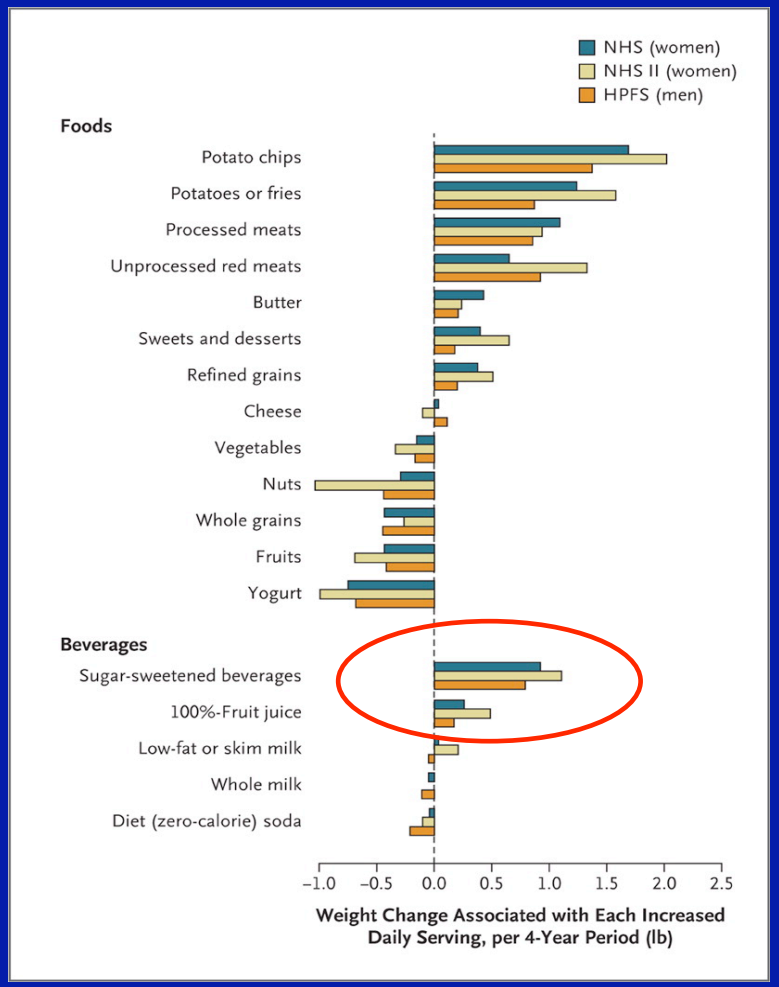
La consommation de fructose est-elle associée au syndrome métabolique ?

Luc Tappy et coll. ; CHUV-UNIL

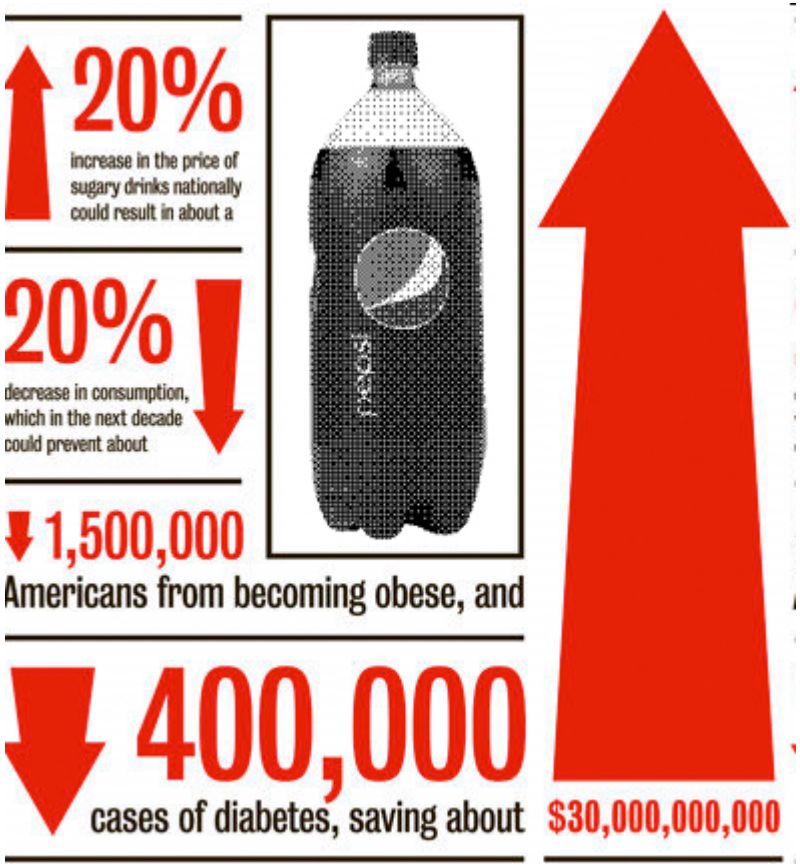
Relationships between Changes in Food and Beverage Consumption and Weight Changes Every 4 Years.



Study participants included 50,422 women in the Nurses' Health Study (NHS), followed for 20 years (1986 to 2006); 47,898 women in the Nurses' Health Study II (NHS II), followed for 12 years (1991 to 2003); and 22,557 men in the Health Professionals Follow-up Study (HPFS), followed for 20 years (1986 to 2006).

Mozaffarian D et al. N Engl J Med 2011;364:2392-2404.

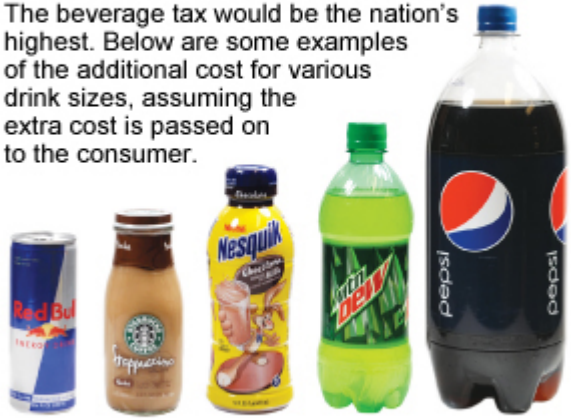
The NEW ENGLAND JOURNAL of MEDICINE



Proposed Sugar Tax

In an effort to find new revenue to plug the city's budget gap, Mayor Nutter has proposed a **2-cent-per-ounce tax** on sugary drinks (any beverage with added sugar).

The beverage tax would be the nation's highest. Below are some examples of the additional cost for various drink sizes, assuming the extra cost is passed on to the consumer.



8.4 oz.	9.5 oz.	16 oz.	20 oz.	2 liter
+17¢	+19¢	+32¢	+40¢	+$1.35

The Philadelphia Inquirer

High Fructose Corn Syrup

Amidon

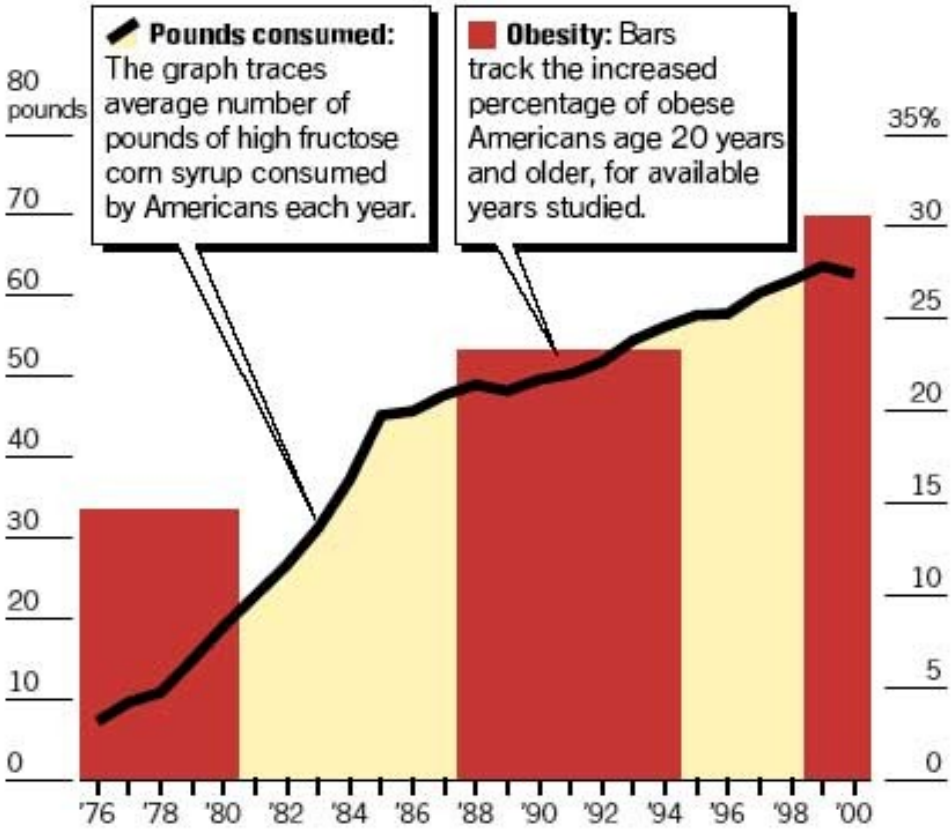
Glucose

Glucose

Fructose

Obesity and high fructose corn syrup

The number of Americans who are obese has quadrupled in recent years, a study shows. At the same time, high fructose corn syrup consumption has risen at parallel rates.



Source: Centers for Disease Control, American Obesity Association, Chronicle research

Chronicle Graphic

http://i101.photobucket.com/albums/m52/phoridflystudios/NEW/obesity-cornsyrup.jpg

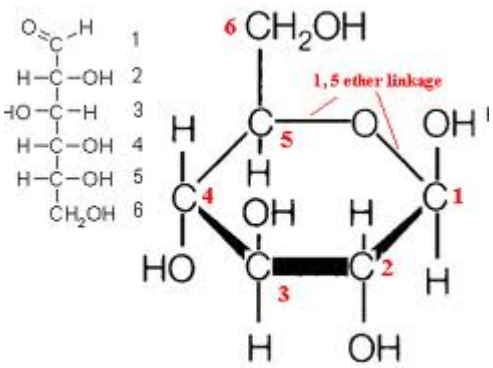
SIMPLY DELICIOUS.

We've got good news. We removed the artificial trans fats, artificial flavors, artificial dyes and high-fructose corn syrup. Now your food not only tastes better, it is better. We hope you enjoy the difference.

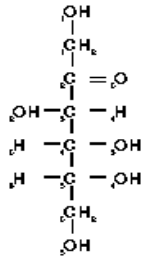
STARBUCKS COFFEE®

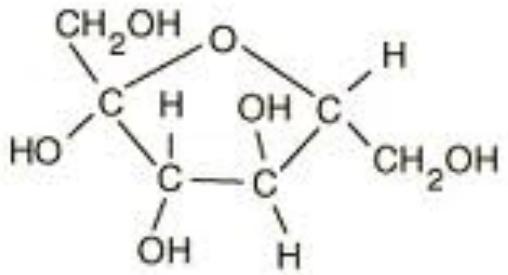
- What is special about fructose?
- Can it cause metabolic disorders?
- When consumed in high amounts, is it different from glucose?
- How much fructose is too much?
- What do we still need to learn?

Sugar = Glucose-Fructose

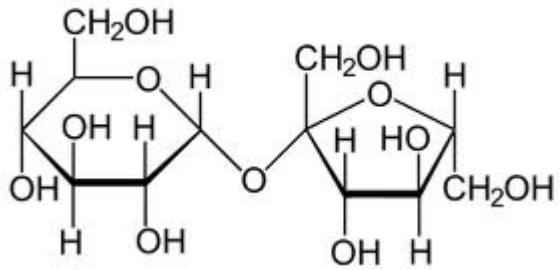


Glucose

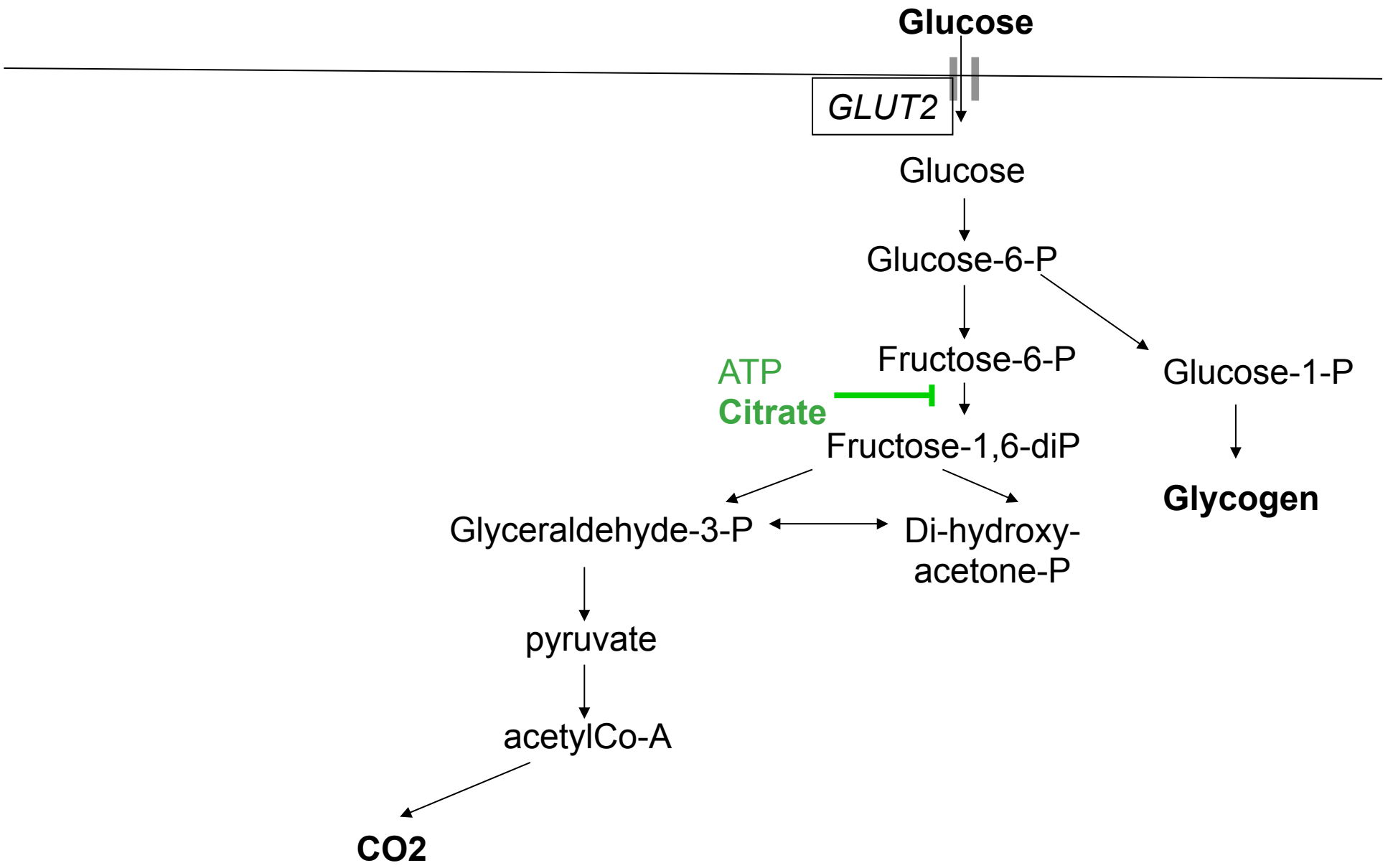


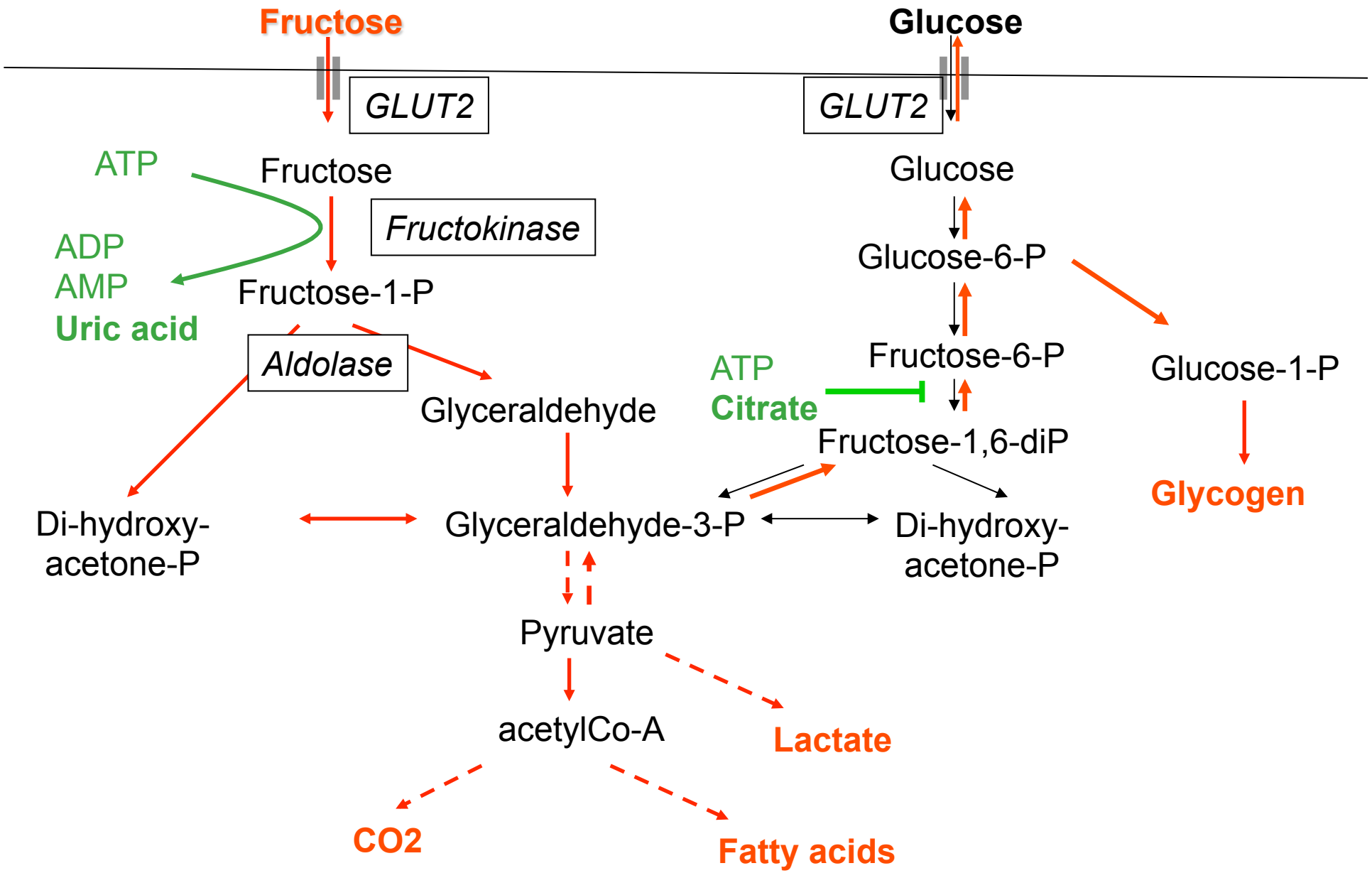


Fructose



Glucose Fructose = Sucrose


Glucose
GLUT2
Glucose
Glucose-6-P
Fructose-6-P
ATP
Citrate
Glucose-1-P
Glycogen
Fructose-1,6-diP
Glyceraldehyde-3-P
Di-hydroxy-
acetone-P
pyruvate
acetylCo-A
CO2


Fructose
Glucose
GLUT2
GLUT2
ATP
Fructose
Fructokinase
ADP
AMP
Uric acid
Fructose-1-P
Aldolase
Glyceraldehyde
Glucose
Glucose-6-P
Fructose-6-P
ATP
Citrate
Fructose-1,6-diP
Glucose-1-P
Glycogen
Di-hydroxy-
acetone-P
Glyceraldehyde-3-P
Di-hydroxy-
acetone-P
Pyruvate
acetylCo-A
Lactate
CO2
Fatty acids

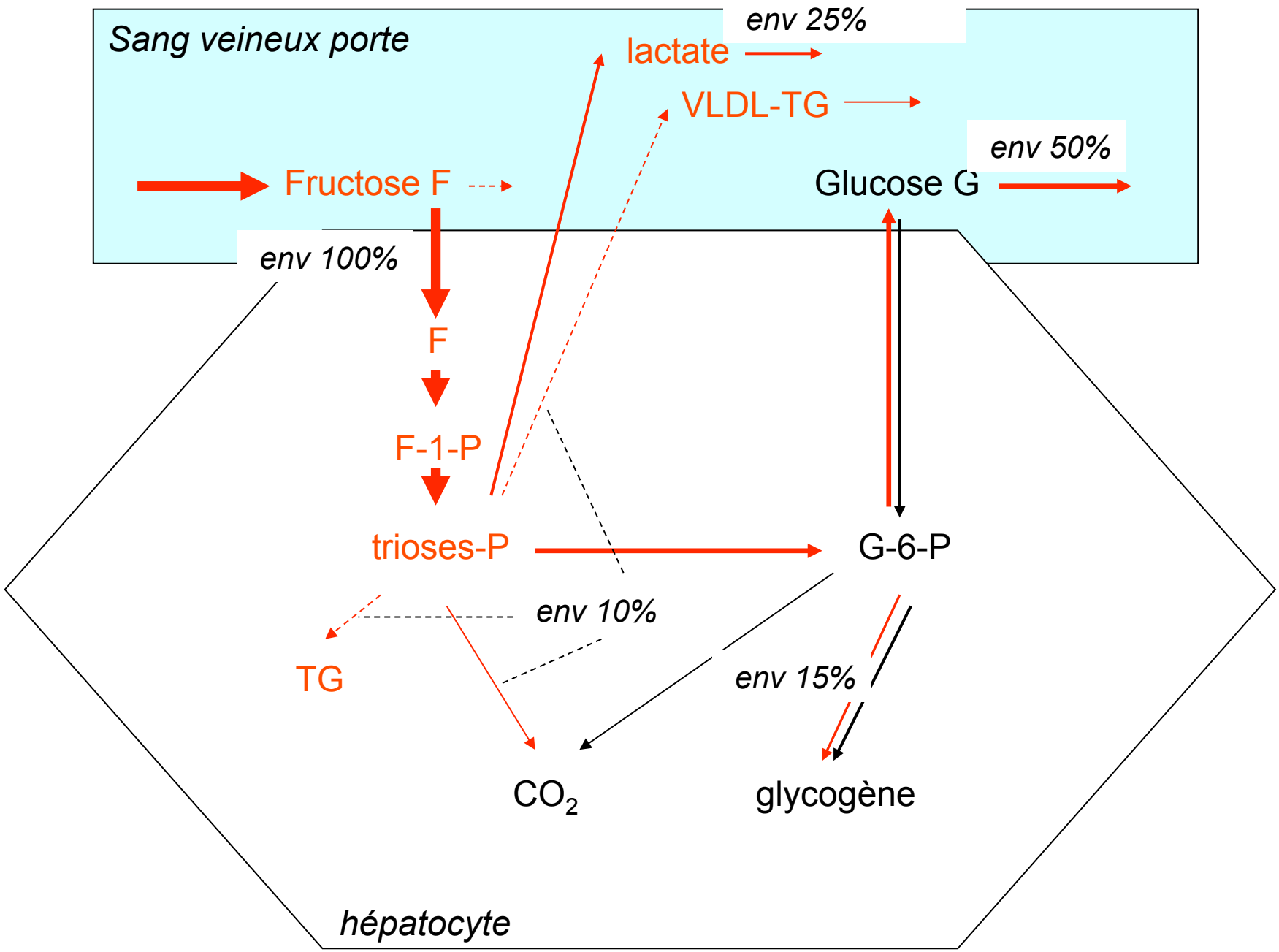
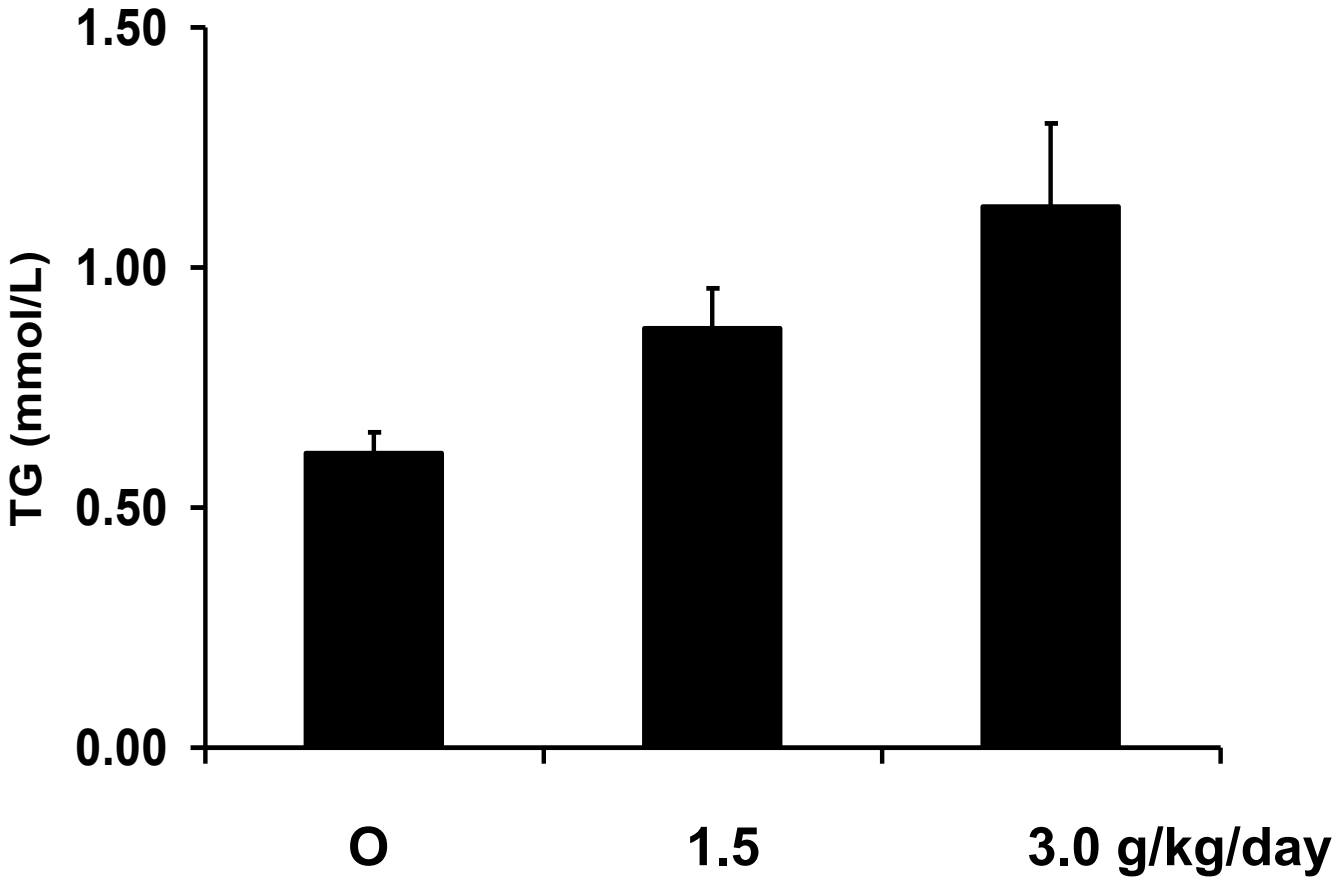


Fig 1: devenir d'une charge orale de fructose chez le sujet sain au repos

- **1990’s: fructose as a sweetener for diabetic patients**
- **Low glycemic response**
- **Metabolism not dependant on insulin secretion**
- **Higher thermic effect**

- **Long term fructose can induce metabolic disorders**
- **Rodent models: high fructose/sucrose diet → obesity, insulin resistance, diabetes, dyslipidemia, HBP**
- **Humans: high fructose/sucrose diets → hypertriglyceridemia**
- **Other features of the metabolic syndrome in humans?**

Fructose overfeeding dose-dependantly increases fasting (and post prandial) plasma triglycerides

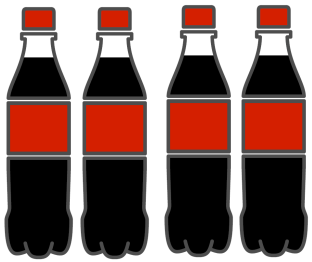


Lê et al, 2006, 2009

1.Short-term High Fructose (6 days)

Subjects: 7 healthy male volonteers

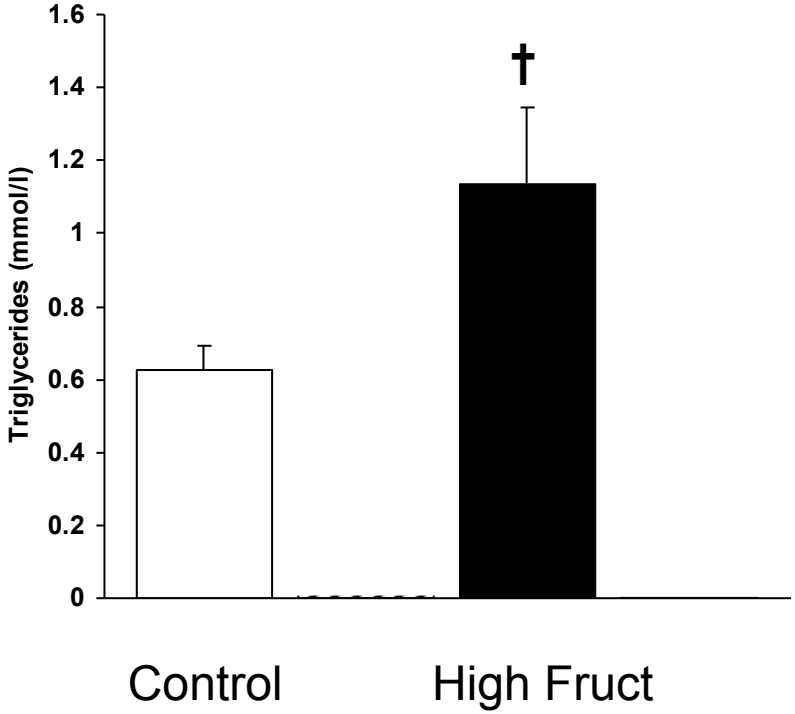
Fructose supplementation: 3 g / kg / day

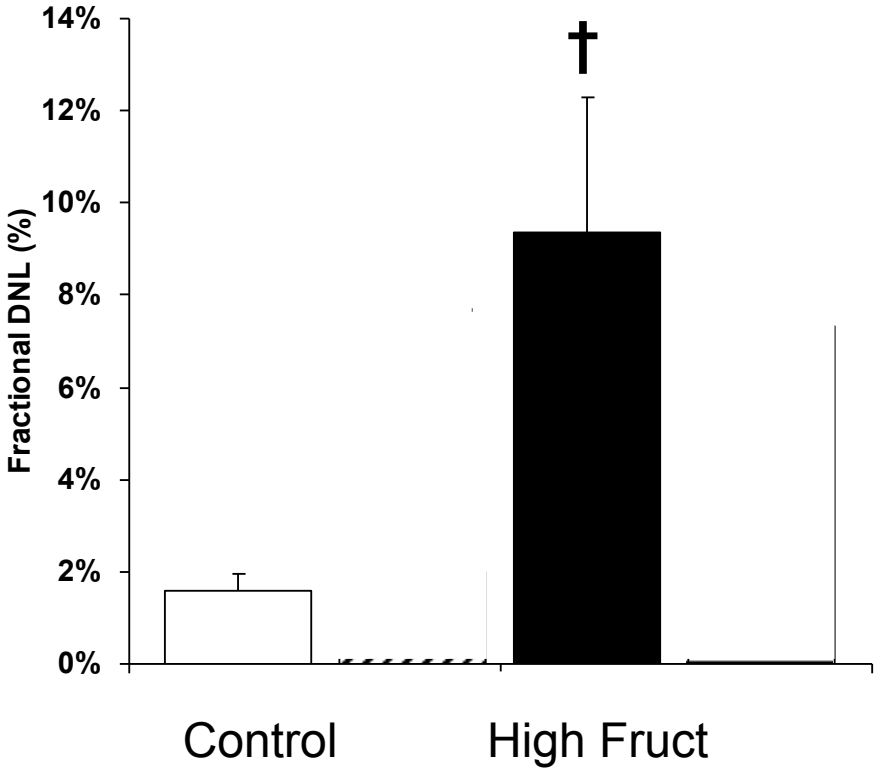


4 L soda

Faeh et al, 2005

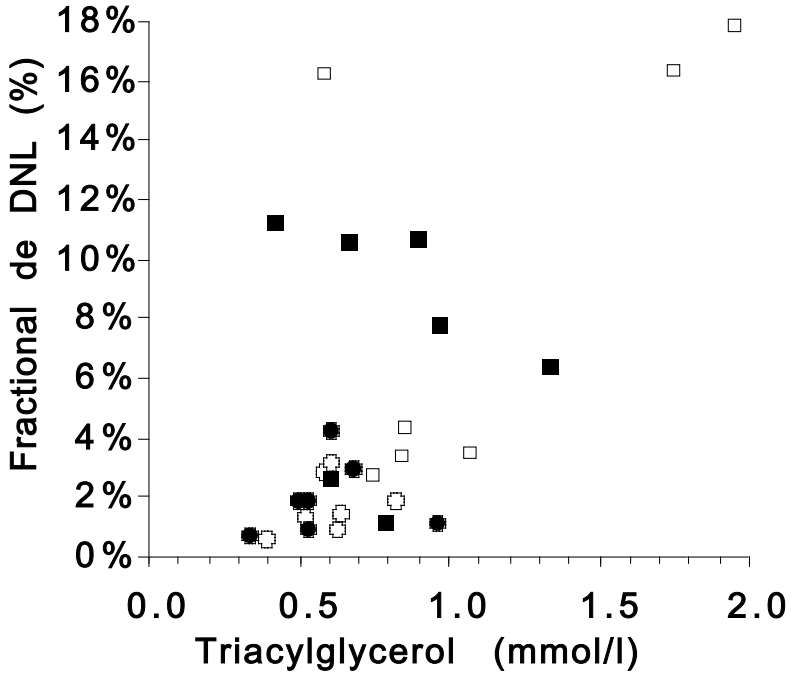
Fructose overfeeding stimulates hepatic de novo lipogenesis





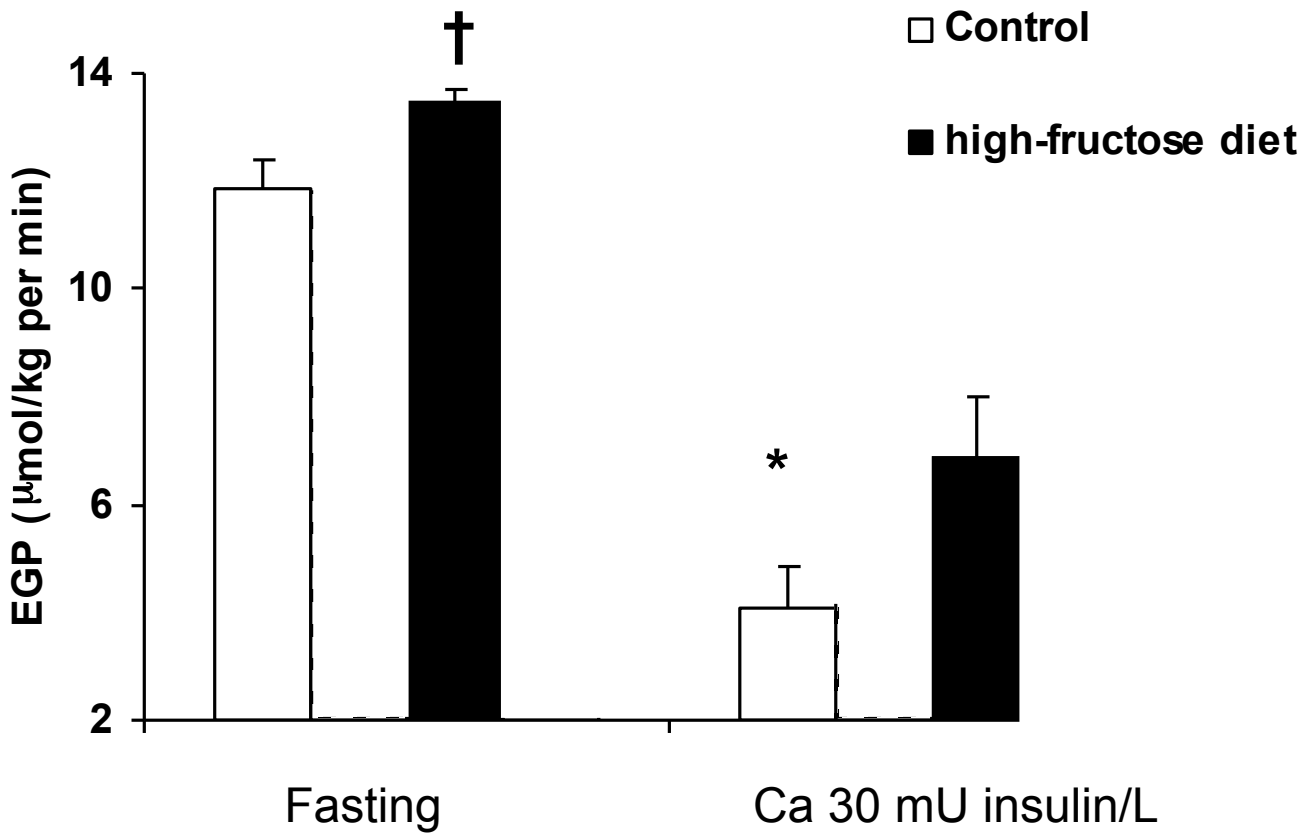
Faeh et al, Diabetes 2005

Effects on fasting VLDL-TG and on hepatic de novo lipogenesis are inter-related



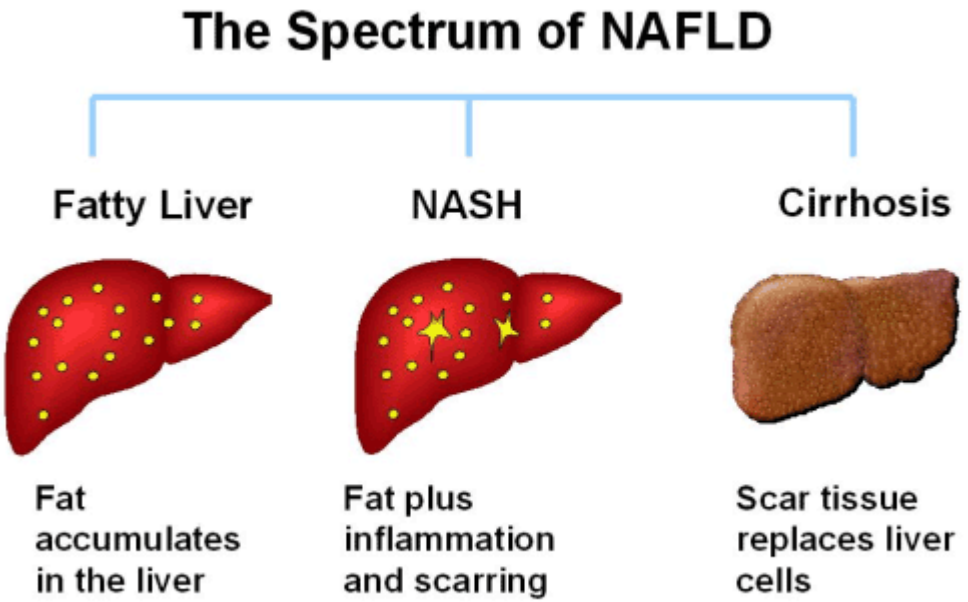
Faeh et al, Diabetes 2005

Fructose overfeeding decreases hepatic insulin sensitivity



Faeh et al, Diabetes 2005

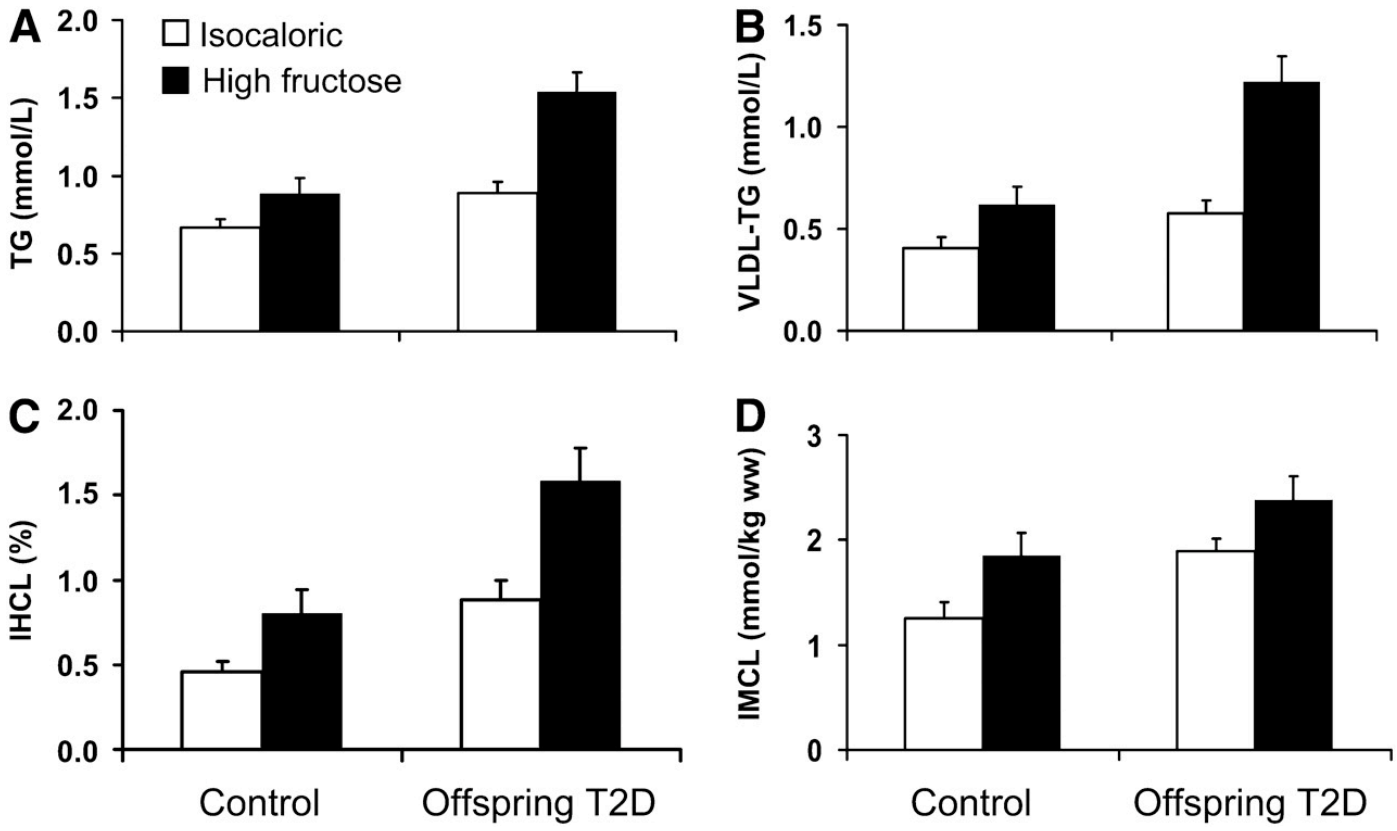
Non-alcoholic fatty liver disease
= hepatic component of the metabolic syndrome



http://www.gi.org/patients/gihealth/images/fld.gif

Fructose overfeeding increases intrahepatic lipid concentrations

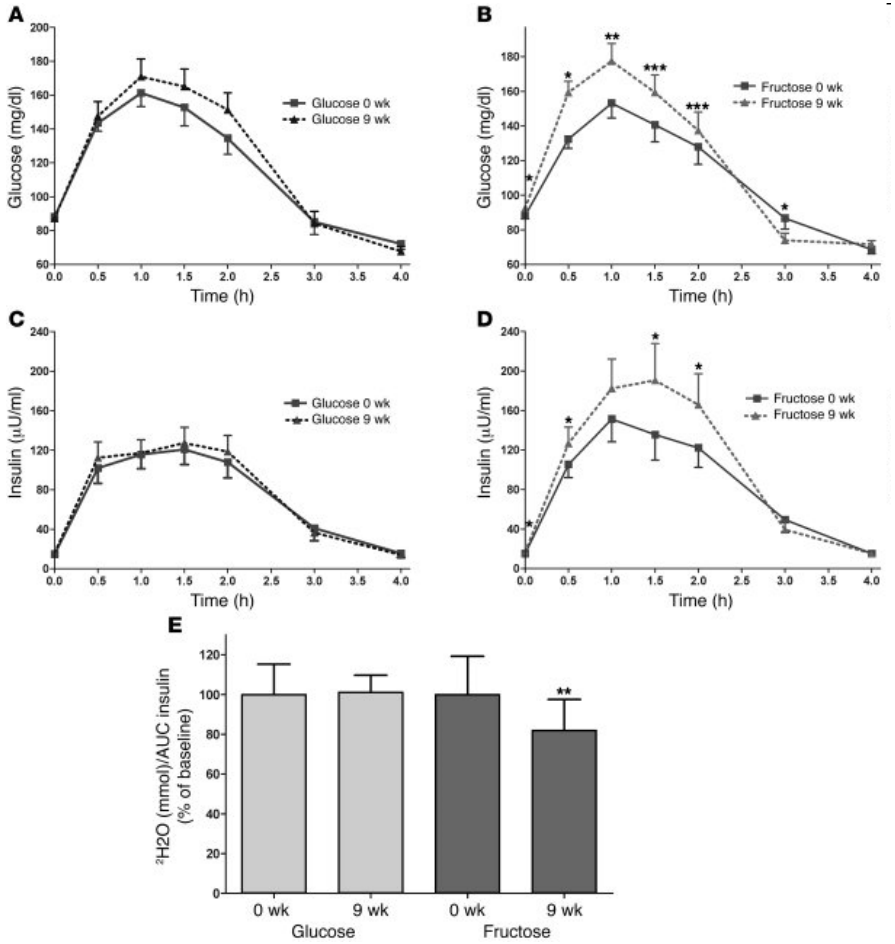
The American Journal of Clinical Nutrition



Le, K.-A. et al. Am J Clin Nutr 2009;89:1760-1765

Is excess fructose different from excess glucose?

Fructose, but not glucose, causes impaired glucose tolerance

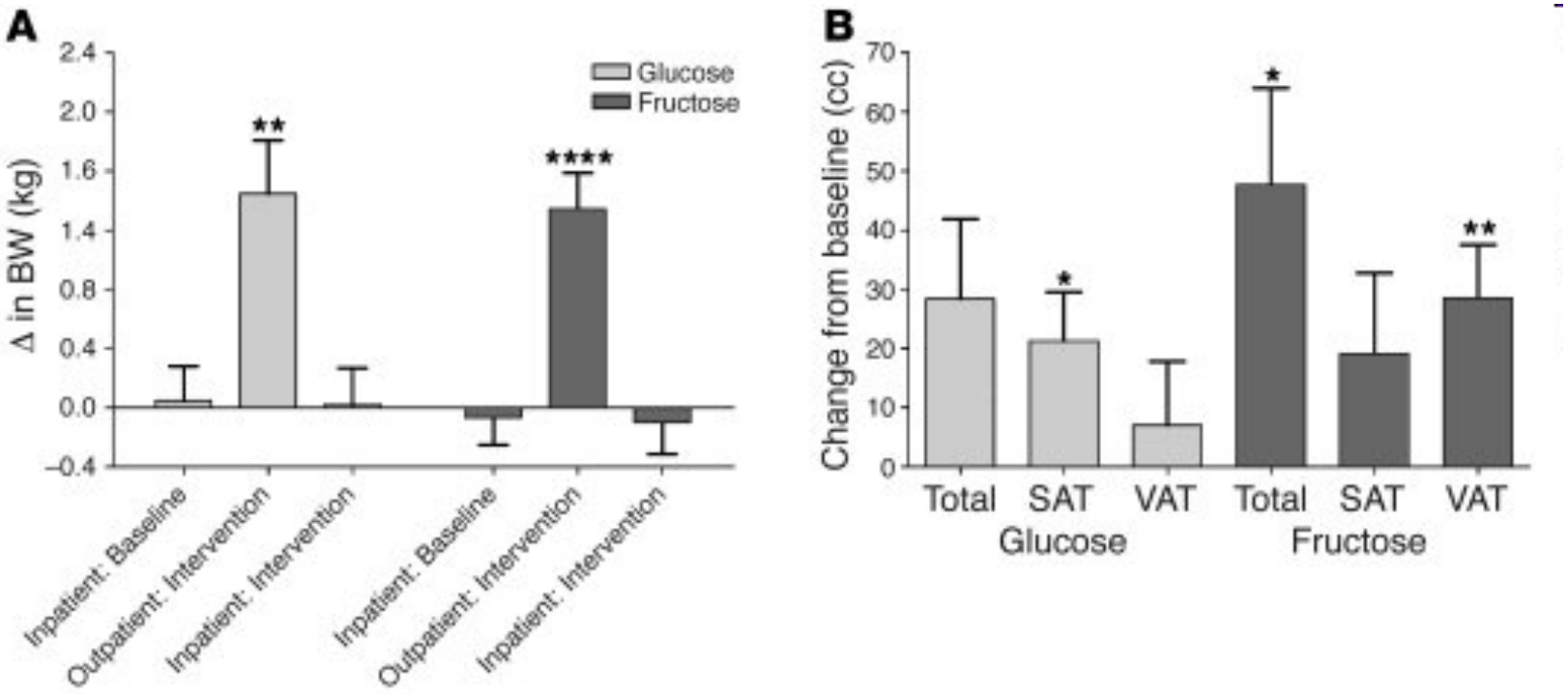


Overweight females and males

10-week supplementation with fructose or glucose drinks (ca 30% total energy expenditure)

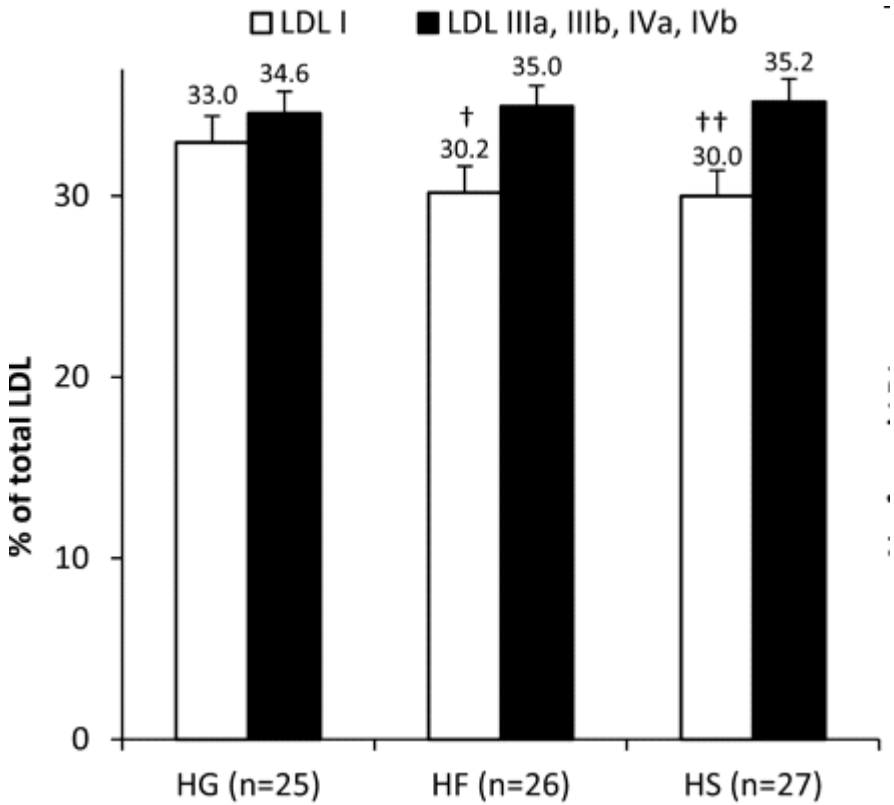
Stanhope et al, J Clin Invest 2009

Fructose increases visceral adipose tissue



Stanhope et al, J Clin Invest 2009

Fructose and sucrose (consumed in moderate amounts) increase small dense LDL particles



29 healthy subjects consuming
Over 3 weeks
-40 g fructose (MF)
-80 g fructose (HF)
-40 g glucose (MG)
-80 g glucose (HG)
-80 g sucrose (HS)
-Low sugar intake

All sugars :↑ CRP

Aeberli et al, Am J Clin Nutr 2011

How much fructose is too much???

- Livesey et al, Am J Clin Nutr 2008; 42 reports between 1966 and 2006
  - No effect on body weight with intake<100g/d (ca 30-40% total EI as sugars)
  - Effect on fasting triglycerides for intake>100g/d
  - Effect on post-prandial triglyceride for intake>50g/d (ca 15-20% total EI as sugars)

- Sievenpieper et al, Diabetes Care 2009; 16 reports between 1950 and 2009
  - Fructose increase plasma TG in type 2 DM when substituted for starch and intake > 60g/j

Consommation brute de sucre dans le monde

Continent	Consommation de sucre per capita (g/ day)		Consommation de HFCS per capita (g/day)	
	1986	2006	1985	2005
Europe	107	124		
Amérique du Nord	83	88	40	52.4
Amérique du Sud	117	143		
Asie	30	45		
Afrique	40	46		
Océanie	122	118		

Données selon
-ISO Sugar Year Book, 2008
- (http://www.corn.org/percaphfcs.htm))

Consommation de sucres en France
Etude de consommation alimentaire INCA2
2007

Hommes adultes:	**103g/j**	**17-20% AESA**	**ca 51 g F**
Femme adulte:	**93g/j**		**ca 46 g F**
Enfants / adolescents:	**97-100g/j**	**20-25% AESA**	**ca 50g F**

Physical Activity

Le tour de France
W Saris et al, 1989

- Tour de France 1988
- 22 cycling days + 1 resting day
- 4000 km
- 30 mountain passes

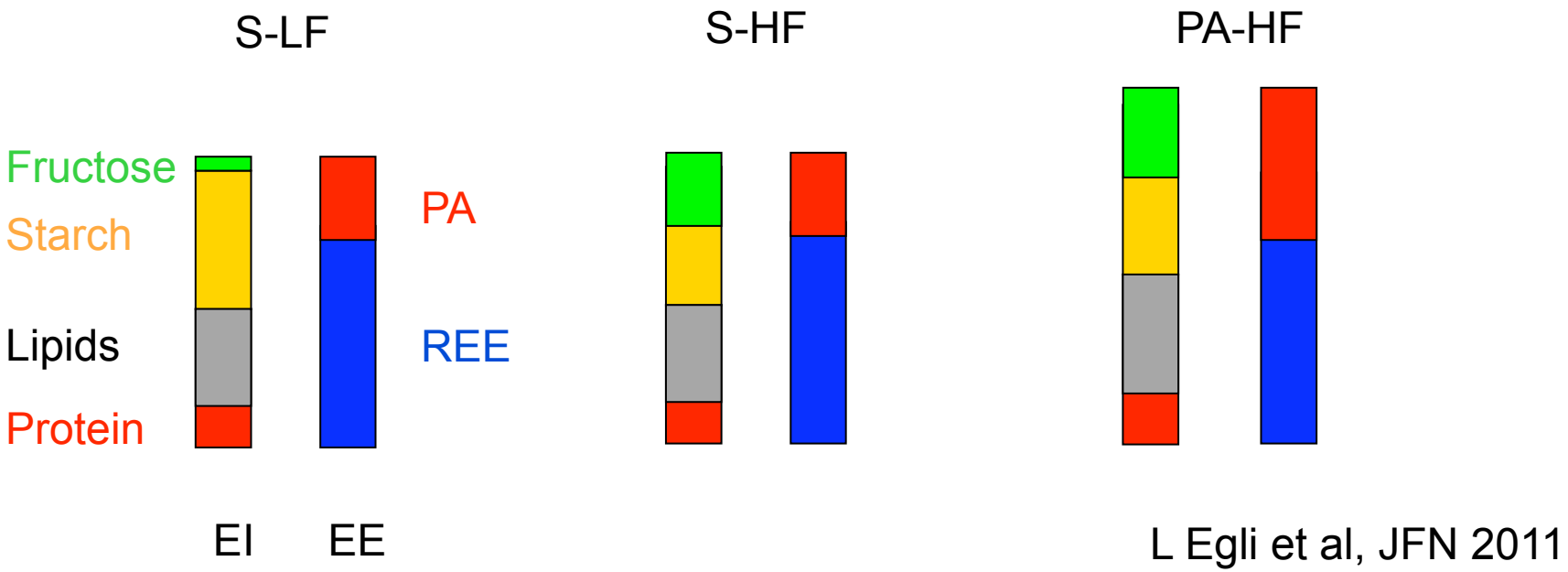
	Tour de France	pop. « normale »
Energy Expenditure	25.4 MJ	ca 12 MJ
Energy intake	24.3 MJ	ca 12 MJ
% protein	15%	15%
% lipids	23%	30-45%
% carbohydrate	61%	40-55%

Food/drinks Consumed

	% energy	% carbohydrate
Cookies	13.7	14.9
Maltodextrines	9.8	15.8
Sugar	5.9	9.4
Liquid Formulas	5.5	4.2
Soft Drinks	4.1	6.6
Energy Drinks	3.5	5.6
…		

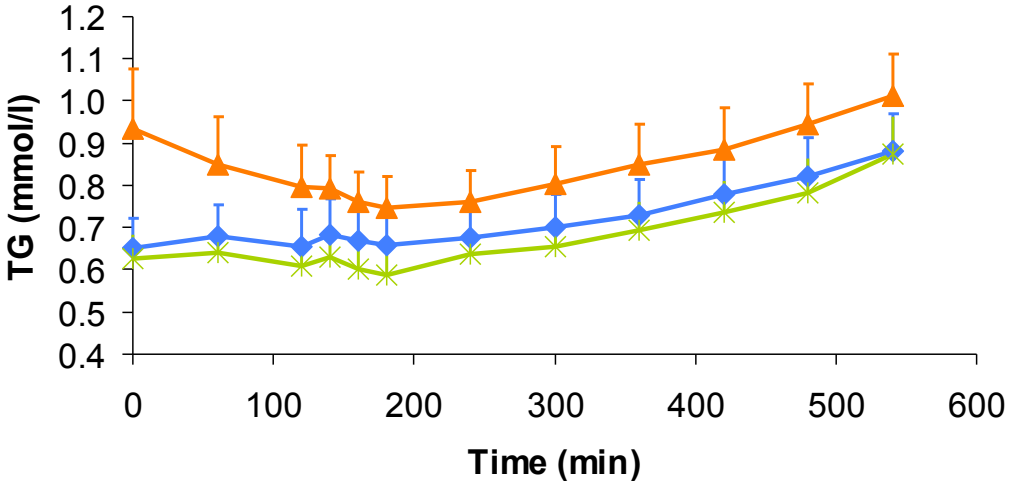
Does physical activity mdulate fructose's effects

- **8 M, aged 21.50±0.96, BMI 22.09±0.67 studied during**
  - **Sedentary conditions-isocaloric-low fructose**
  - **Sedentary conditions-isocaloric-high fructose (3g/kg/d)**
  - **Moderate physical activity-isocaloric-high fructose**



L Egli et al, JFN 2011

Lipid metabolism



Triglycerides

Ctrl
Fru
FruEx

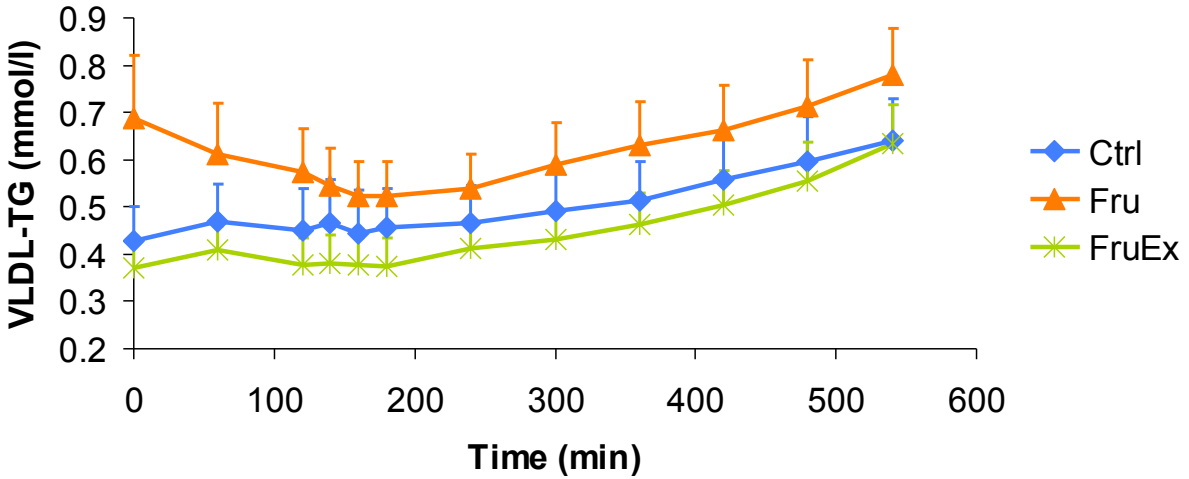
Ctrl vs Fru: P≤0.001

Fru vs FruEx: P<0.001

VLDL-TG

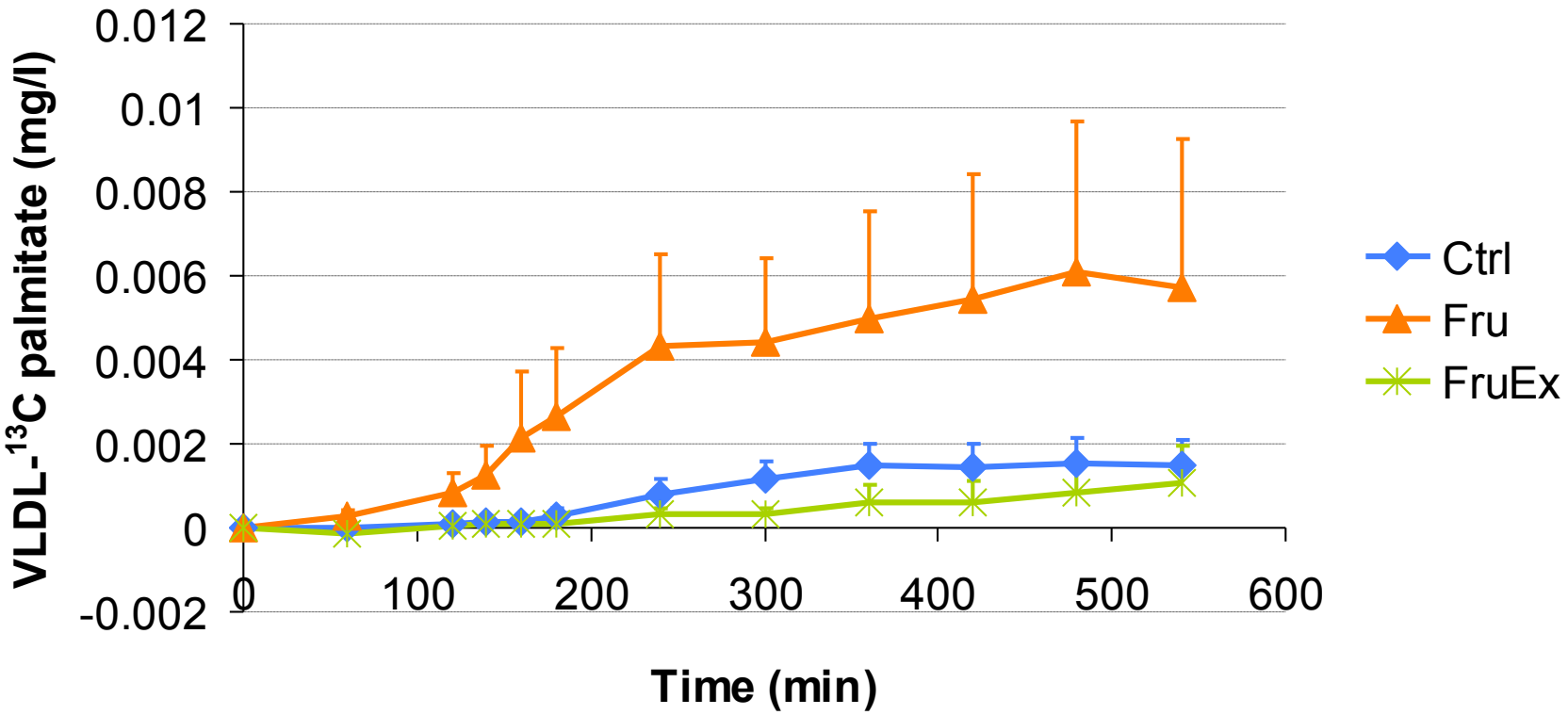
Ctrl vs Fru: P≤0.05

Fru vs FruEx: P<0.001



Egli et al, JFN 2011

^{13}C palmitate-VLDL



Ctrl vs FruEx: P<0.001

Fru vs FruEx: P<0.001

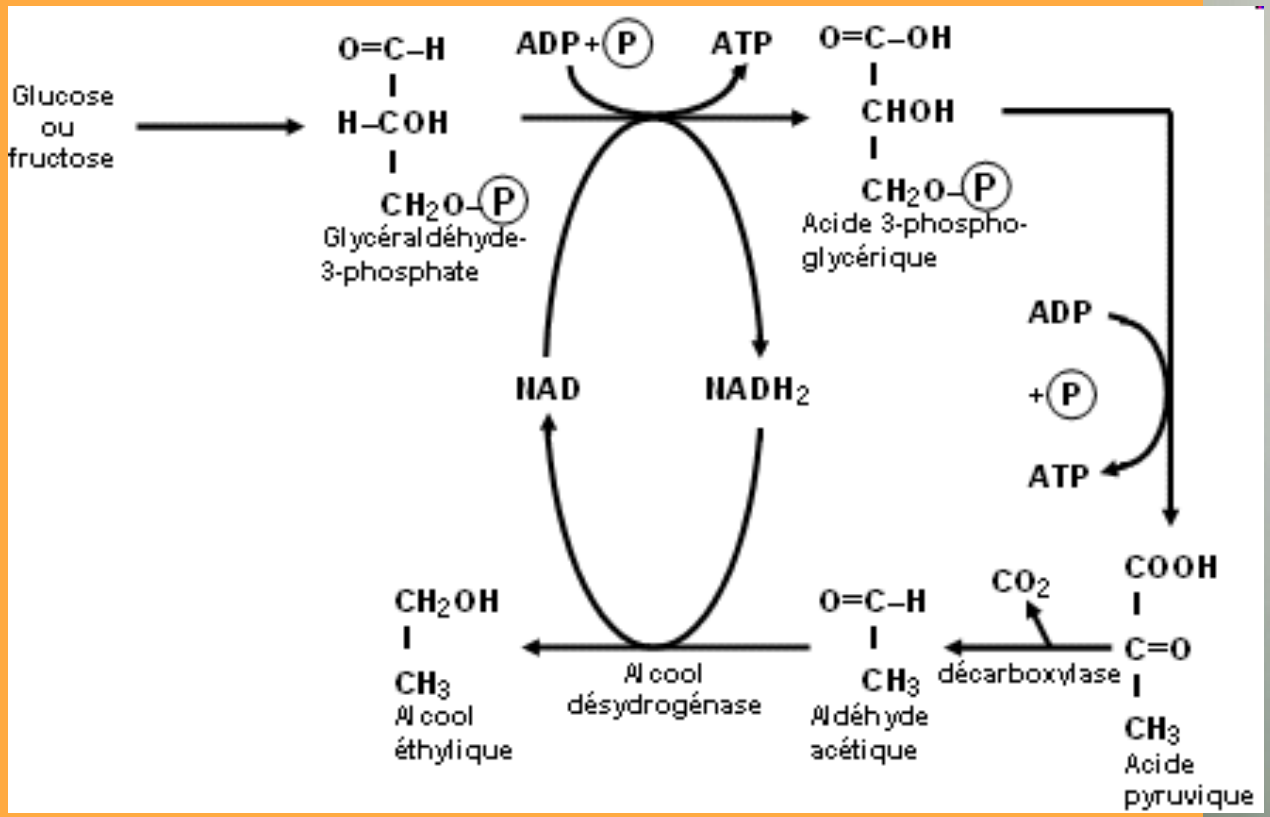
Egli et al, JFN 2011

Conclusions

- Sugars when given in large amounts can have deleterious effects
- Effects essentially on hepatic lipids, plasma lipoproteins, and hepatic insulin sensitivity
- Effects related to fructose more than glucose
- Effects with sugar intake > 50 g/j total energy intake (> 10% total energy intake)
- Effects of fructose can be attenuated by exercise
- Define high risk individuals

Fructose « detoxification »?

- Exercise (Egli et al, JFN 2011)
- Protein/essential amino-acids (Theytaz JFN 2011)
- Coffee (Carrel et al, in preparation)


Glucose
ou
fructose
O=C–H
H–COH
CH2O–P
Glycéraldéhyde-
3-phosphate
ADP+P
ATP
O=C–OH
CHOH
CH2O–P
Acide 3-phospho-
glycérique
ADP
+P
ATP
COOH
C=O
CH3
Acide
pyruvique
CO2
décarboxylase
O=C–H
CH3
Aldéhyde
acétique
NAD
NADH2
Alcool
désydrogénase
CH2OH
CH3
Alcool
éthylique


C Boesch and R Kreis, Bern
J-M Schwarz, UCSF, San Francisco, CA
K Frayn and B Fielding, Oxford, UK
K Berneis, Zürich
B Mittendorfer,St-Louis, MO
Le Talent