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

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

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

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

Set G(1) = 5 mmol

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

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

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

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

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

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

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

Initial Value

$$G(1) = 5$$

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

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

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

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

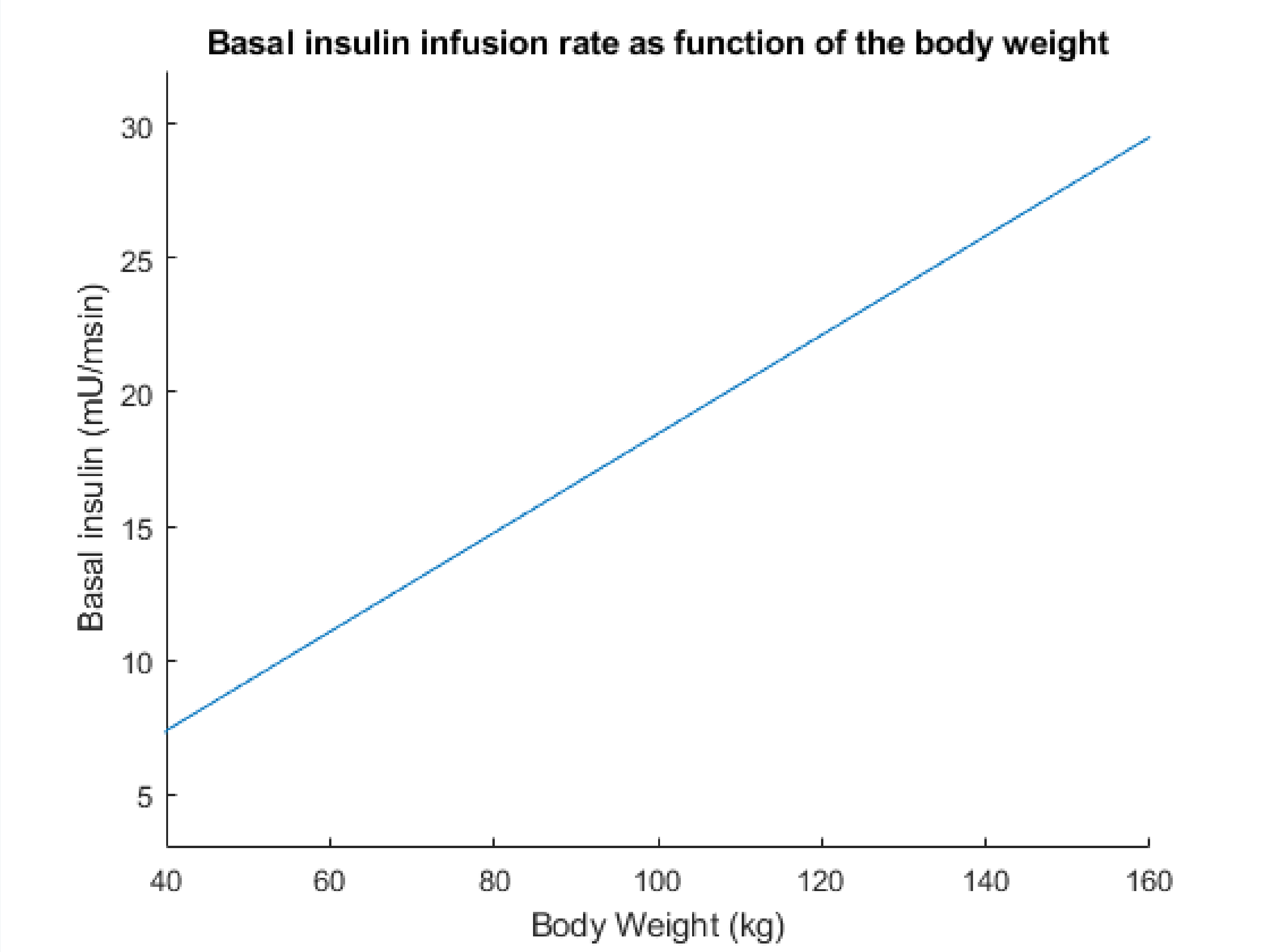
$$x_3(1) = 3.2206 \cdot \frac{k}{BW}$$

$$\mathrm{Q}_1(1) = 0.8 \cdot BW$$

$$\mathrm{Q}_2(1) = -0.2292 \cdot BW + 4.5307k$$

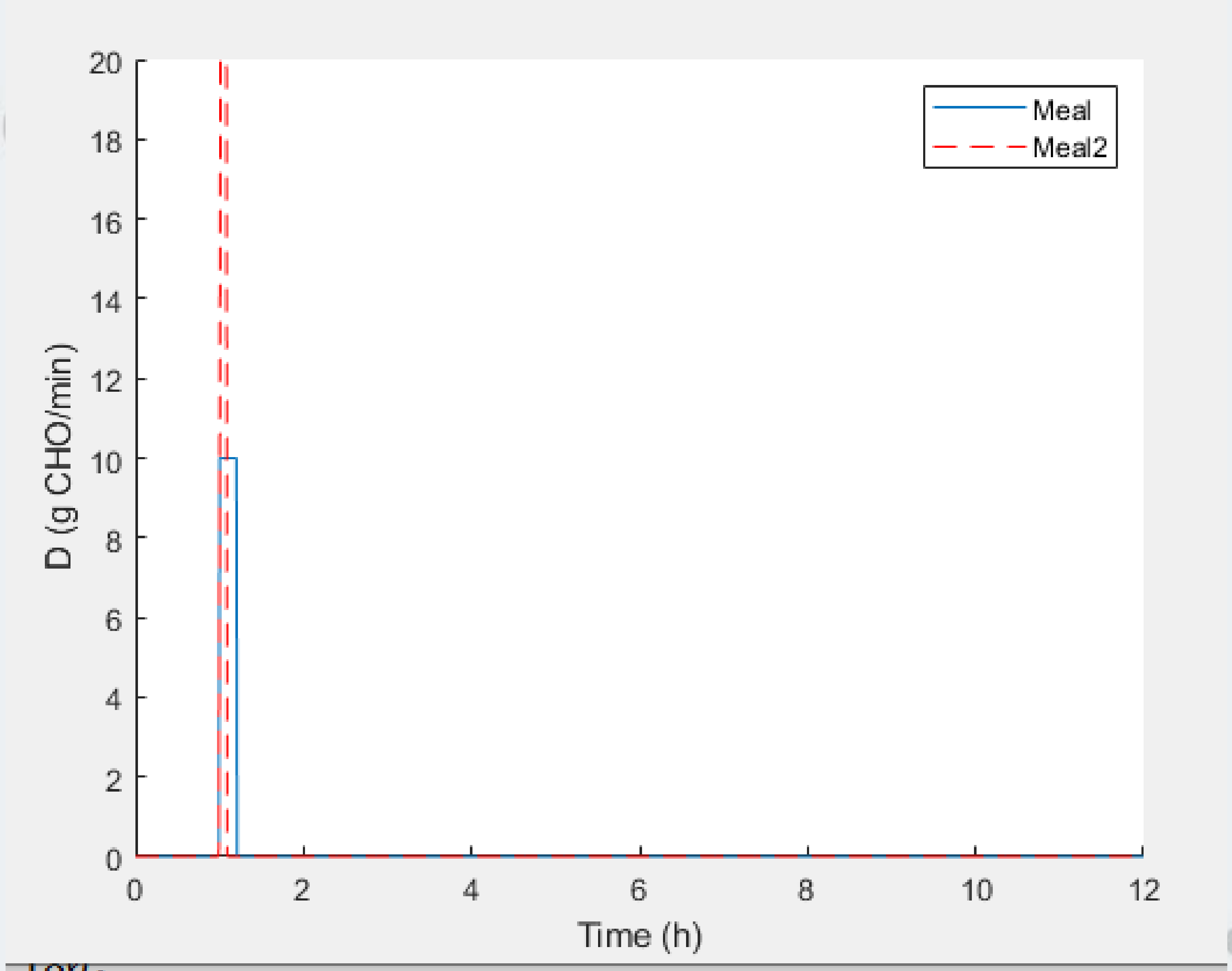
$$u(1) = 12.9127 \text{ when Body Weight = 70 kg}$$

Basal insulin infusion rate as function of the body weight



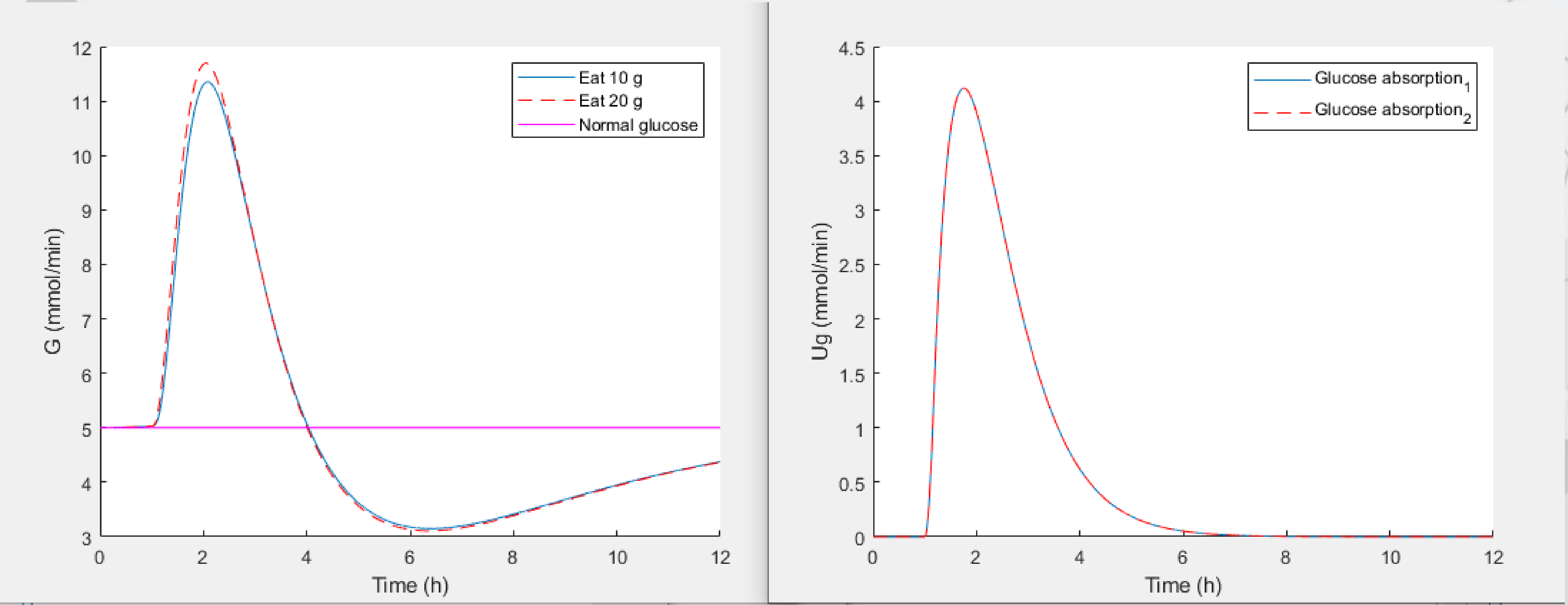
Simulation

Meal-Fig3.2

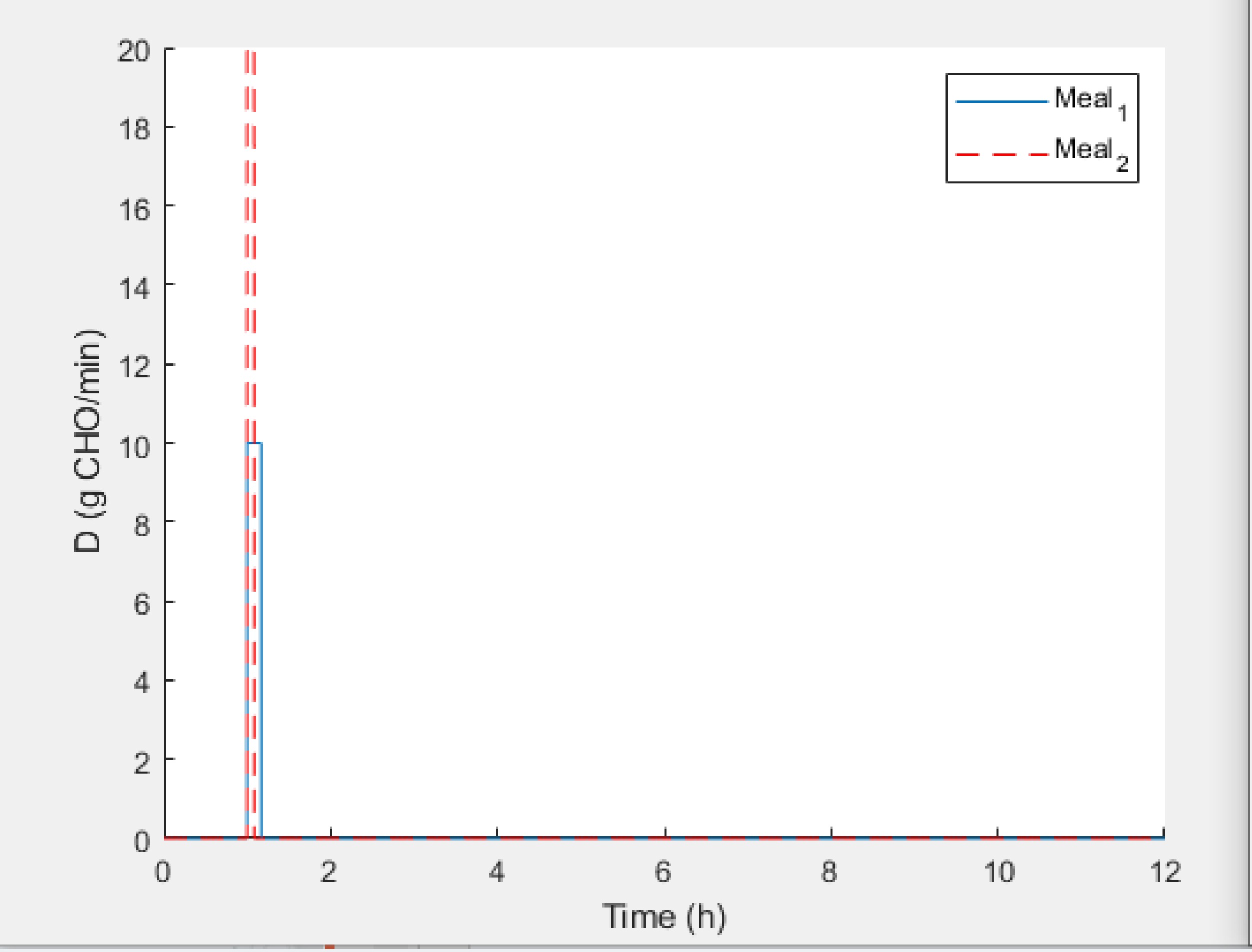


Meal1: 10g
Meal2: 20g

Plasma glucose – Fig3.4



Plasma glucose – Fig3.4



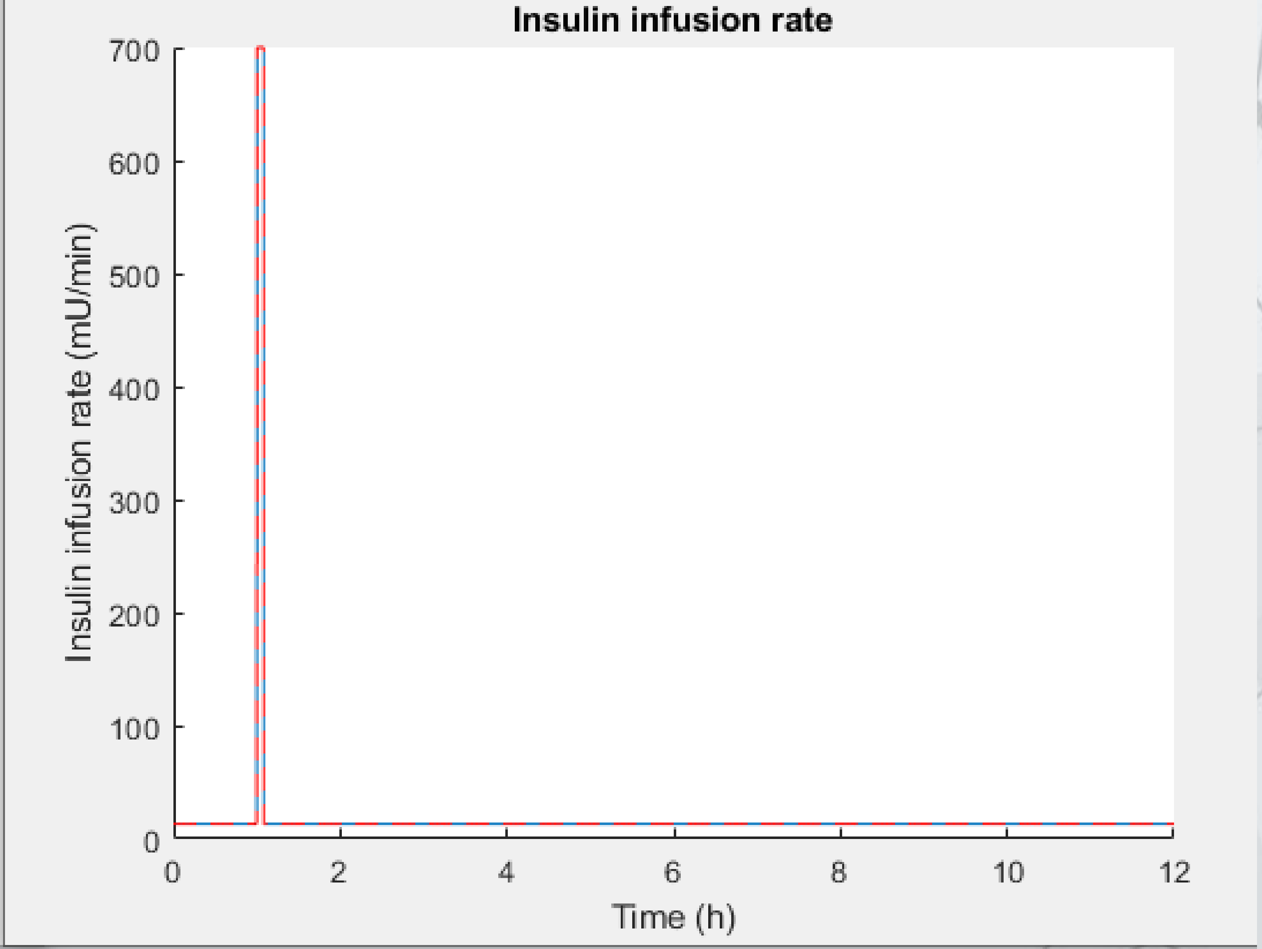
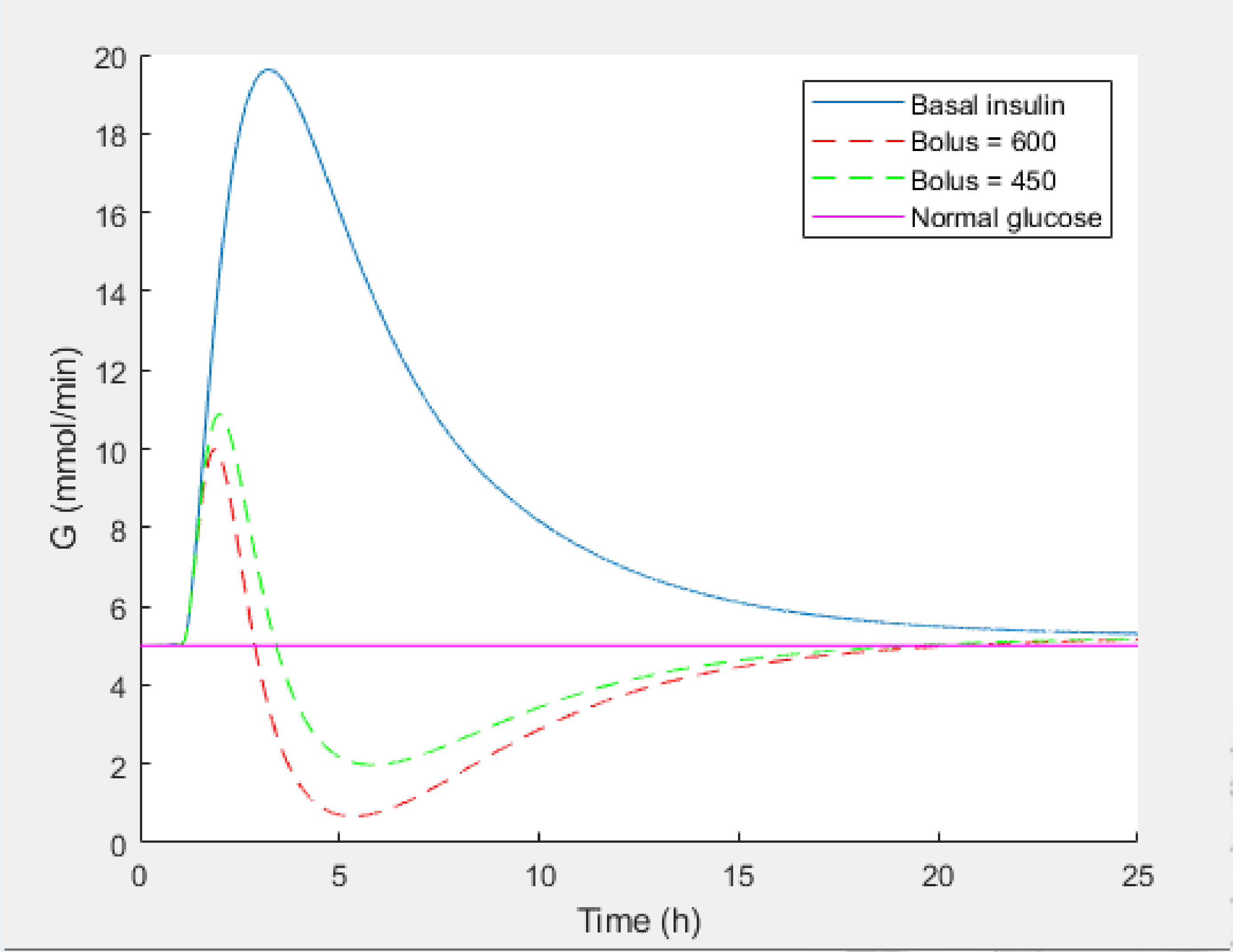
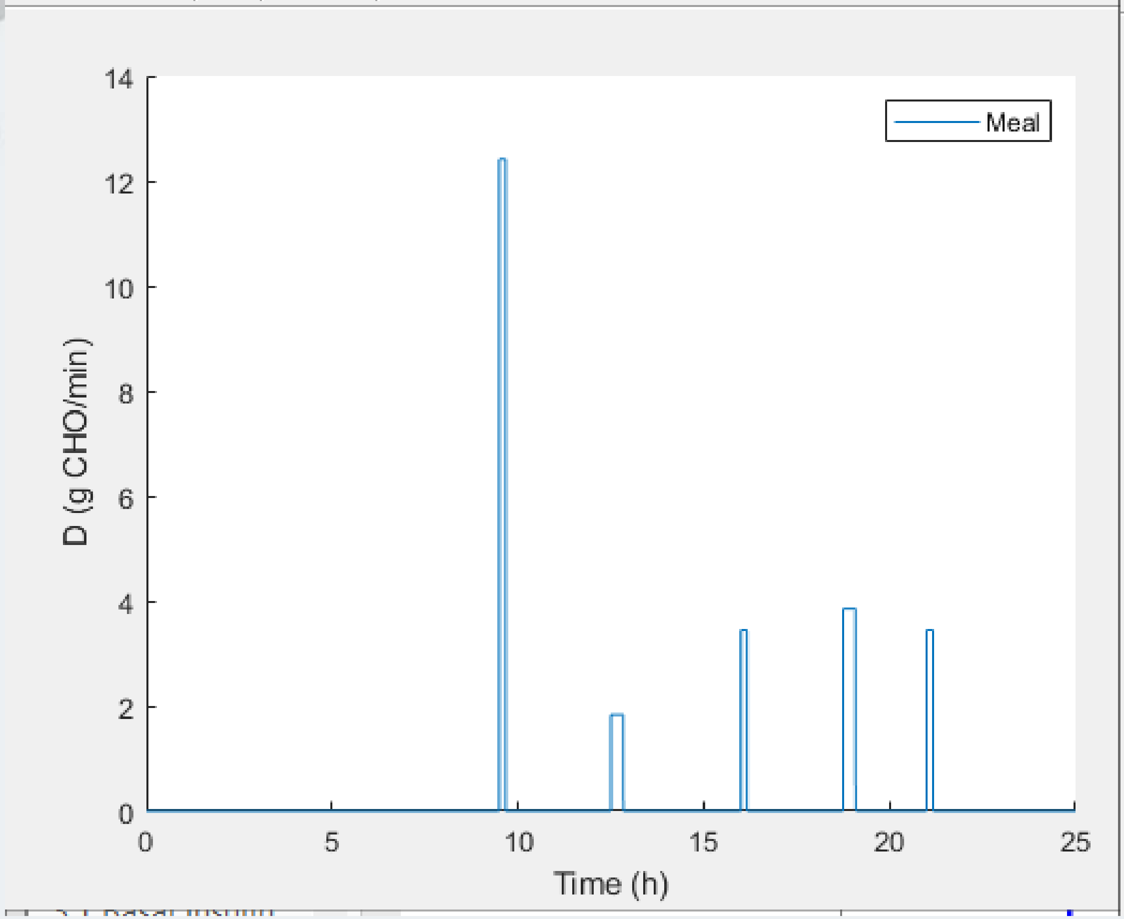


Fig 3.5(simulation for one meal)

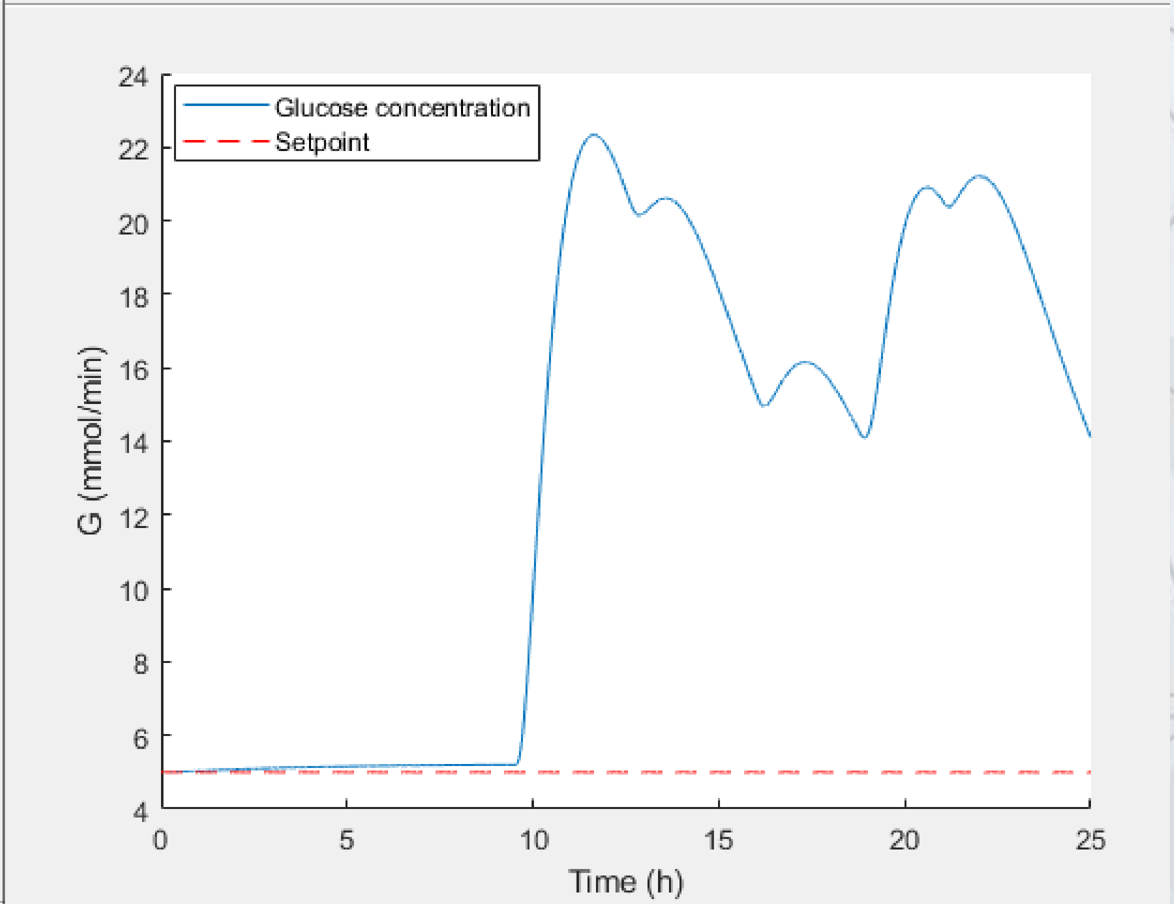


Simulation

Five meals in one day

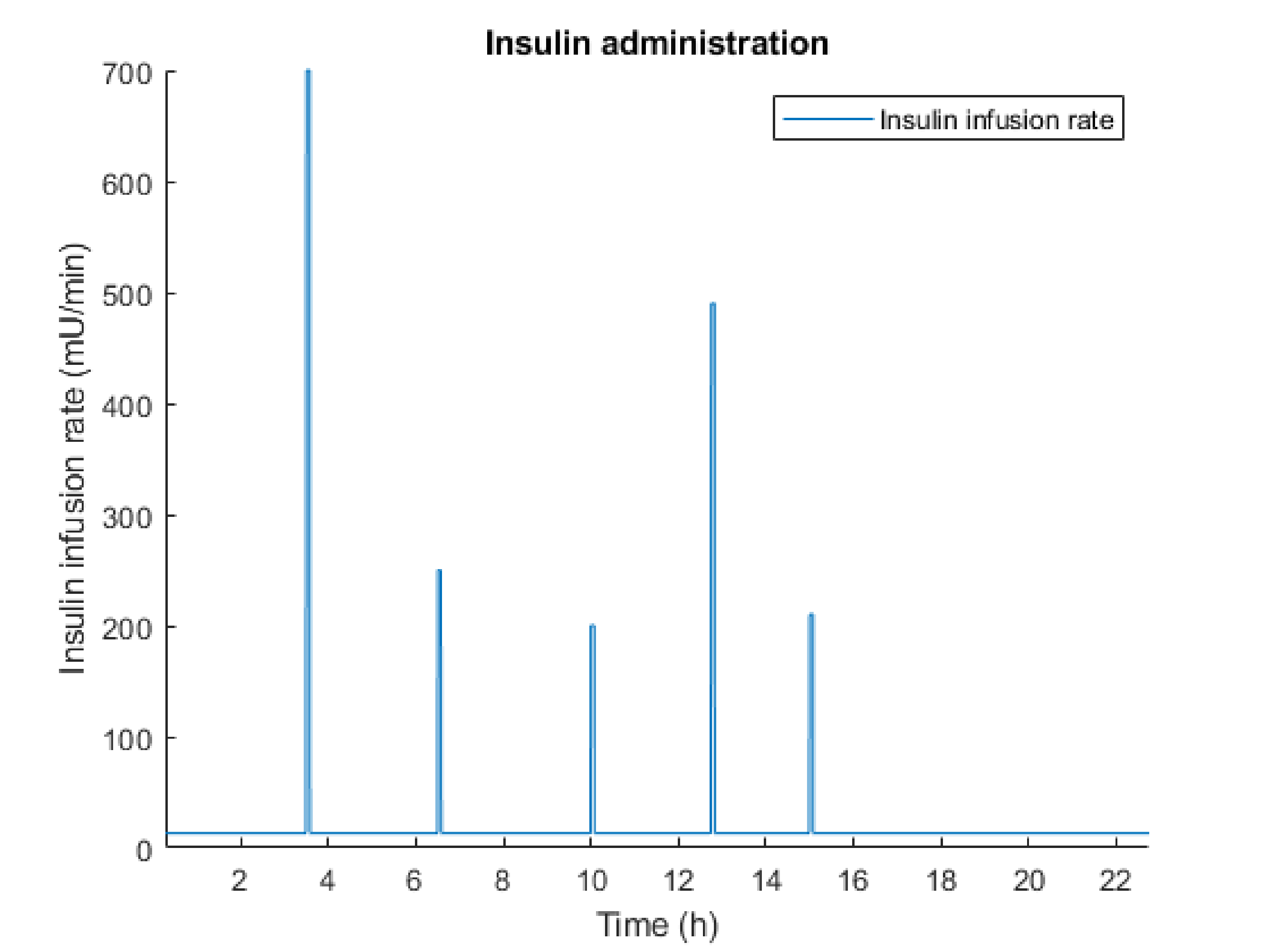


Only the base insulin



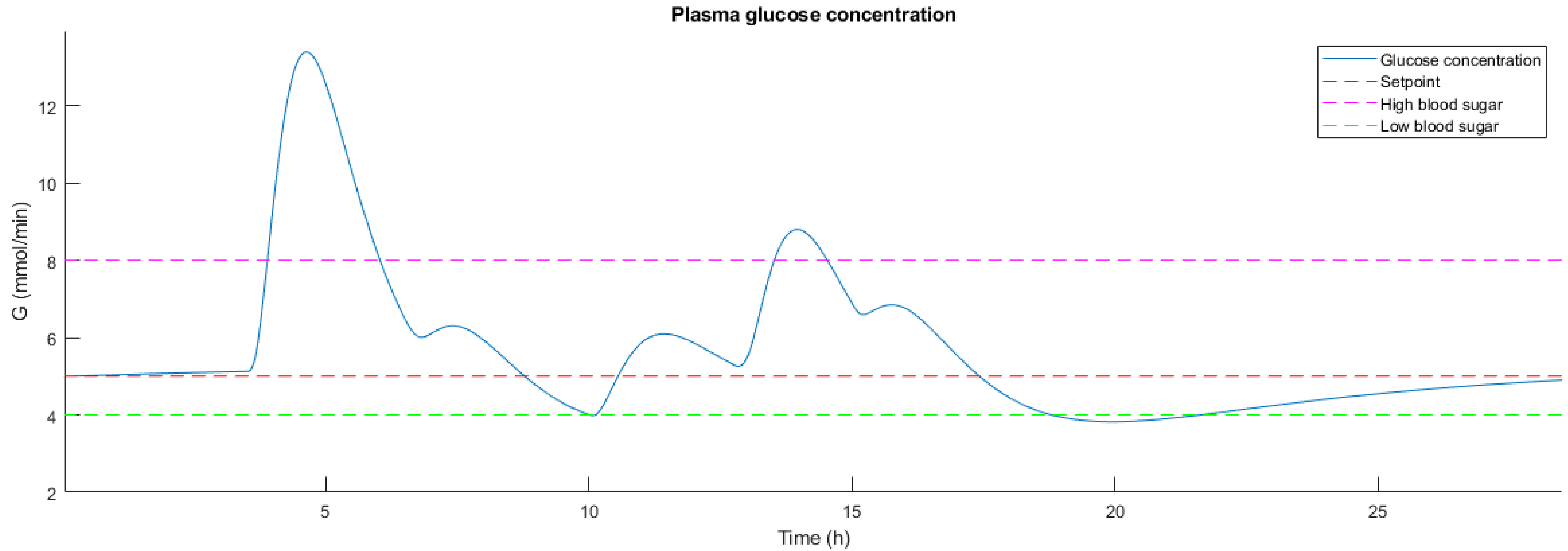
Simulation

Jet insulin

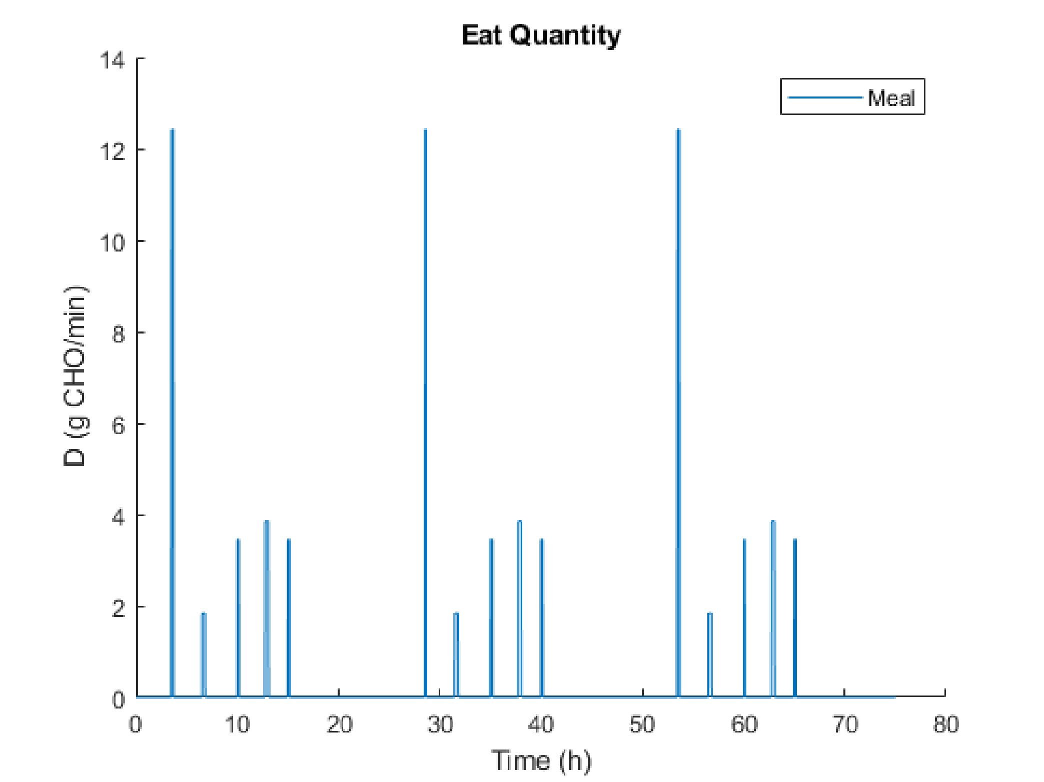


Simulation one day

Jet injection



Simulation Three Day



5 meals everyday

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

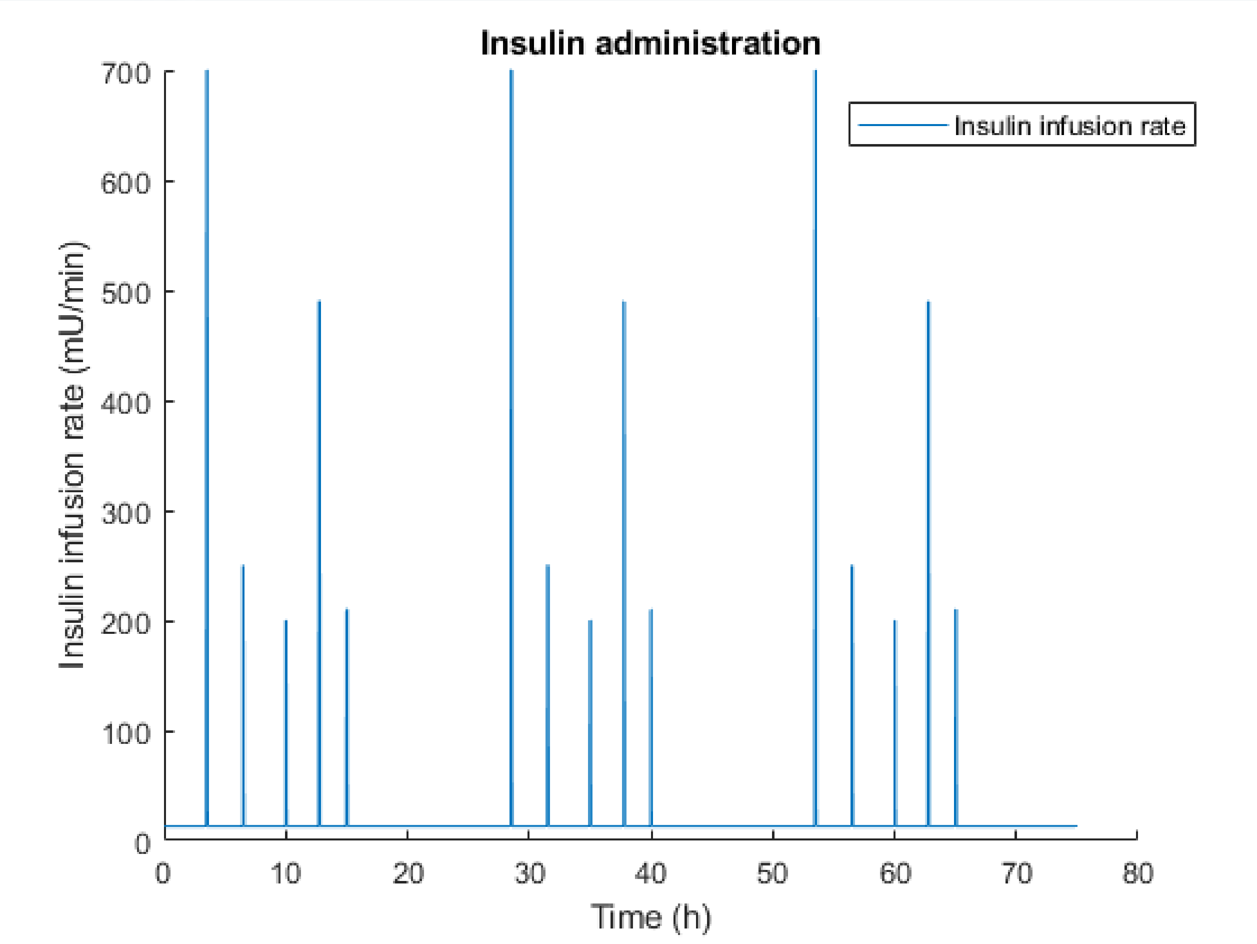
Lunch：34.5g CHO， Lasts 20 mins， 1.83(g/min)

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)

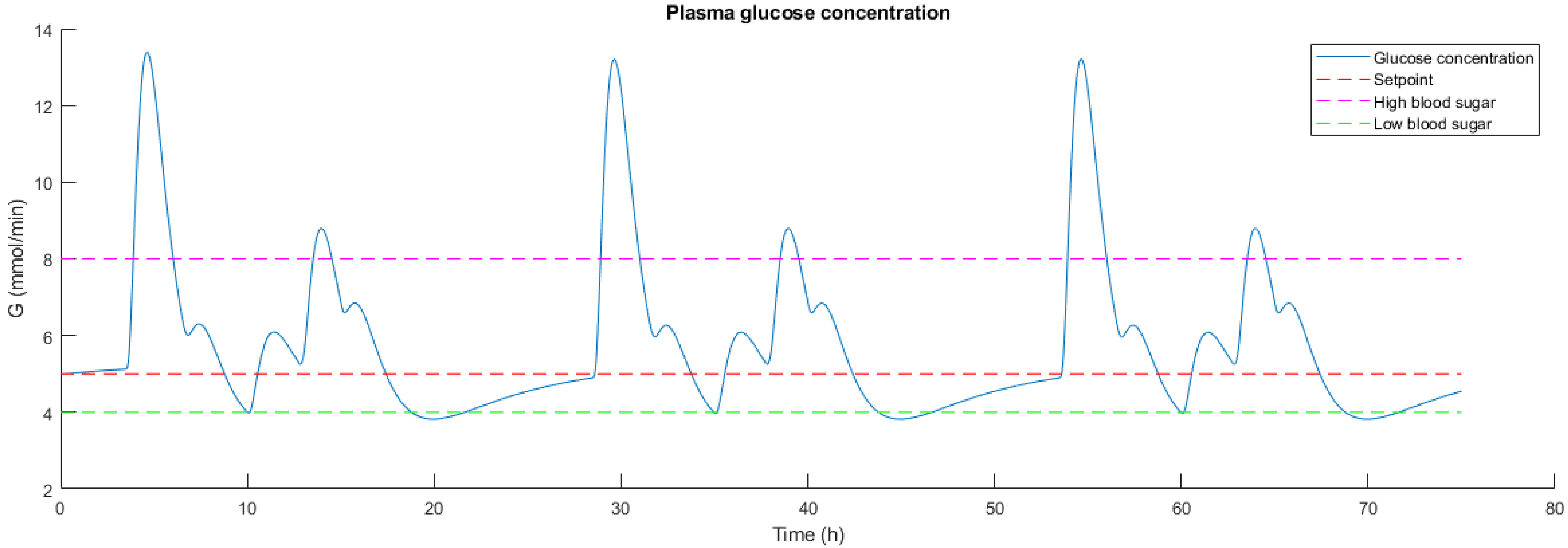
Lunch: 250 (mU/min)

dessert： 200 (mU/min)

dinner: 490 (mU/min)

Midnight： 210 (mU/min)

Simulation Three Day



The End