

The background features a light gray field with various geometric elements. In the upper left, there are several gray circles of different sizes. A large blue diamond shape is centered in the upper half of the image. In the lower right, a network diagram is visible, consisting of gray circles (nodes) connected by thin gray lines. Some areas of the network are filled with light gray triangles. The text "Initial Value" is written in a blue, sans-serif font within the blue diamond.

Initial Value

# Hovorka's differential equation

$$\begin{bmatrix} \frac{dD_1(t)}{dt} \\ \frac{dD_2(t)}{dt} \\ \frac{dS_1(t)}{dt} \\ \frac{dS_2(t)}{dt} \\ \frac{dQ_1(t)}{dt} \\ \frac{dQ_2(t)}{dt} \\ \frac{dI(t)}{dt} \\ \frac{dx_1(t)}{dt} \\ \frac{dx_2(t)}{dt} \\ \frac{dx_3(t)}{dt} \end{bmatrix} = \begin{bmatrix} A_G D(t) - \frac{D_1(t)}{\tau_D} \\ \frac{D_1(t)}{\tau_D} - \frac{D_2(t)}{\tau_D} \\ u(t) - \frac{S_1(t)}{\tau_s} \\ \frac{S_1(t)}{\tau_s} - \frac{S_2(t)}{\tau_s} \\ U_G - F_{01,C} - F_R(t) - x_1(t)Q_1(t) + k_{12}Q_2(t) + EGP_0(1 - x_3(t)) \\ x_1(t)Q_1(t) - (k_{12} + x_2(t))Q_2(t) \\ \frac{U_I(t)}{V_I} - k_e I(t) \\ -k_{a1}x_1(t) + k_{b1}I(t) \\ -k_{a2}x_2(t) + k_{b2}I(t) \\ -k_{a3}x_3(t) + k_{b3}I(t) \end{bmatrix}$$

All differential equation must be zero because these states are steady.

Assume  $u(1) = k$

$$\begin{cases} k - \frac{S_1(t)}{\tau_s} = 0 \\ \frac{S_1(t)}{\tau_s} - \frac{S_2(t)}{\tau_s} = 0 \end{cases} \Rightarrow S_1(1) = S_2(1) = 55 \cdot k, \quad U_I(1) = u(1) = k$$

$$\frac{k}{V_I} - k_e I(1) = 0 \Rightarrow I(1) \frac{k}{V_I \cdot k_e} = \frac{k}{0.12 \cdot BW \cdot 0.138} = \frac{k}{0.01656 \cdot BW}, \quad \text{BW} = \text{Body Weight}$$

$$\begin{cases} 3.07 \cdot 10^{-5} \cdot \frac{k}{0.01656 \cdot BW} = 0.006 \cdot x_1(1) \\ 4.92 \cdot 10^{-5} \cdot \frac{k}{0.01656 \cdot BW} = 0.06 \cdot x_2(1) \\ 0.0016 \cdot \frac{k}{0.01656 \cdot BW} = 0.03 \cdot x_3(1) \end{cases} \Rightarrow \begin{cases} x_1(1) = 0.30898 \cdot \frac{k}{BW} \\ x_2(1) = 0.04951 \cdot \frac{k}{BW} \\ x_3(1) = 3.2206 \cdot \frac{k}{BW} \end{cases}$$

Set  $G(1) = 5 \text{ mmol}$

$$\therefore Q_1(1) = 5 \cdot V_G = 0.8 \cdot BW$$

$$\begin{cases} U_G - F_{01,C} - F_R(1) - x_1(1)Q_1(1) + k_{12}Q_2(1) + EGP_0(1 - x_3(1)) = 0 \\ x_1(t)Q_1(1) - (k_{12} + x_2(1))Q_2(1) = 0 \end{cases}$$

$$\Rightarrow \begin{cases} 0 - 0.00097 \cdot BW - 0.30898 \cdot \frac{k}{BW} \cdot 0.8 \cdot BW + 0.066 \cdot Q_2(1) + 0.0161 \cdot BW(1 - 3.2206 \cdot \frac{k}{BW}) = 0 \\ 0.30898 \cdot \frac{k}{BW} \cdot 0.8 \cdot BW - (0.066 + 0.04951 \cdot \frac{k}{BW}) = 0 \end{cases}$$

$$\Rightarrow \begin{cases} 0.01513 \cdot BW - 0.29903k + 0.066 \cdot Q_2(1) = 0 \\ 0.24718k = (0.066 + 0.04951 \cdot \frac{k}{BW})Q_2(1) \end{cases}$$

$$\Rightarrow \begin{cases} Q_2(1) = -0.2292 \cdot BW + 4.5307k \\ Q_2(1) = \frac{0.24718k}{0.066 + 0.04951 \cdot \frac{k}{BW}} \end{cases}$$

$$\Rightarrow -0.2292 \cdot BW + 4.5307k = \frac{0.24718k}{0.066 + 0.04951 \cdot \frac{k}{BW}}$$

$$\Rightarrow 0.2242k^2 + 0.0405k \cdot BW - 0.0151 \cdot BW^2 = 0$$

# Initial Value

$$G(1) = 5$$

$$S_1(1) = S_2(1) = 55k$$

$$I(1) = \frac{k}{0.01656 \cdot BW}$$

$$x_1(1) = 0.30898 \cdot \frac{k}{BW}$$

$$x_2(1) = 0.04951 \cdot \frac{k}{BW}$$

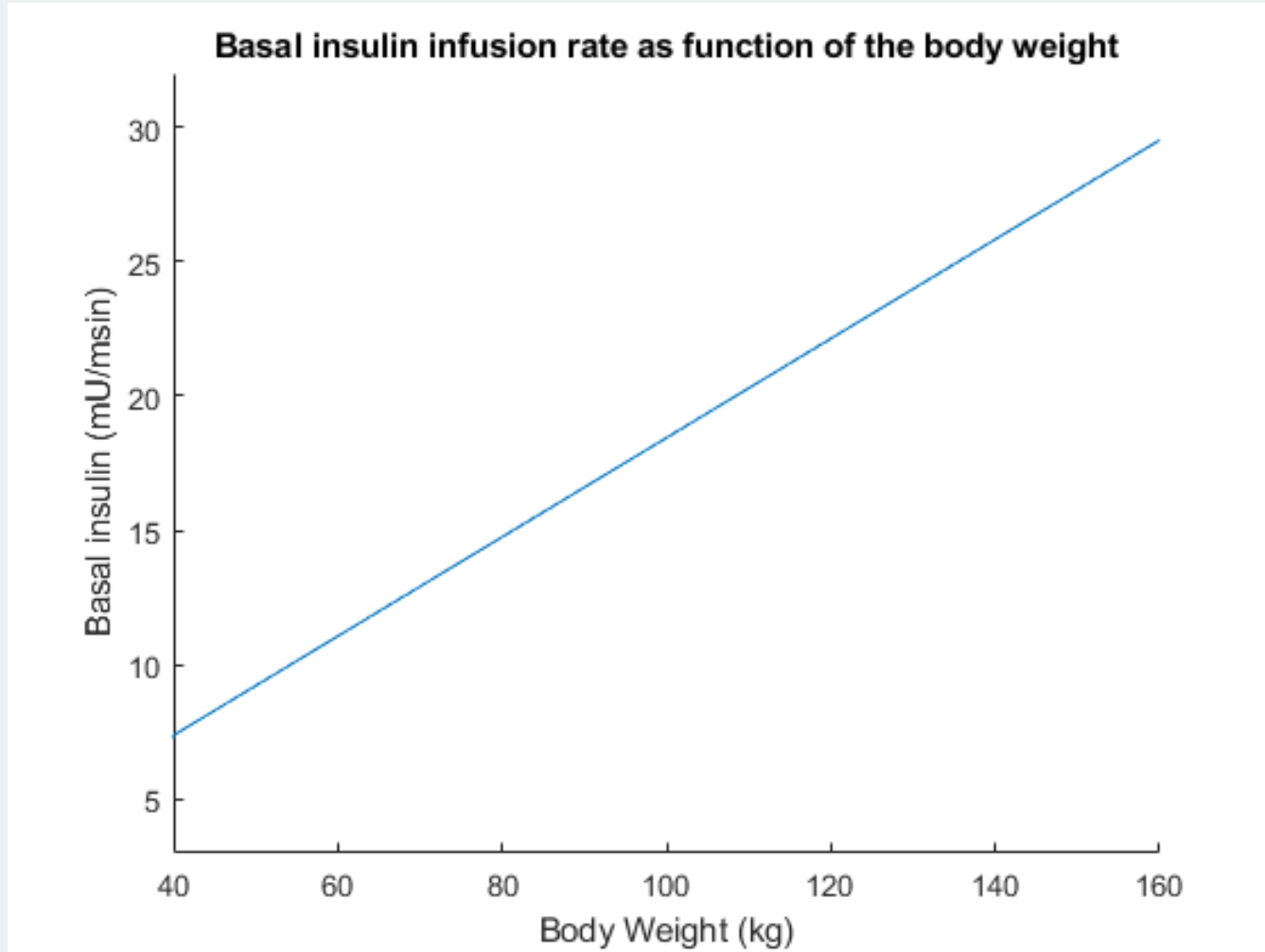
$$x_3(1) = 3.2206 \cdot \frac{k}{BW}$$

$$Q_1(1) = 0.8 \cdot BW$$

$$Q_2(1) = -0.2292 \cdot BW + 4.5307k$$

$$u(1) = 12.9127 \text{ when Body Weight} = 70 \text{ kg}$$

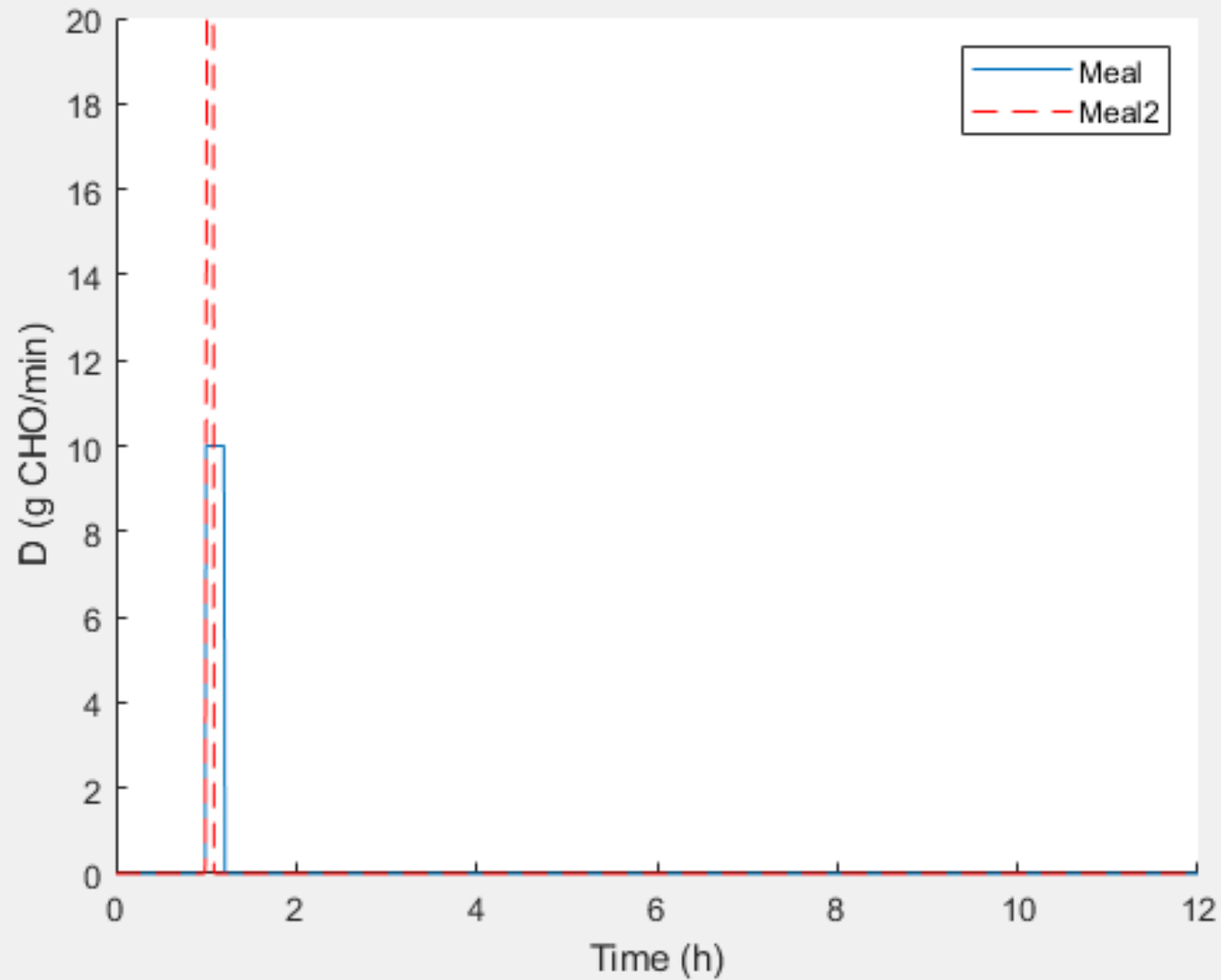
# Basal insulin infusion rate as function of the body weight





Simulation

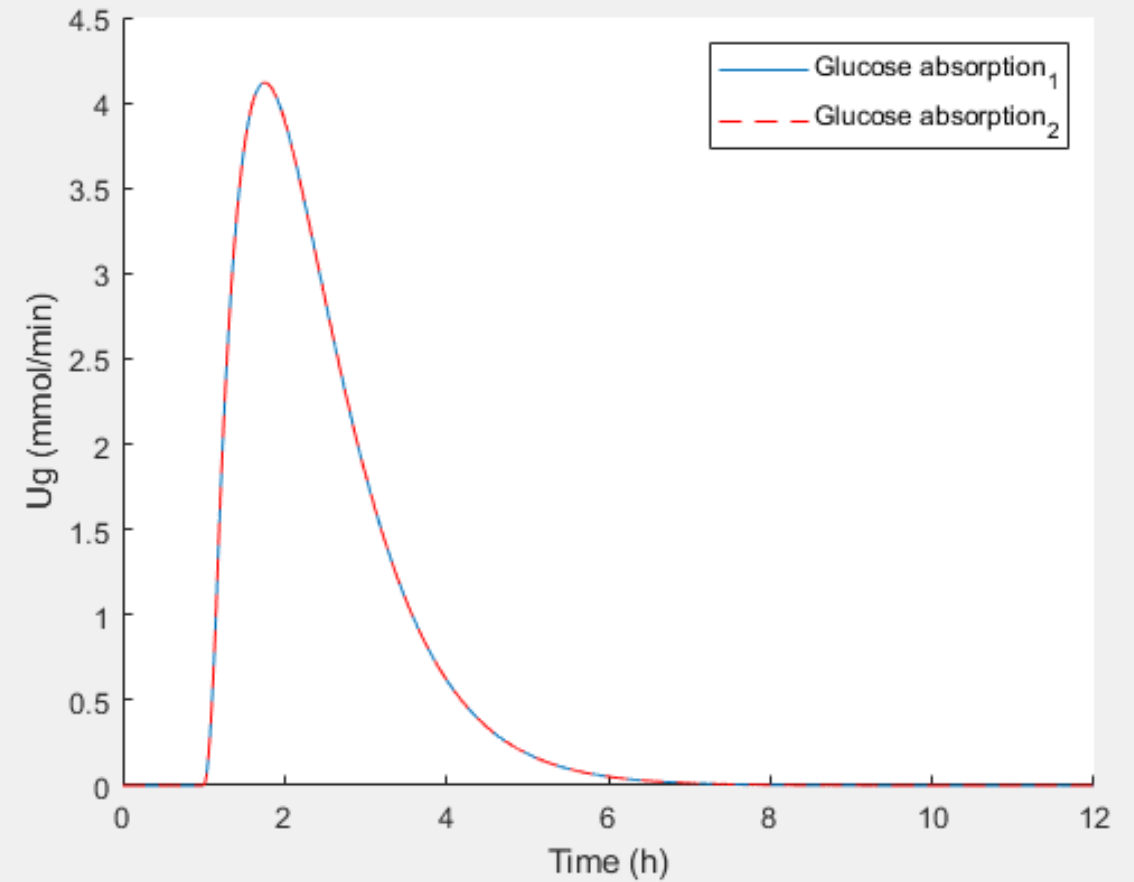
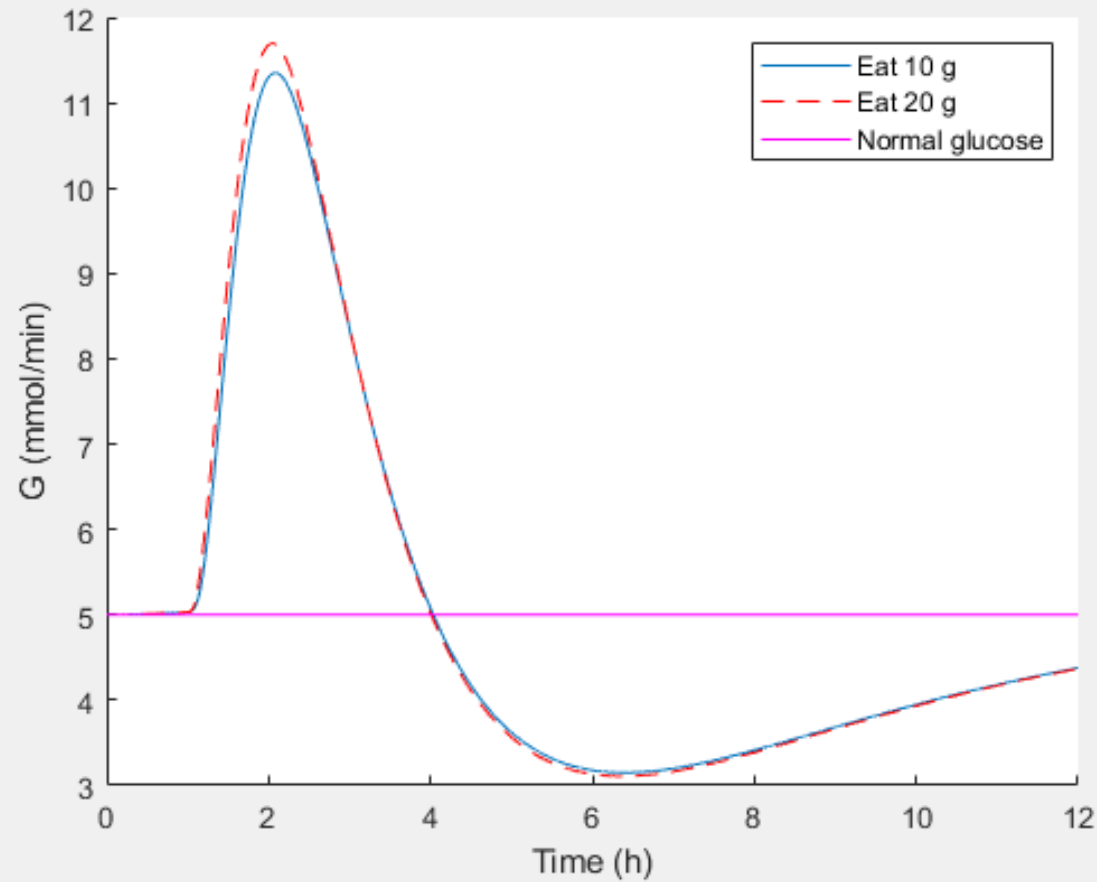
# Meal-Fig3.2



Meal1: 10g  
Meal2: 20g



# Plasma glucose – Fig3.4



# Plasma glucose – Fig3.4

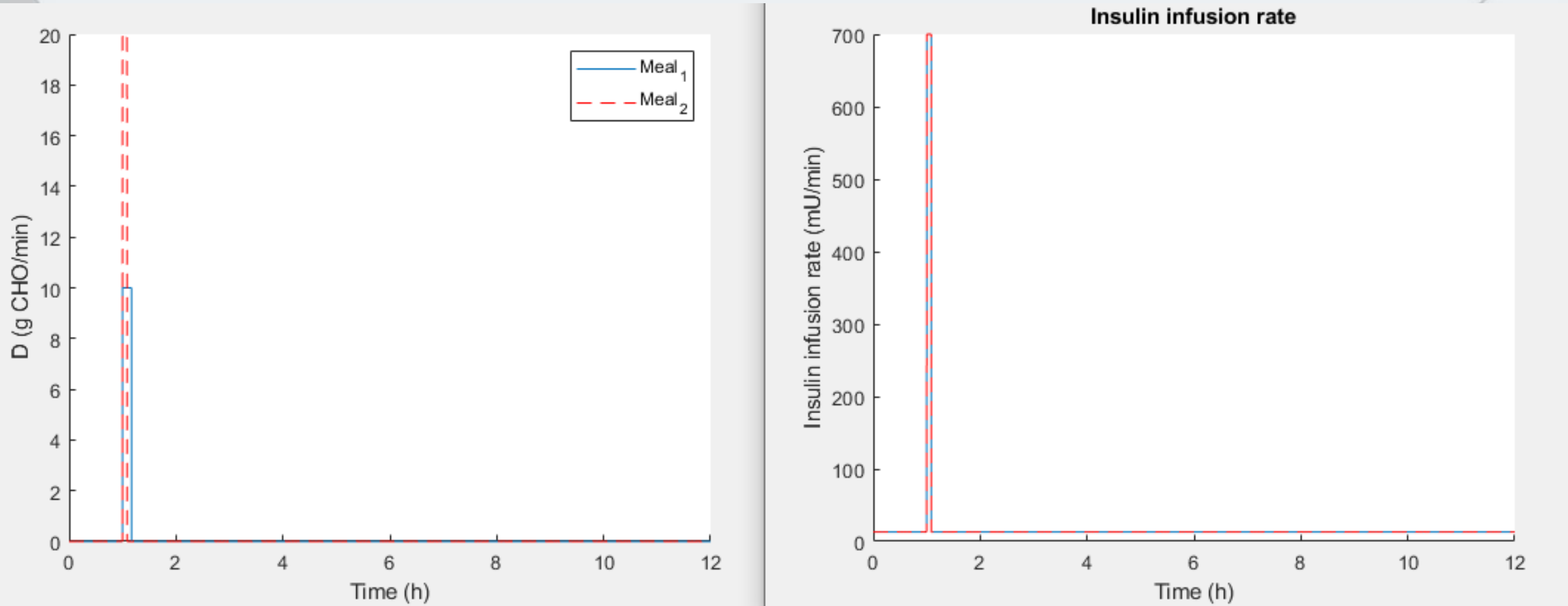
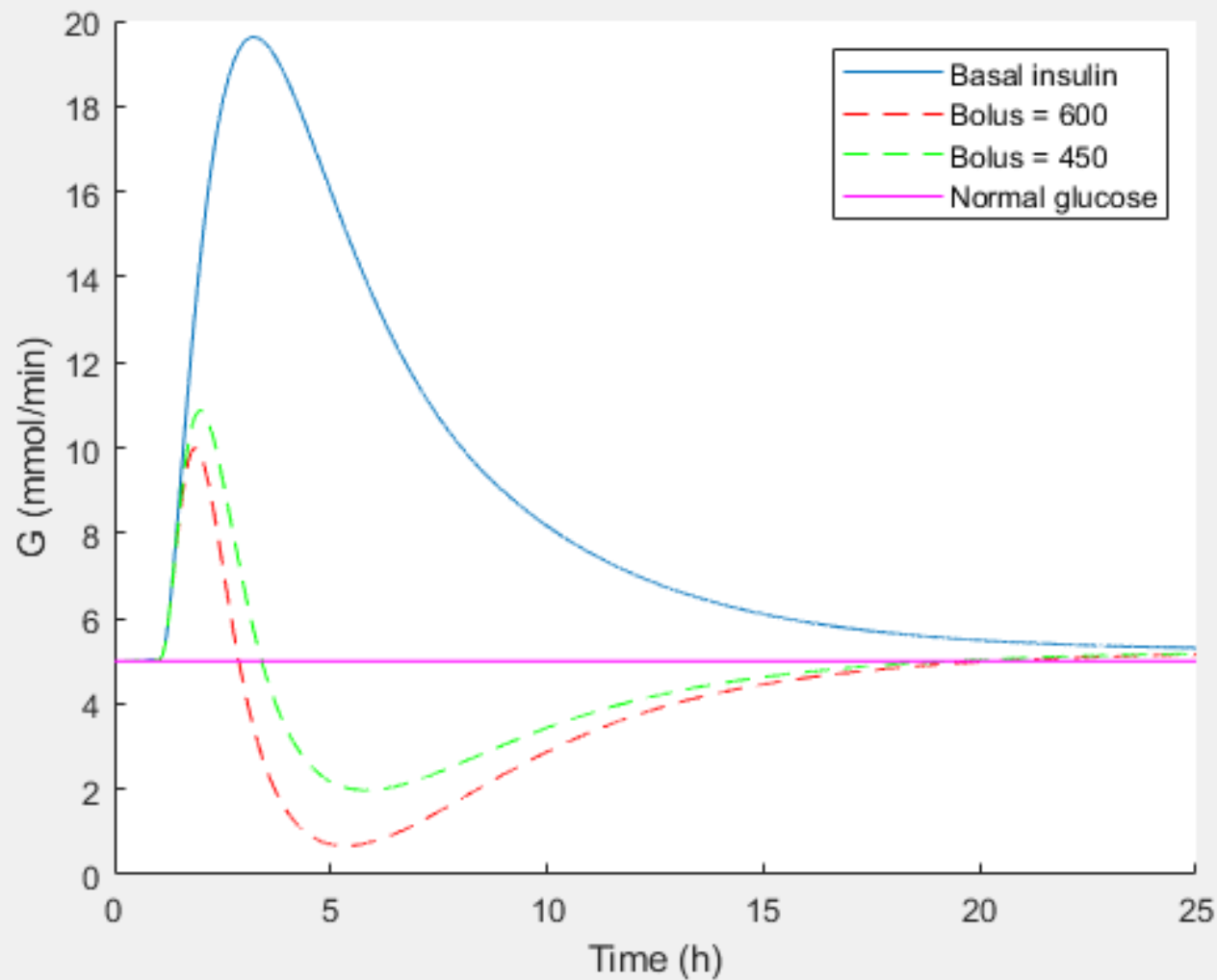
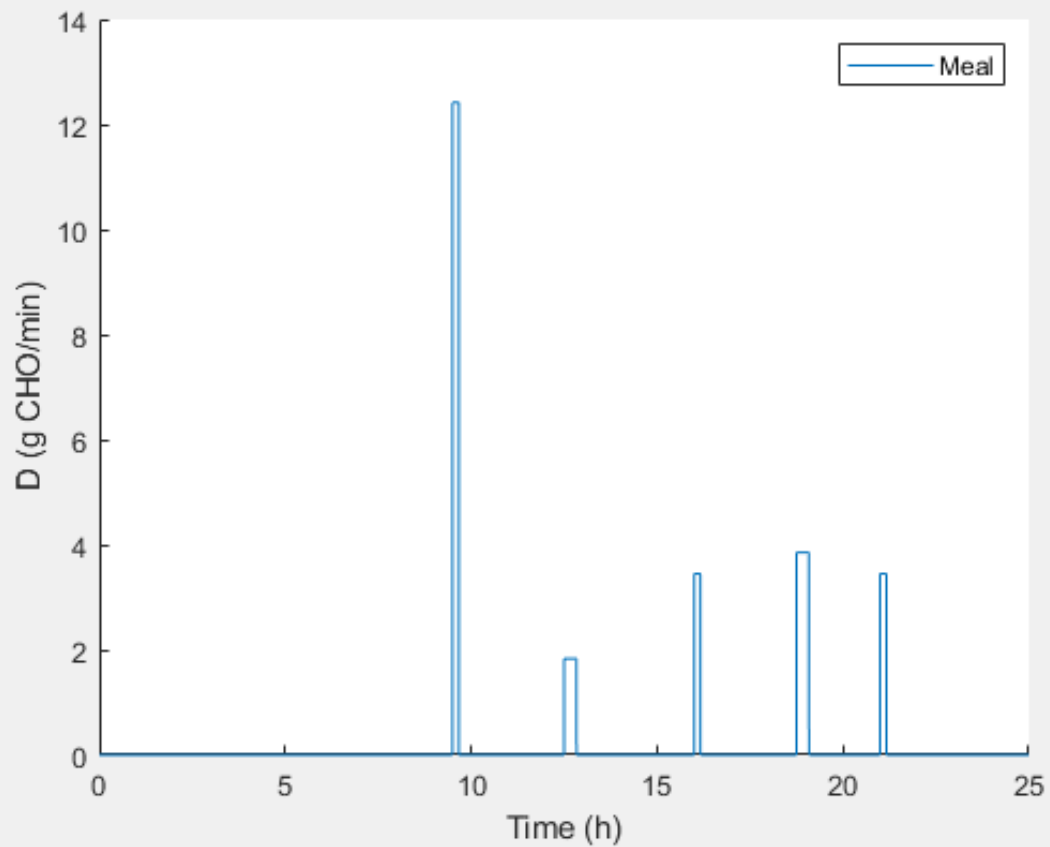


Fig 3.5(simulation for one meal)

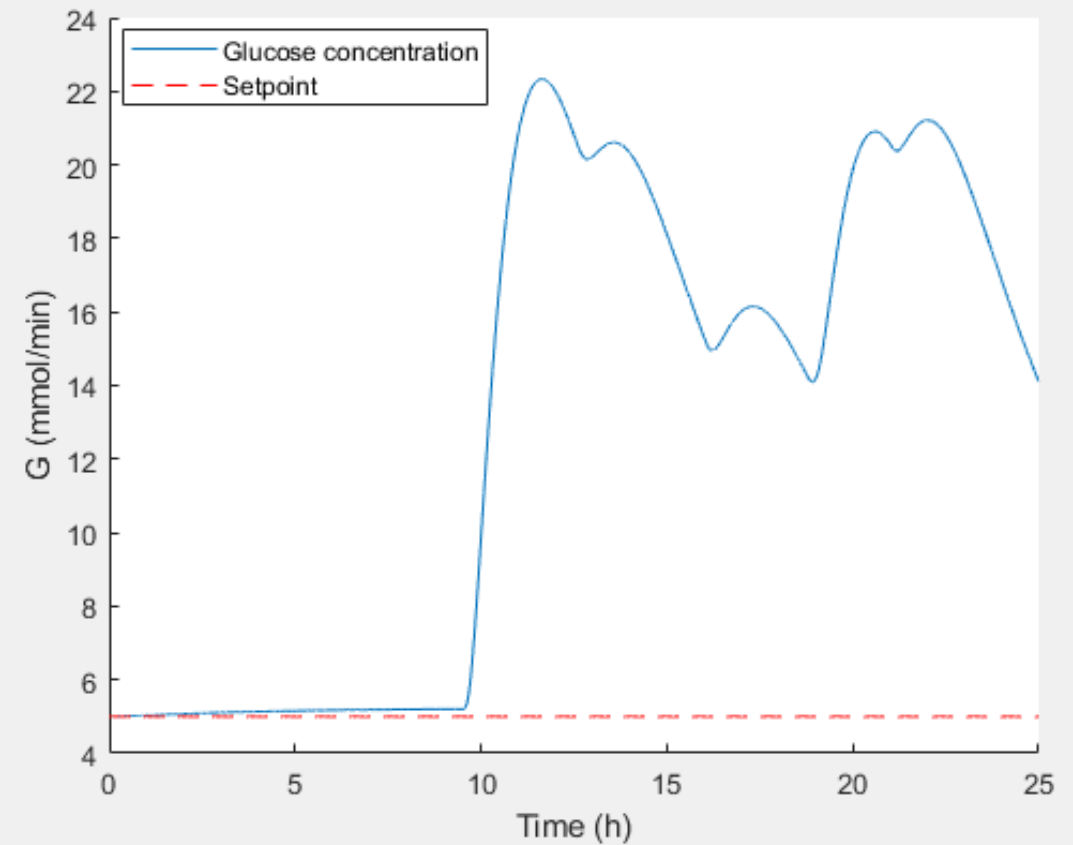


# Simulation

Five meals in one day

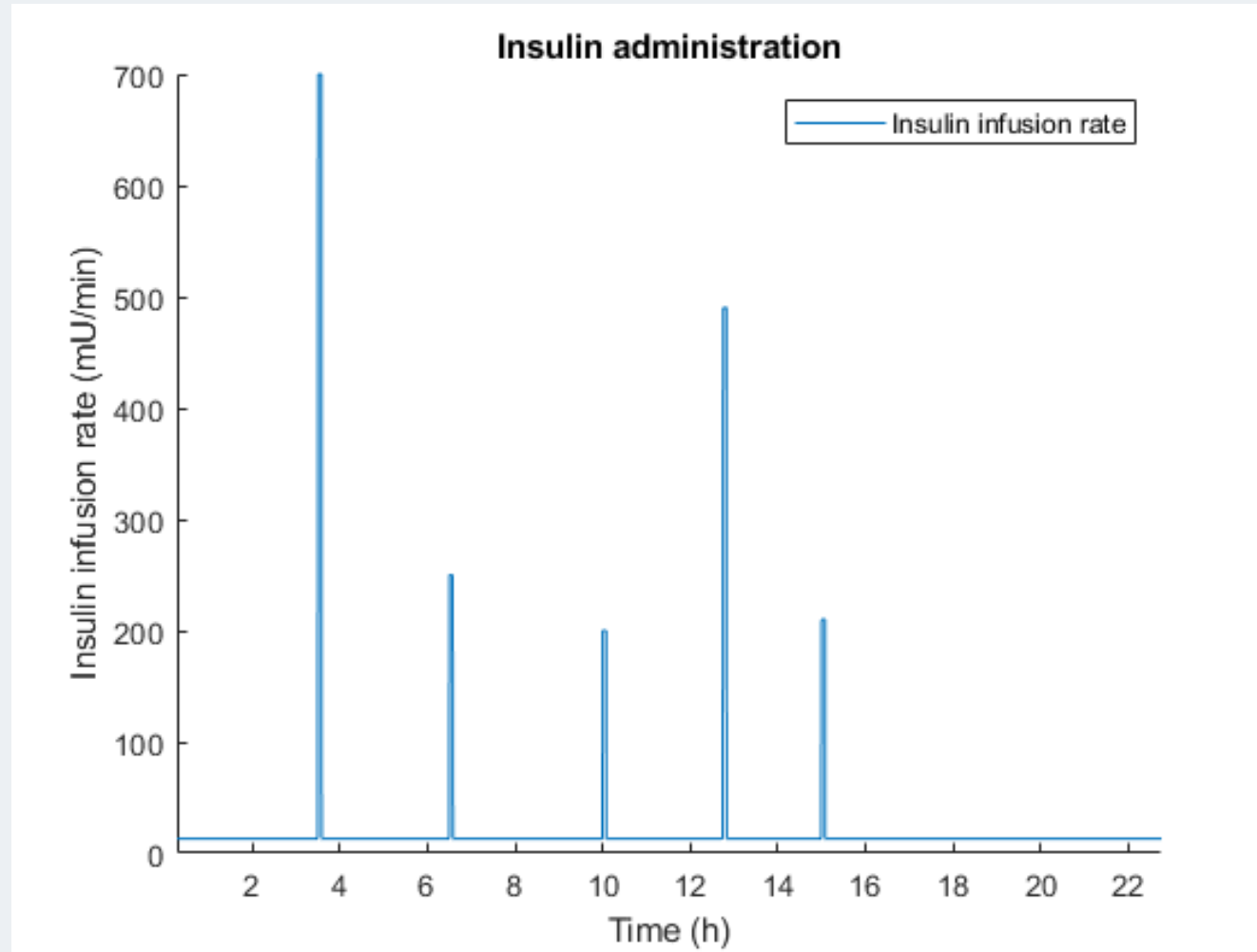


Only the base insulin



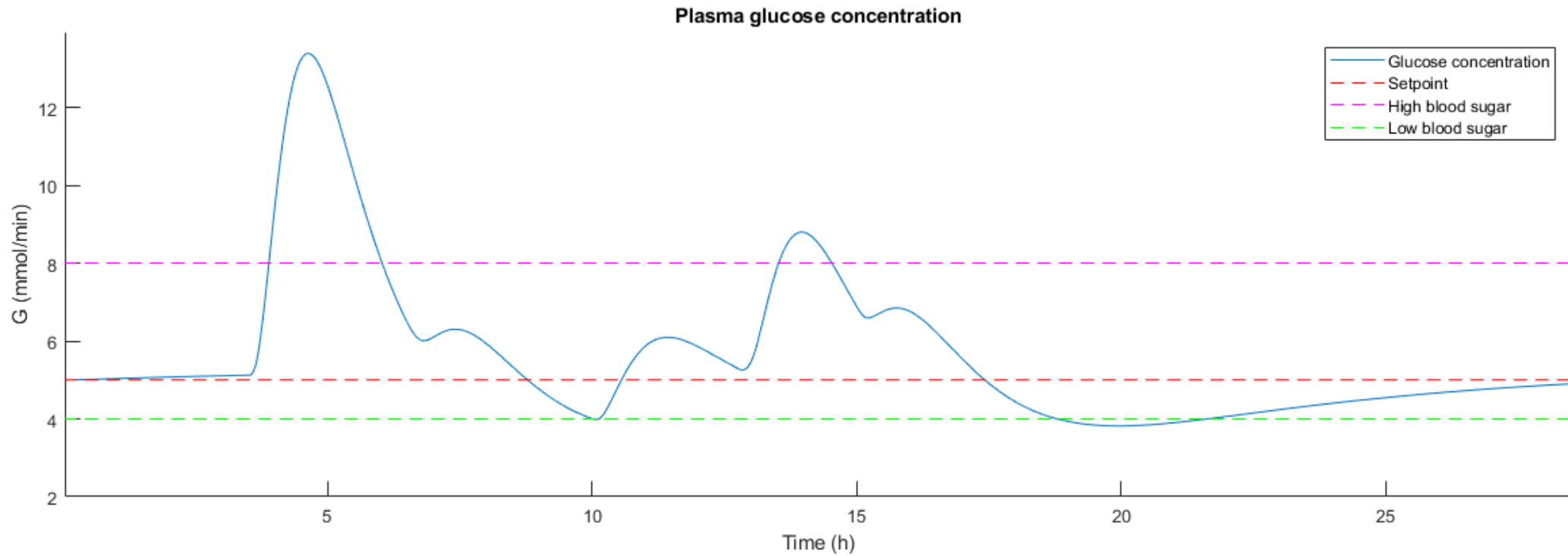
# Simulation

Jet insulin

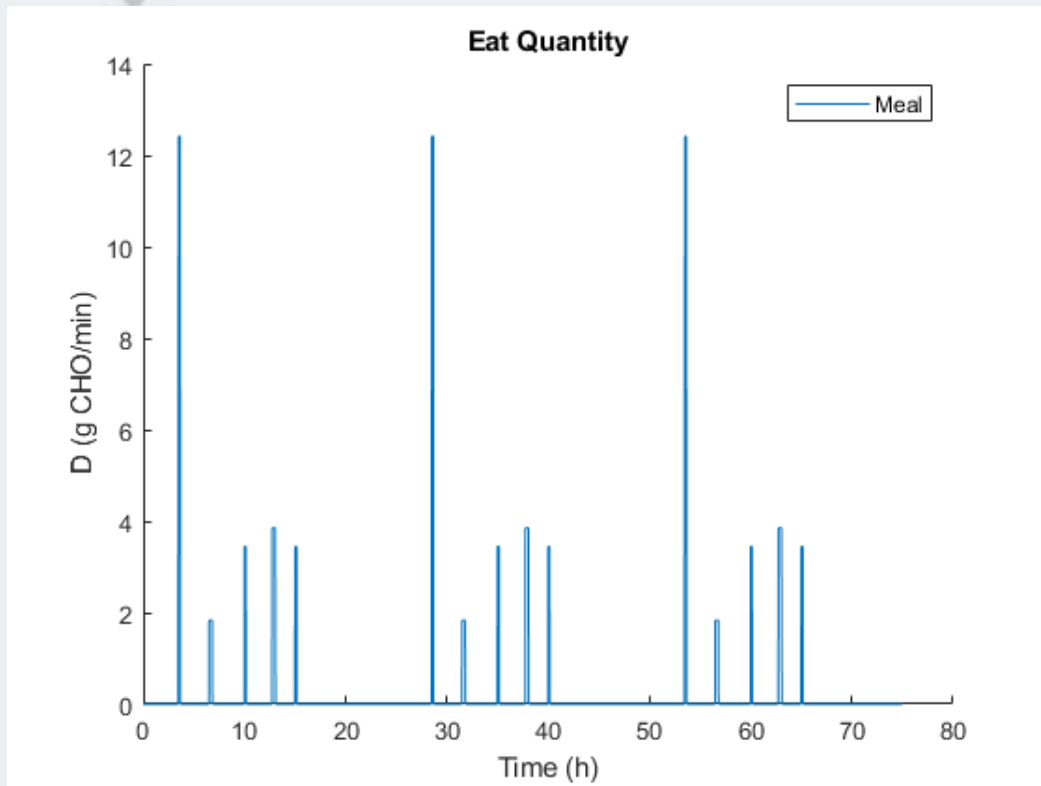


# Simulation one day

Jet injection



# Simulation Three Day



5 meals everyday

Breakfast : 124.17g CHO, Lasts 10 mins , 12.42(g/min)

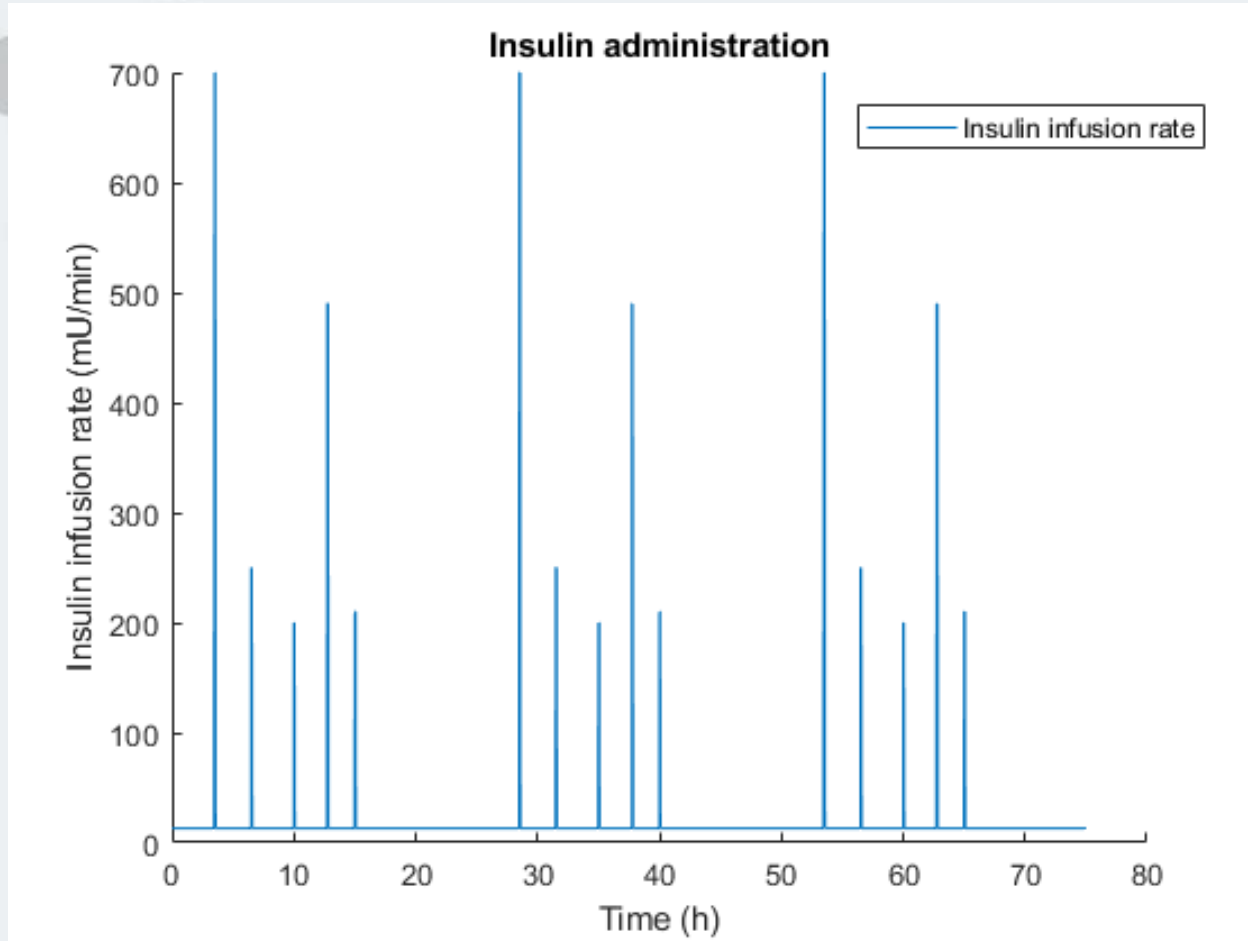
Lunch: 34.5g CHO, Lasts 20 mins , 1.83(g/min)

dessert : 34.5g CHO, Lasts 10 mins , 3.45(g/min)

Dinner: 76.95g CHO , Lasts 20 mins , 3.85(g/min)

Midnight : 34.5g CHO, Lasts 10 mins , 3.45(g/min)

# Simulation Three Day



Insulin that is taken with every meal, 5 mins/every

Breakfast : 700 (mU/min)

Lunch: 250 (mU/min)

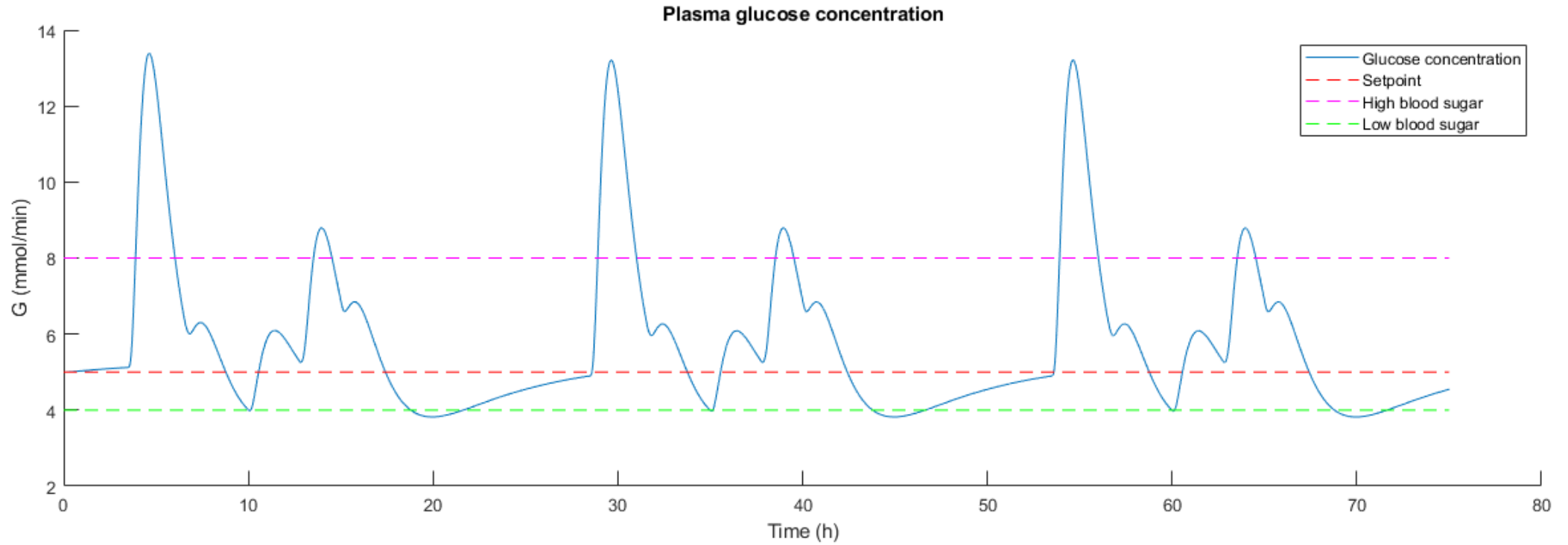
dessert : 200 (mU/min)

dinner: 490 (mU/min)

Midnight : 210 (mU/min)



# Simulation Three Day





The End