

Calculations on ¹³C Breath Tests

Isotope Ratio (R)

$$R = \frac{{}^{13}\text{C}}{{}^{12}\text{C}}$$

Mole Fraction (MF)

$$MF = \frac{{}^{13}\text{CO}_2}{{}^{13}\text{CO}_2 + {}^{12}\text{CO}_2} \qquad MF = \frac{1}{1/R + 1}$$

$$R = \frac{1}{1/MF - 1}$$

Mole Percent (MP) [%]

$$MP = MF * 100$$

Delta (δ) [‰]

$$\delta = 1000 * \left(\frac{R_{meas}}{R_{PDB}} - 1 \right) \qquad \delta = 1000 * \left(\frac{1/(1/MF - 1)}{R_{PDB}} - 1 \right)$$

$$MF = \frac{1}{1 + 1/(R_{PDB} * (1 + \delta/1000))}$$

PDB-Standard:

calcium carbonate of a fossil **Belemnitella** of the
Pee-Dee-formation in South Carolina

$$R_{PDB} = 0,01123686 \quad MF_{PDB} = 0,011112 \quad \delta = \pm 0 \text{ ‰}$$

European:

C3-plants (potato, cabbage, beet sugar, rice)

$$R = 0,0109537 \quad MF = 0,010835 \quad \delta = -25,5 \text{ ‰}$$

American:

C4-plants (corn, cane sugar)

$$R = 0,011102 \quad MF = 0,0109 \quad \delta = -19,3 \text{ ‰}$$

Delta over base line (DOB) [‰]

$$DOB = \delta_t - \delta_0$$

δ₀ - delta value just before taking the test meal (base line)

δ_t - delta value at time t after taking the test meal

Calculations on ^{13}C Breath Tests

Percentage Dose Recovery (PDR) [%/h]

$$PDR = \frac{\text{mmol } ^{13}\text{C in breath (a)}}{\text{mmol } ^{13}\text{C administered (b)}} * 100$$

$$a = (MF_t - MF_{t_0}) * CO_2 \text{ production}$$

with

$$CO_2 \text{ production} = 300 \text{ mmol} / m^2 \text{BSA h}$$

where

$$BSA = 0,024265 * W^{0,5378} * H^{0,3964}$$

$$W = \text{weight (kg)}$$

$$H = \text{height (cm)}$$

$$b = (MF_{\text{substr}} - MF_{t_0}) * \frac{m}{M} * n$$

with

m = amount of substrate administered

M = molar mass of substrate

n = number of ^{13}C - labelled atoms

Cumulative Percentage Dose Recovery (cPDR) [%]

$$cPDR_{t_{i+1}} = cPDR_{t_i} + \left(\frac{PDR_{t_i} + PDR_{t_{i+1}}}{2} \right) * \frac{\Delta t}{60}$$

Mathematical Analysis of Gastric Emptying

1.

The cumulative excretion curve of breath test resembles the reversed retention curve, obtained by radiosciintigraphy:

$$cPDR = m(1 - e^{-kt})^\beta$$

with

$$t = \text{time}$$

$$m = \text{total cumulative percentage of the dose recovered}$$

The parameters m , k and β are estimated in fitting the model to the originally measured data via the least squares method.

The **half emptying time** (in minutes) is calculated by taking $cPDR$ equal to $m/2$:

$$t_{1/2} = \frac{-\frac{1}{k} \ln(1 - 2^{-1/\beta}) * 60 - 66}{1,12}$$

The **lag phase** for breath test (in minutes) is defined as:

$$t_{lag} = \frac{\frac{\ln \beta}{k} * 60 - 66}{0,94}$$

2.

To describe the excretion curve of breath test, the following model has been derived from the χ^2 -distribution

$$PDR = a t^b e^{-ct}$$

with

$$t = \text{time}$$

The parameters a , b and c have to be determined by least squares fit of the measured data.

The **gastric emptying coefficient** is defined as:

$$GEC = \ln a$$