V = 1.50 L = 1500 mL

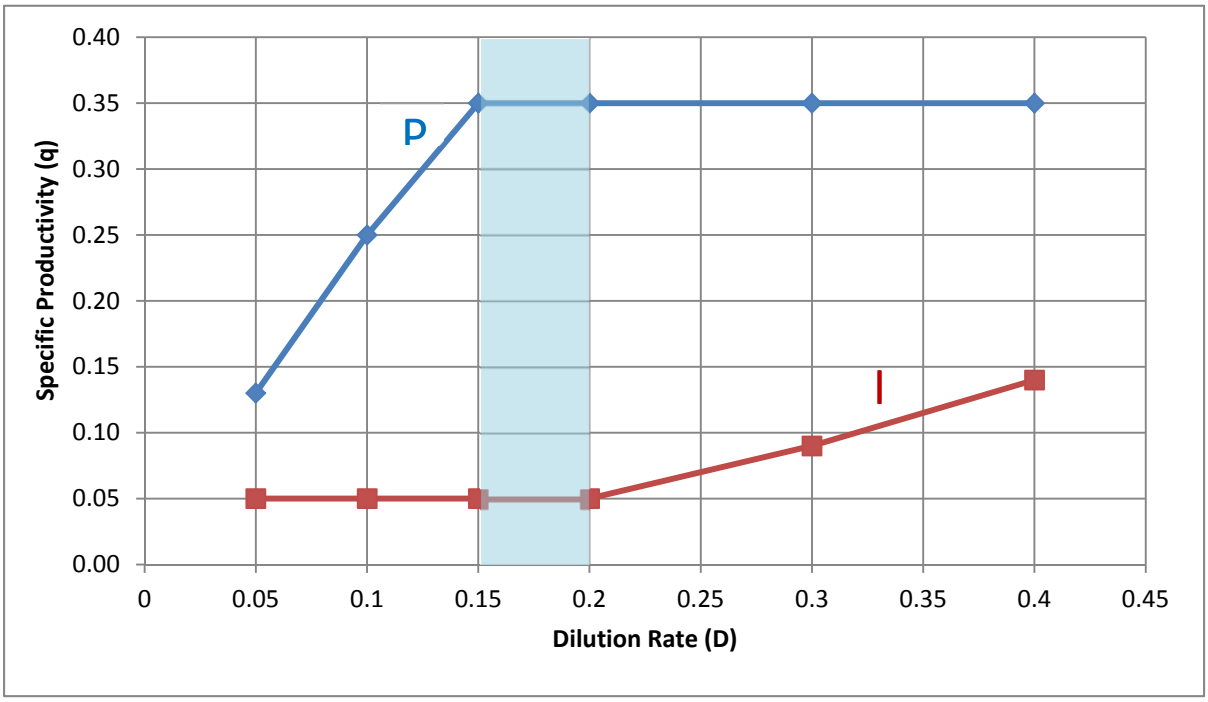
| F (mL/h) | D ($h^{-1}$) | X (g/L) | $Q_P$ (g/Lh) | $Q_I$ (g/Lh) | $q_P$ (g/gh) | $q_I$ (g/gh) |
|---|---|---|---|---|---|---|
| 75 | 0.05 | 2.86 | 0.36 | 0.143 | 0.13 | 0.05 |
| 150 | 0.10 | 3.33 | 0.83 | 0.167 | 0.25 | 0.05 |
| 225 | 0.15 | 3.45 | 1.21 | 0.173 | 0.35 | 0.05 |
| 300 | 0.20 | 3.64 | 1.27 | 0.182 | 0.35 | 0.05 |
| 450 | 0.30 | 3.75 | 1.31 | 0.338 | 0.35 | 0.09 |
| 600 | 0.40 | 3.81 | 1.34 | 0.533 | 0.35 | 0.14 |

Note: $q_P = Q_P/X$
$q_I = Q_I/X$

Plot $q_P$ and $q_I$ versus D (on same figure)

a) According to the figure, specific P production increase to a growth rate of 0.15 $h^{-1}$ and then levels off. This would be considered a *mixed-growth associated product.* I is low and then increases. Given my definitions, this would be considered an *overflow metabolite*.

b) The fed-batch process should use a constant growth rate which maximizes P relative to I. A growth rate between 0.15 – 0.20 $h^{-1}$ has a maximum $q_P/q_I$ (shaded area of figure).



In a chemostat for a given constant dilution rate, the effluent cell concentration is directly related to the concentration of the limiting substrate:

$D(S_{IN} - S) = X(m_S + D/Y_{X/S})$ or

$X = D(S_{IN} - S)/(m_S + D/Y_{X/S}) = \alpha \times (S_{IN} - S)$

If the concentration of carbon source in the feed has been changed from 10 g/L to 8 g/L with no effect on cell density, then clearly the carbon source is ***not*** limiting growth. You could further support the conclusion by continuing to reduce the carbon source concentration: eventually the cell concentration will decrease in proportion to $S_{IN}$. Alternatively, you could propose a hypothesis for what nutrient is limiting growth (N, P, S, etc.) and add a metabolizable compound containing that nutrient. If the cell concentration increases in proportion to the addition of another nutrient, then that nutrient is limiting under those conditions.

If the carbon source is not limiting, then it is in excess. The 2 g/L excess (between 8 g/L and 10 g/L) is not metabolized. Thus, one would predict that the concentration of S in the ***effluent*** is 2 g/L greater when 10 g/L S was used in the feed than when 8 g/L S was used in the feed.

Note that if the carbon source was limiting, considering the Monod model for growth, the concentration of S in the effluent does not change when the feed concentration changes.