodities for conventional forms does not result in any appreciable reduction of consumer risks, and (3) the methodology used by the environmental advocacy group to rank commodities with respect to pesticide risks lacks scientific credibility.

Checking Out EWG's Claim

- Data from USDA Pesticide Program
- 6 indicators of pesticide contamination
 - % **samples** with detectable residues
 - % with **2+** detectable residues
 - **Ave. #** per sample
 - Average concentration of all pesticides found
 - **Max. #** on a commodity
 - **Total #** on a commodity
- Summed up relative rankings from each indicator to determine total score



Winter CK, Katz JM. J Toxicol. 2011;2011:589674.

How Useful Is the EWG List

- 10 most frequently detected pesticides
 - According to 2010 PDP data - 10 most frequently detected pesticides on produce compared with the "Dirty Dozen"
- PDP ranking
 - 1st Blueberries (#5)
 - 2nd cherries (#9)
 - 3rd kale (#10)



HIGHEST exposure <0.003% RfD

Winter CK, Katz JM. J Toxicol. 2011;2011:589674.

How Dirty are the “Dirty Dozen?”

Measured levels and calculated exposure

- Compared with EPA reference doses
- All exposures far below Reference Doses (RfD)
 - At least 100 lower than NOEL
 - > 0.1% Reference Dose 7/120
 - <0.01% Reference Dose 80/120
- E.g. 75% were 10^6 lower than NOEL

Winter CK, Katz JM. J Toxicol. 2011;2011:589674.



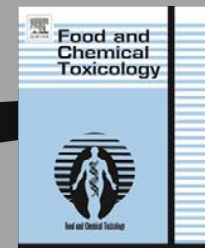
- "We recommend that people eat healthy by eating more fruits and vegetables, whether conventional or organic," says Ken Cook, president and founder of Environmental Working Group. "But people don't want to eat pesticides with their produce if they don't have to. And with EWG's guide, they don't."
- **Ken Cook, EWG President**

Pesticide Beliefs

- 40% - believe the risk of pesticides in food **outweighs the benefits of eating fresh fruits & vegetables**
 - U Mich survey
 - NHANES – organophosphate metabolites in urine of 1,139 kids 8 – 15 yrs
- 95% excrete at least one byproduct
- Those with highest levels were 93% more likely to have received an ADHD diagnosis

Bouchard et al Pediatrics 2010; 125: e 1270-2

PESTICIDE RESIDUES - CONVENTIONAL VS. ORGANIC



ology

journal homepage: www.elsevier.com/locate/foodchemtox

Comparison of pesticide exposure from consumption of domestic and imported fruits and vegetables

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University of California, Department of Food Science and Technology, One Shields Ave., Davis, CA 95616, USA

ARTICLE INFO

Article history:

Received 24 July 2008


Accepted 11 November 2008

Keywords:

Pesticides
Residues
Risk assessment
Food safety
Fruits
Vegetables

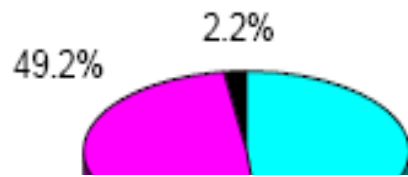
ABSTRACT

Estimates of daily dietary human exposure to 18 common pesticides found in fruits and vegetables were developed from residue data obtained from the 2003 US Food and Drug Administration's Regulatory Monitoring Program using probabilistic dietary exposure modeling. The differences between the exposures from domestic versus imported fruit and vegetable residues were compared. Of the 15 pesticides for which quantifiable residues were detected from both domestic and imported fruit and vegetable samples, domestic exposures were significantly higher for 11 pesticides while imported exposures were higher for the remaining four. The five pesticides showing the highest exposures all demonstrated greater domestic exposures than imported exposures. The mean daily exposure estimate for one pesticide, methamidophos, was above the reference dose for domestic fruits and vegetables while slightly below the reference dose for imported fruits and vegetables. Exposures to the other 17 pesticides were well below the established reference doses for domestic and imported fruits and vegetables. Exposure from pesticides in domestic foods exceeds exposure from imported foods and demonstrates that probabilistic modeling of

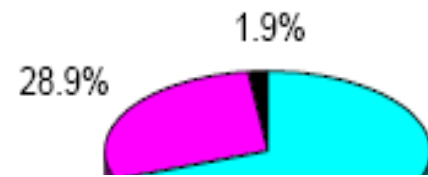


Imported 48.8 percent of fresh fruits
25 percent of fresh vegetables
consumed in the U.S. - 2010

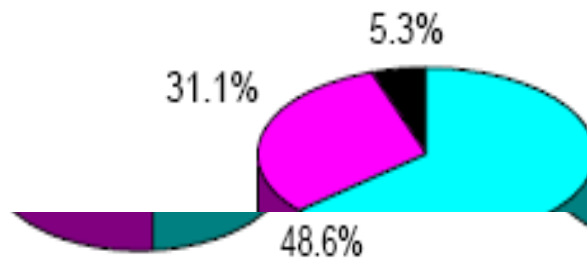
DOMESTIC VS IMPORTED



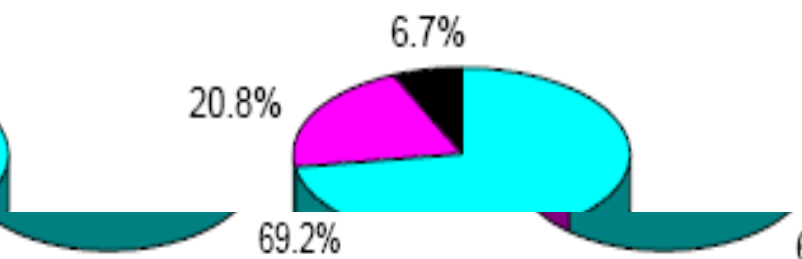
Grains and Grain Products
215 samples



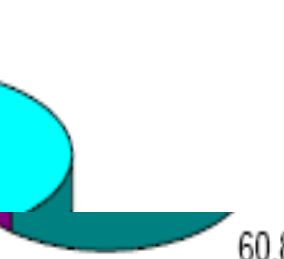
Milk/Dairy Products/Eggs
59 samples



Fruits
813 samples



Vegetables
1132 samples



Other
102 samples


No Residue Found

Residue Found Not Violative

Residue Found Violative

Imp

RESULTS

- 15 /18 pesticides detected on both
 - 11/15 higher for **domestic** F & V
 - 5 pesticides with highest exposures
 - **domestic** > imported exposures
 - Exposures in all cases were **well below EPA RfD**
- 

Methamidophos

Example

- Responsible for **39%** of violations among all 18 pesticides studied
- **1 domestic violation** vs 36 imported violations
 - BUT all foreign were detected on commodities for which no tolerance was established
- **Domestic exposure to methamidophos** – **1.7** times higher than imported exposure

2012 - Imported Food Has More?

- Modeling studies of pesticides possibilities using amounts and substances allowed in other countries
- *"suggested that a total of 120 439 kg of excess pesticide residue **could be imported** into the U.S. if every exporter to the U.S. followed their originating country but not U.S. tolerances."*
- Fussed about targeted sampling by EPA



Neff RA et al Global Health.
2012;8:2.

ORGANIC VS CONVENTIONAL





R: Concise Reviews in Food Science

Sensory

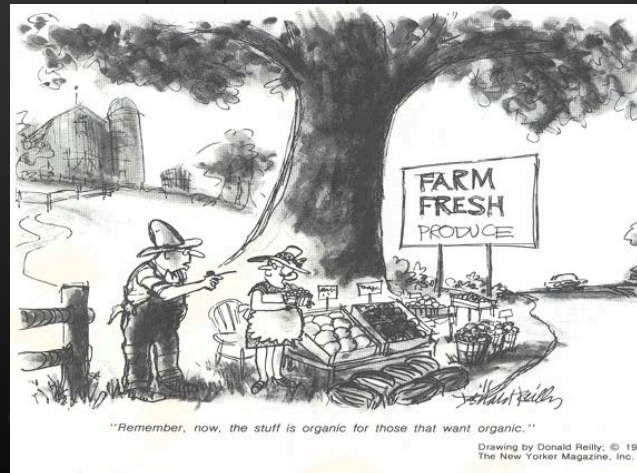
- **KANSAS STATE UNIV. N=100**
- **72% OF THE SUBJECTS BOUGHT ORGANIC BECAUSE IT IS “HEALTHIER”**
- **28% OF THEM SAID THAT ‘ORGANIC FOOD TASTES BETTER’ BEFORE THE TEST**
- **“ ...ORGANICALLY AND CONVENTIONALLY GROWN FOODS DID NOT SHOW A SIGNIFICANT DIFFERENCES IN CONSUMER LIKING OR CONSUMER-PERCEIVED SENSORY QUALITY.”**

CAREY, E ”J Fd Sci. 72(2007) 87-91



ORGANIC - PESTICIDE RESIDUES LOWER, BUT NOT ZERO

- Inadvertent contamination
 - Mixing and drift
 - 40% of UK Crops to have pesticides due to cross contamination Worsley, L. Brit Fd J. 107(2006) 855-869
 - Pesticides found on the polar ice cap
- Some "organic" growers may not follow organic rules



Organic Has More C



- 27 varieties of spinach
 - Organic higher vitamin C (40.8 vs 25.7 mg/kg) and flavonoids
- Lower nitrates. Carrots, Bell peppers & Tomatoes – Poland
 - Organic increased carotenoids, phenolic compounds and vitamin C
 - BUT variety and seasonality

Hallman E J Sci Food Agric. 2012 Feb 20. doi: 10.1002/jsfa.5617.

Sikora et al Rocz Panstw Zakl Hig. 2009;60(3):217-20.

Hallmann E, Rembiałkowska E J Sci Food Agric. 2012 Feb 24. doi: 10.1002/jsfa.5624. Koh et al J Agric Food Chem. 2012;60:3144-50;²⁵

Organic Has Less C

- Organic vs conventional, IPM -
- Lower vitamin C, lycopene, Cu
- Higher Cd and Pb levels – It.
- US - Tomato cultivar choice made more impact on vitamin C and antioxidants than
 - Cultivation method or season



Rossi et al [Eur J Nutr.](#) 2008;47:266-72.

Aldrich et al [J Sci Food Agric.](#) 2010;90:2548-55;

Vitamin C is the same

- Green and red peppers - soil-less
- vitamin C 52 – 80 mg /100 g (fw) similar in IPM and organic
- Carotenoids highest in soil-less red peppers

[Marín A, et al J Agric Food Chem.](#)
2008;56:11334-41.



No Difference in Bioavailability

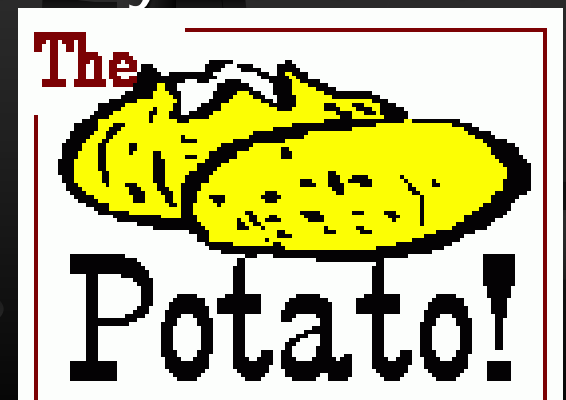
- 43 healthy men
 - apples (500 g/day; 4 weeks) or no apples
- No increase polyphenol concentrations in plasma and urine compared controls

Stracke BA, et al Eur J Nutr. 2010;49:301-10.



Organic More Alkaloids

- Organic potatoes more bitter
 - Solanine and other glycolkaloids **50% higher**
 - Research comparing plant toxins in organic vs. conventional foods - lacking
 - Differences may be greater than most differences reported for nutritionally beneficial chemicals



Organic Yields Less

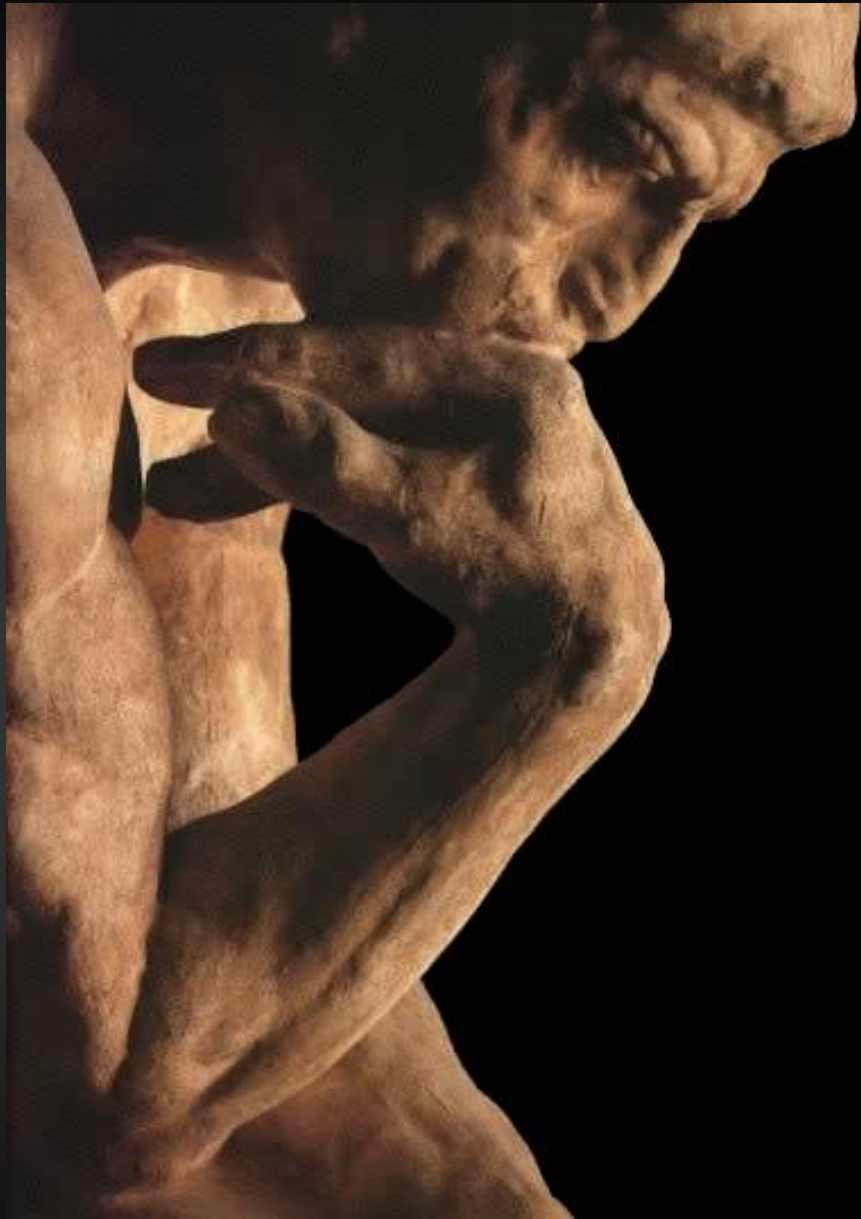
- Conventional foods – 25% > yield
- U Minn / McGill University -66 studies, 34 crops.
 - Fruits / some legumes (e.g., chickpeas or beans), organic farms 3-5% less
 - Seufert V et al Comparing the yields of organic and conventional agriculture. Nature. 2012.

Are crop yields the Achilles heel of organic farming?

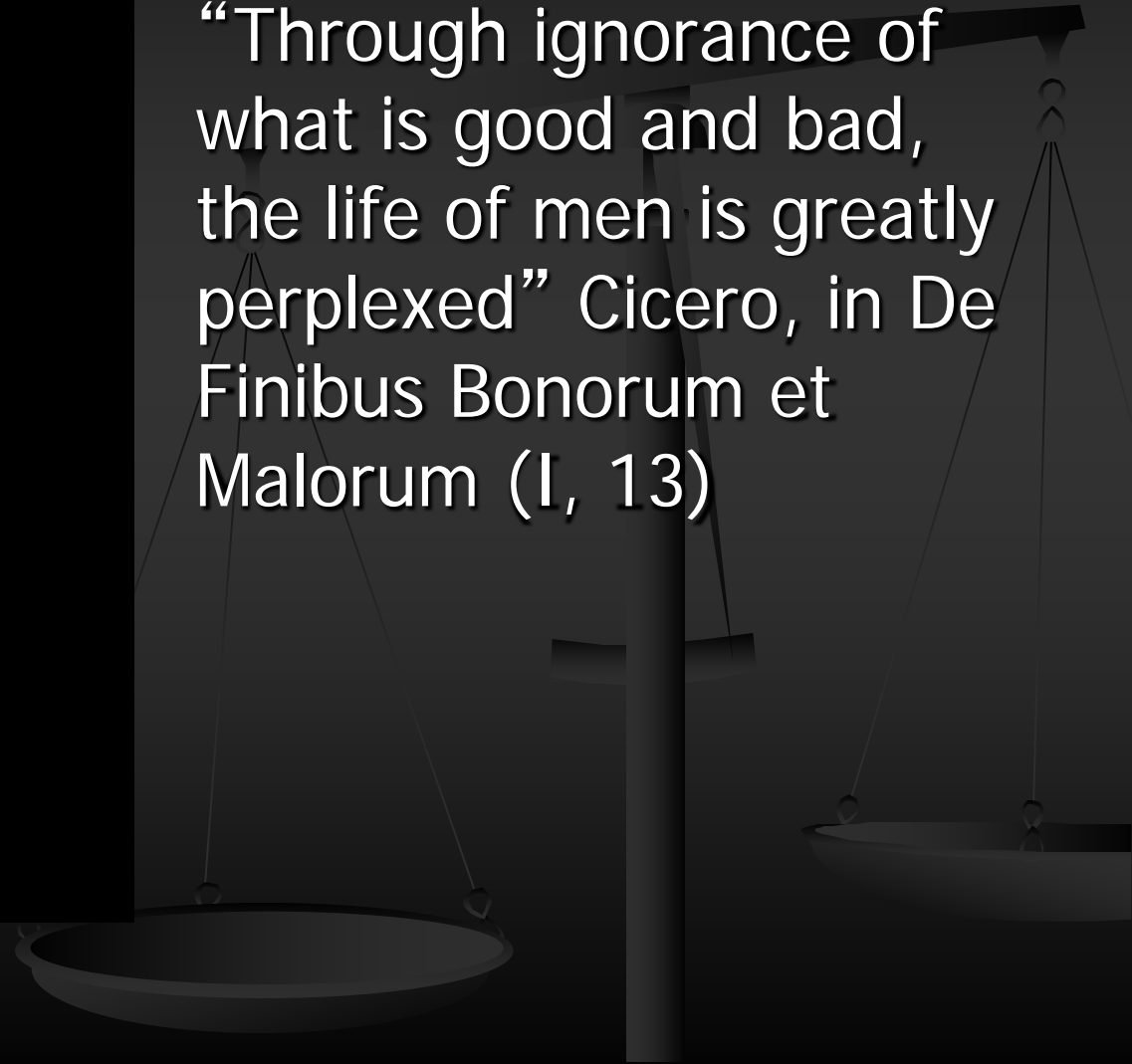
- Organic agriculture can't compete with conventional in terms of crop yields, according to a new study
- By [Nora Doyle-Burr](#), [Contributor](#) / April 25, 2011



Nathanson, A. Buyouts. 21(2008)28-31



“Through ignorance of what is good and bad, the life of men is greatly perplexed” Cicero, in *De Finibus Bonorum et Malorum* (I, 13)



Acrylamide – Exposure Adults

- Exposure est. adults $\mu\text{g}/\text{kg}$ bodyweight/day
 - **US FDA** 0.4
 - WHO estimate 0.3 - 0.8
 - Health Canada 0.3 - 0.4
 - Sweden NFA 0.5
 - Holland NFC 0.48



- **Ave. daily dietary acrylamide intake $\sim 21 \mu\text{g}/\text{d}$**
Schouten et al. . Am J Epidemiol. 2009 ;170:873-84; Tareke, AACC Sept 2003; Svensson et al, Food Chem Toxicol. 2003 41:1581-1586

Acrylamide exposure levels

- Ave intake 0.5 $\mu\text{g}/\text{kg}$ bw
 - Intake is 1000 X lower than the NOEL for neurotoxic effects ---500 $\mu\text{g}/\text{kg}/\text{day}$
 - Intake is 600 X less than NOEL for mammary tumors in rats - 300 $\mu\text{g}/\text{kg}/\text{day}$

“Despite being a carcinogen in the laboratory, many epidemiological studies have reported that everyday exposure to acrylamide in food is too low to be of concern.”

KILLER FRENCH FRIES



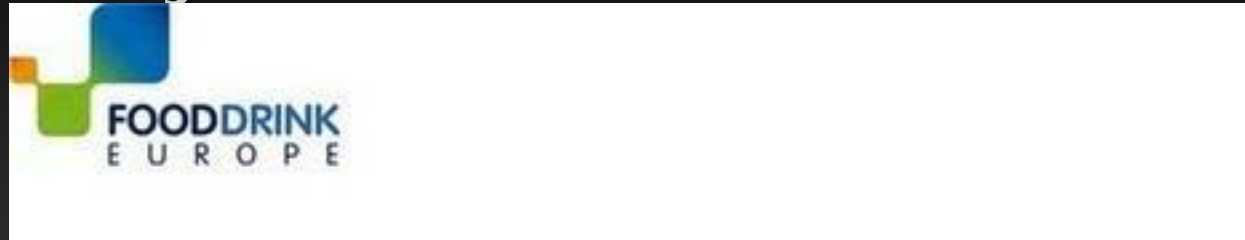
Even those in the
population with the
5% highest intakes
ingest levels far
below the TDI

Claes Oldenburg 1960s - he was wrong??

Walker Art Center Minneapolis

- “ Total intakes are so low that the Food Standards Agency (UK) advises **not to alter diets or cooking methods of consumers.**”
- BREAD - n=192 - ave 30 $\mu\text{g}/\text{kg}$
 - 5 - 1987 $\mu\text{g}/\text{kg}$
 - Normal bread types (rye, wheat; white, wholemeal; loaf, bread rolls) seldom exceeded 30 $\mu\text{g}/\text{kg}$.

Acrylamide – Reduction



■ FoodDrinkEurope toolbox

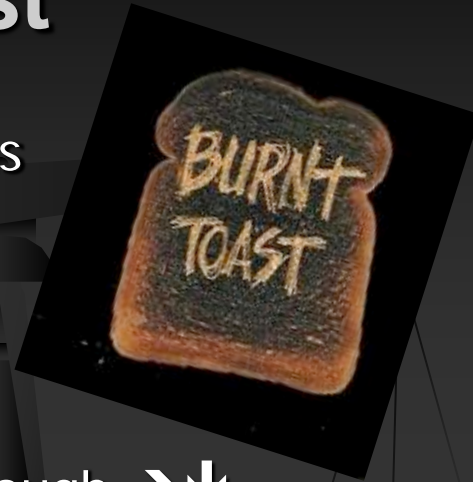
Despite being a carcinogen in the laboratory, many epidemiological studies have reported that “**everyday exposure to acrylamide in food is too low to be of concern.**”



Tardiff et al Food and Chemical Toxicology 2010;48:658-67.

Acrylamide – Reduction Strategies for Baked Goods and Toast

- **Toast lightly** - Scrape off very dark or burnt areas
- Bake at the right temperature; not too high
 - Golden not overbrown
 - Fiber in potato skin reduces effect
- **Allow long** yeast-fermentation to ↓ asparagine in dough → ↓ formation of acrylamide.
 - Leavening raises pH – ↓
- Salt, fat and gluten ↓
- Olive oil antioxidants ↓



Dobrowski et al Nutrition 2012. 28: 428-435; Rodríguez-Ramiro I, Martín MÁ, et al. Toxicology. 2011;288(1-3):43-8.

Calories and Nutrient intakes Associated with Acrylamide

38% of calories

- 33% of CHO
- 36% of fiber *
- 28% of fat
- 20% of Ca *
- 47% of Fe *
- 25-35% of other micronutrients*
- 15% of vitamin A
- 34% of vitamin E *
- 22 to 44% of B, C and folate*

* Nutrient of concern

- *Breakfast 8%*
- *Lunch 21%*
- *Dinner 22%*
- *Snacks 13%*
- *Coffee 36%*

Schouten LJ, et al: Results From the Netherlands Cohort Study. Am J Epidemiol. 2009;170:873-84

Acrylamide – Take Out A Food

- What happens to the Population Mean=**0.37** $\mu\text{g}/\text{kgbw-d}$ - if you remove acrylamide from?

	Mean - $\mu\text{g}/\text{kgbw-d}$
■ French Fries	0.26
■ Snack Food	0.31
■ Breakfast Cereal	0.33
■ Coffee	0.34

CSFII, 1994-96, 98, 2+ Population



Acrylamide vs Antioxidant

Product Trolox Equivalents/100g*

Wheat Flour 1,000

White Bread 1,600

Bread, White 1,100

Bread, Crust 2,050

* Dry Weight Basis

TOASTING PRODUCES SUBSTANTIAL ANTIOXIDANT ACTIVITY

Acrylamide, Coffee and Health Outcomes

■ Cancer

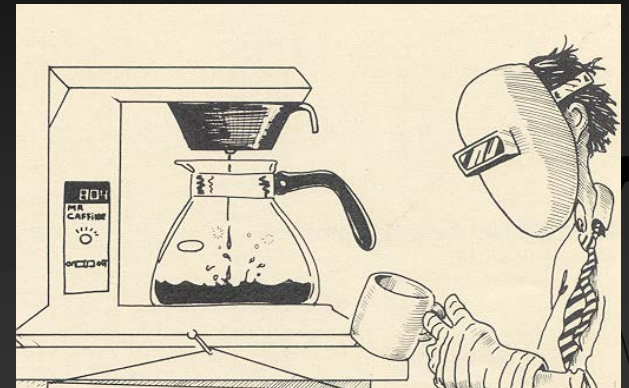
- Either no association
- Or strong inverse associations

■ Inverse correlation with

- Diabetes mellitus
- Alzheimer's disease

Parkinsonism

- Butt MS, Sultan MT. Crit Rev Food Sci Nutr. 2011;51:363-73; Beaudoin MS, Graham TE. Handb Exp Pharmacol. 2011;509-48

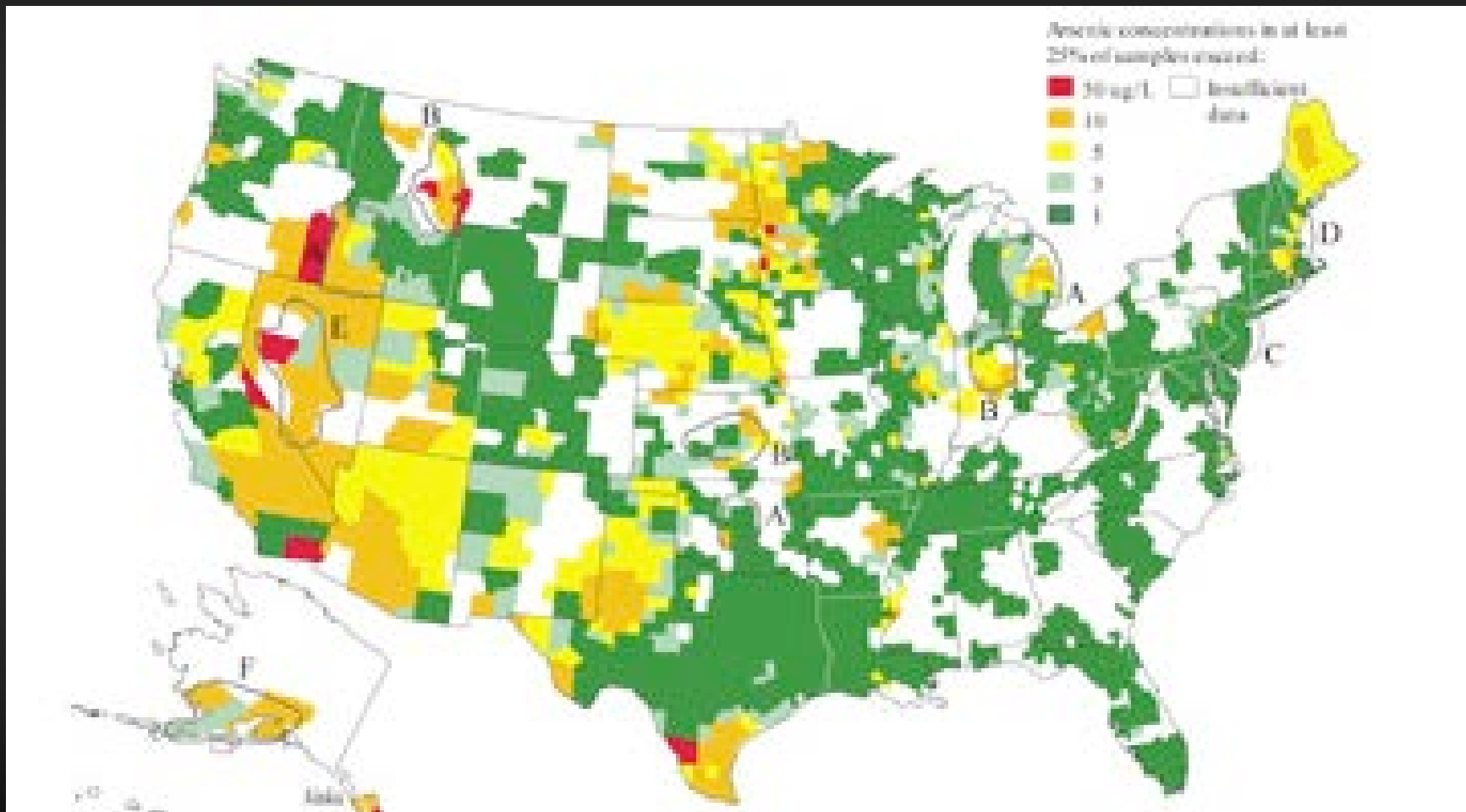


Is this really a dangerous process and should be avoided?

Mercury and Fish

- 1286 pregnant women, 522 postpartum women
- 1349 non-pregnant/non-postpartum
- Most aware of Hg
- All groups \ll recommended 340.2g/wk
 - Median intakes g/wk
 - Pregnant 51.6 Postpartum 71.4
 - Control 85.3
- Missing health benefits to themselves and their children Lando A et al Environ Res. 2012 Apr 23. [Epub ahead of print]





Arsenic



31 rice samples - 60% US grown NYC stores

- range 0.090 ± 0.004 to 0.85 ± 0.03 mg/kg
 - mean 0.275 ± 0.161 mg/kg
- Samples with >0.20 mg/kg, $n = 18$ *in vitro digestion*
Extractable - As 53 - 102%
- Bioaccessibility
 - Extra long grain $>$ long grain $>$ long grain
parboiled $>$ brown rice

He et al J Environ Sci Health B. 2012;47:74-80.

Arsenic : Se Interactions

- Se ↓ As accumulation
- Se ↓ oxidative stress from As and Cd
 - Sequesters As & Cd -inert conjugates
 - Se-dependent antioxidant enzymes detoxify
 - Se - potential countermeasure against toxicity induced by As and Cd

Zwolak I, Zaporowska H. Cell Biol Toxicol. 2012;28:31-46.



BPA & Food Packaging



BPA Exposure - Food Packaging

- Polycarbonate plastic
 - Hard, plastic reusable bottles
- Epoxy resins used in cans
- Fear of BPA effects has
 - Created fear esp. among young Mothers
 - Spawned a variety of BPA-free products



European Food Safety Authority (EFSA)

- **“current safe intake levels for bisphenol A (BPA) should remain unchanged.”** Oct 2010
- **Tolerable daily intake** - set in 2006 reaffirmed '08,'10
 - Present tolerable daily intake (TDI) of 0.05mg/kg bodyweight should be maintained. – decision of 19/20 prominent scientists
 - Reviewed 800 studies over the course of 6 months

BPA - Infants 84 to 92% less than previously estimated

- FDA 2012
 - 0.2-0.4 $\mu\text{g}/\text{kg-bw}/\text{day}$ for infants
 - 0.1-0.2 $\mu\text{g}/\text{kg-bw}/\text{day}$ for >2 yrs
- BPA crossing the placenta too low for detection
 - Study orally dosed pregnant rodents with 100-1000 times more BPA than people are exposed to through food, and could not detect the active form of BPA in the fetus 8 hours after the mother's exposure.
 - Converted to inactive aglycone form => rapidly excreted (rodents have less excretion than primates)

FDA's National Center for Toxicological Research

Stump data – Denmark/ Canada

- Uncertain effects on learning ability BUT
- Rat studies with high variability in the results and some methodology issues

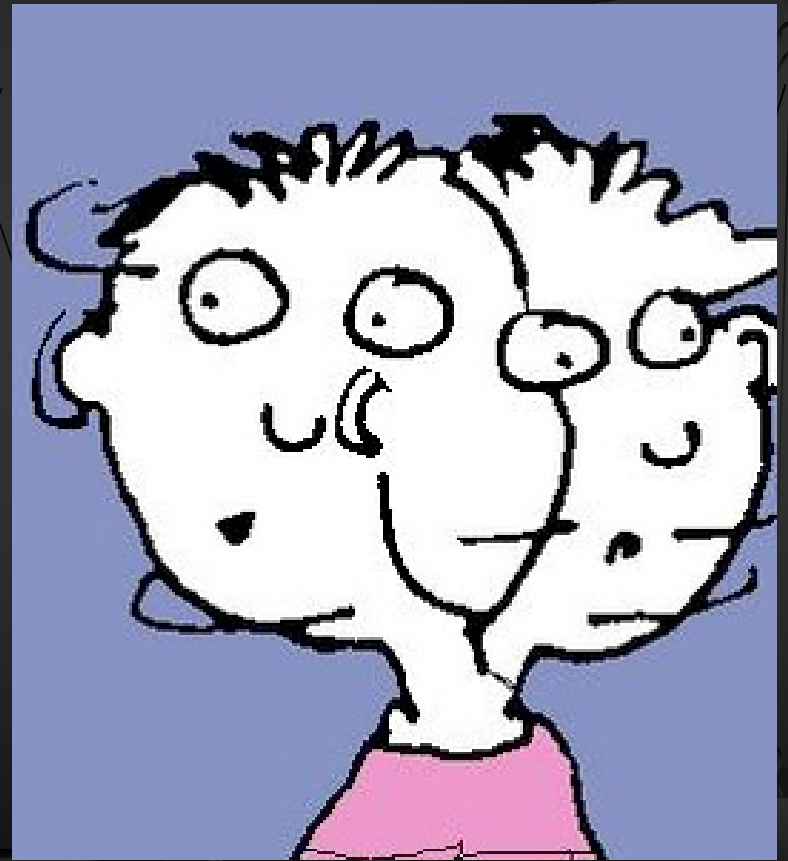


results rendered the research “*inconclusive with respect to learning and memory and of limited value for the risk assessment of BPA*”. EFSA added that its review of the scientific literature had failed to provide convincing evidence that BPA “*has any adverse effects on aspects of behaviour, such as learning and memory*”.

German Federal Institute (BfR) for Risk Assessment

Two major studies show
the chemical is NOT
hazardous.

- Stump et al and Ryan et al
- No indications for adverse health effects on neurological development and behavior
- Yet - the German environment agency asked industry and consumers to find bisphenol A (BPA) alternate



BPA in Canned Food - Health Canada

- *..urine of people who consume canned soup can contain surprisingly high levels of bisphenol A (BPA), a hormone-disrupting compound linked to health problems including heart disease, diabetes, and obesity.*



- BPA ~ all 78 canned products tested
- Canned tuna products – Highest
 - Average 137 ng/g
Max 534 ng/g
- Canned soups - 2nd
 - Condensed 52 ng/g
(Max 94 ng/g)
 - RTE 15 ng/g
(Max 34 ng/g)

Cao XL, Corriveau J, Popovic S. J
Food Prot. 2010;73:1085-9.

BPA in Canned Food - Health Canada

- Tomato paste 1.1 ng/g (Max 2.1 ng/g)
- Tomato products 9.3 ng/g (Max 23 ng/g)
- Average findings of BPA in the canned food products were consistent with those of past surveys and were **not "considered to represent a human health concern"**.

A Word about Dose

- Rats \neq Humans - BPA metabolism and sensitivity to estrogens
- Ig average is 57 ug/can, to get 50 mg/kg bw/day == **14 million cans** of food or beverage.



BPA Needed for Food Safety

- BPA-based epoxy linings are a vital food safety tool
 - No fully tested alternative had yet been found.
- Swiss Ministry of Health, **Bundesamt für Gesundheit**, : "A ban on BPA would inevitably cause manufacturers of packaging and consumer products (food contact materials) to have to switch to other substances, the toxicity of which is less well known. This would mean a well **characterised risk would be replaced with a conspicuously unpredictable risk.**"

Transfer from Baby Bottles

- Worst-case scenario 0.8 μ /kgbw/d transferred
 - \ll TDA 50 μ /kg(bw)/d



Von Goetz et al Risk Anal. 2010;30:473-87



Australia / New Zealand

Food Standards Australia New Zealand

"levels of intake of BPA or plasticisers are very low and do not pose a risk to babies health..."

Is Your BPA Free Bottle Really Safe from the Chemical?

For five years, Dr. Brown's Natural Flow bottle has been a product American Baby magazine has described as a products 'parents can't live without.' But the award-winning BPA-free baby bottle contained the highest traces of the toxic chemical according to recent Health Canada tests. The Dr. Brown's bottle showed trace amounts of 0.9 parts per



A Word about Dose

If 100's or 1000's ppb of endocrine disruptor were "an actual health hazard", then nobody should be eating wheat germ or soy products, which contain significant amounts of phytoestrogens that are much stronger estrogen disruptors than BPA. And the same with bioflavonoids found in many fruits.

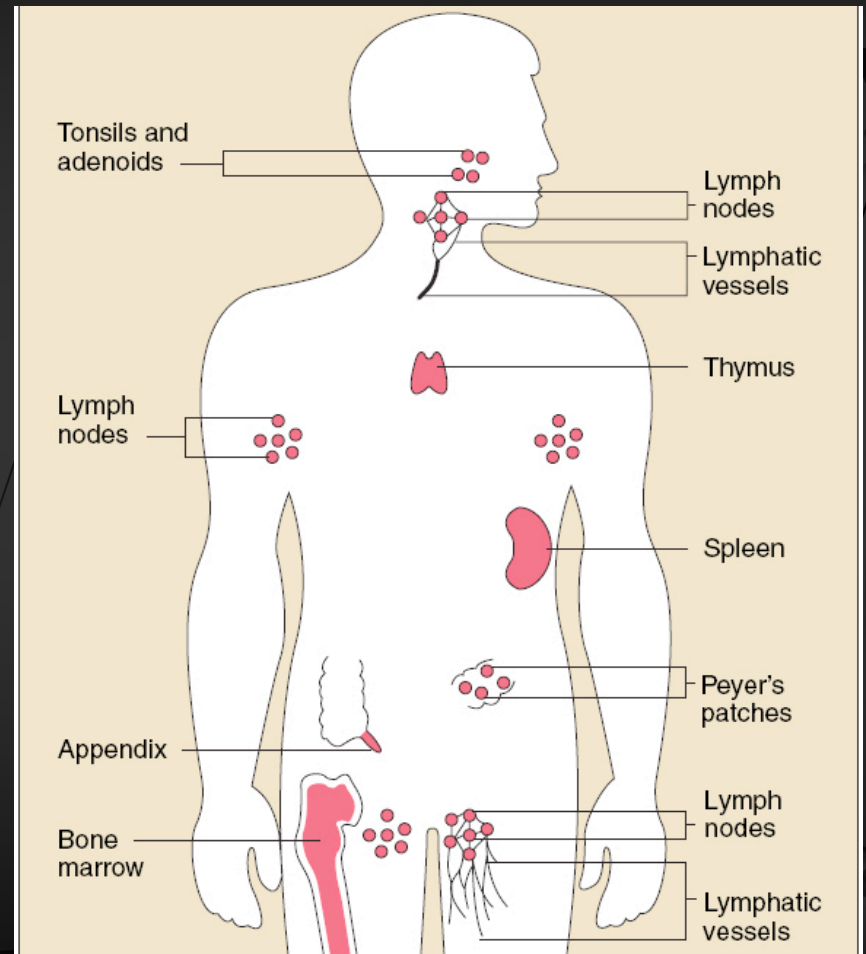
To date there is no convincing data that exposure to environmental estrogens can be regarded as a risk for human health



Next Set of Allegations - BPA and Immune Diseases

BPA postulated to have many adverse effects including being responsible for autoimmune diseases

Chighizola C, Meroni PL.
Autoimmun Rev. 2012;11:A493-501



Risks - My Pipe Dream List for Consumers

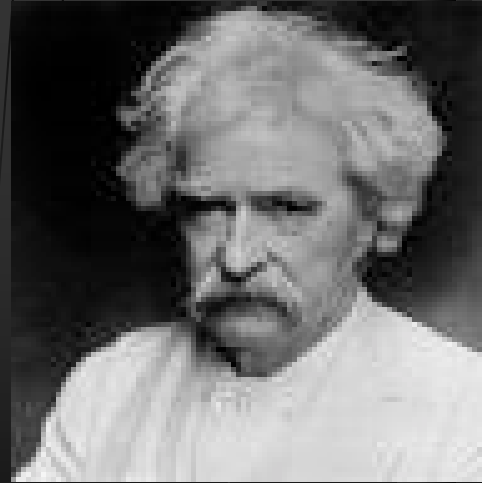
1. Buy, cook, store food safely
2. Eat according to MyPlate – learn to cook
3. Control portions
4. Eat food that satisfies you in every way –

ENJOY YOUR FOOD

What We Know for Sure

It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.

Mark Twain



3 SEPTEMBER 1983 VOL. 227 NO. 457

SCIENCE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



SACCHARIN



AIR



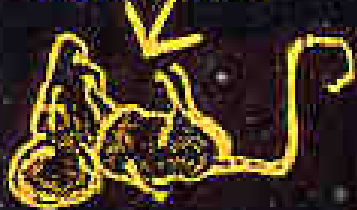
FRIED CHICKEN



TEA



MALTED MILK BALLS



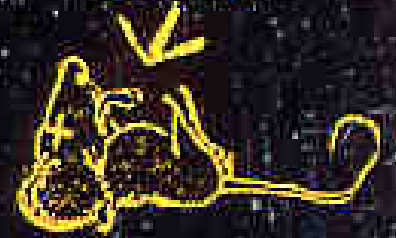
WATER



BLUEBERRY WAFFLES



COFFEE



LASAGNA



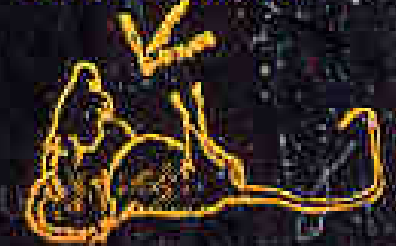
RUTABAGA FILLET



TOBACCO



APHRODISIAC



W. D. M.