# 1. Metabolic Stoichiometry

| Component | Type | Purpose |
|---|---|---|
| Ascorbic Acid | Other | Also known as Vitamic C, this functions in formation of collagen<br>Detoxifier |
| Beta Carotene | Fatty acid/other | Coloring<br>Vitamin A precursor |
| Calcium Carbonate | Inorganic | Source of calcium for bone remodeling |
| Calcium Pantothenate | Other | Enzyme cofactor vitamin |
| Dextrin | Carbohydrate | Starch-like but with less complex molecule<br>Binder and filler<br>Glucose source |
| Ferrous Fumarate | Other | Source of iron |
| FD&C Yellow #6 | Inorganic | Color additive |
| Folic Acid | Nucleotide derivative/other | Helps produce red blood cells, synthesize nucleic acids including DNA, maintain proper nervous system function |
| Gelatin | Amino acid | Binder, encasulation and coating agent<br>Thickening agent |
| Modified Cellulose Gum | Carbohydrate | Thickener |
| Niacinamide | Other | Enzyme cofactor vitamin |
| Pyridoxine Hydrochloride | Other | Nucleotide precursor |
| Riboflavin | Nucleotide derivative/other | Source of Vitamin B2 |
| Starch | Carbohydrate | Binder and filler<br>Glucose source |
| Tartrazine | Inorganic | Color additive, Yellow dye |
| Thiamine Mononitrate | Nucleotide derivative/other | Source of Vitamin B1 |
| Titanium Dioxide | Inorganic | White pigment |
| Vitamin A Acetate | Fatty acid derivative/other | Source of Vitamin A<br>Antioxidant |
| Vitamin B12 | Nucleotide derivative/other | Hematopoietic vitamin |
| Vitamin D | Other | Calcium and phosphorus metabolism |
| Vitamin E Acetate | | Source of Vitamin E<br>Antioxidant |
| Zinc Oxide | Inorganic | Source of zinc |

**2. Metabolic Stoichiometry**

a) Since we are finding the stoichiometric formula for the fertilizer, we to first determine what blend of ammonium phosphate and nitrate make up the formula. There are multiple forms of ammonium phosphate, and for this problem we choose to use the diammonium phosphate, $(NH_4)_2HPO_4$. The formula for ammonium nitrate is $NH_4NO_3$. Thus,

$A*((NH_4)_2HPO_4) + B*(NH_4NO_3)$ --> 1 (mol) ferliziler

$A*(2N + 9H + P + 4O) + B*(2N + 4H + 3O)$

so we can isolate the N and P terms, convert moles to molecular weight *(mw),* and compare these to the NPK values

| | | |
|---|---|---|
| A*P*(*mw* P) = 8 | and | (2*A*N + 2*B*N)*(*mw* N) = 28 |
| A*(30.974) = 8 | and | (2*A + 2*B)*(14.007) = 28 |

A = 0.25828
B = 0.74121

so

$0.25828*(2N + 9H + P + 4O) + 0.74121*(2N + 4H + 3O) =$
$= 1.9990N + 5.2894H + 0.25828P + 3.2568O$

So now, knowing that we want one N in the formula we get $\mathbf{H_{2.65}NO_{1.62}P_{0.13.}}$

b) For inorganic phosphate we use $H_2PO^-_4$.
The reaction that takes place is something like:

Oil + Fertilizer + Bacteria + $O_2$ --> Bacteria + MoreBacteria + $H_2O$ + $CO_2$ + $H_2PO^-_4$

Since bacteria appears on both sides of the equation, we can remove it and we get our stoichiometric expression:

$$\mathbf{a*C_{24.7}H_{43.2}N_{0.31}O_{0.27} + b*H_{2.65}NO_{1.62}P_{0.13} + c*O_2 \rightarrow \rightarrow d*CH_{1.66}N_{0.14}O_{0.50}P_{0.0057} + e*H_2O + f*CO_2 + g*H_2PO^-_4}$$

c) We calculate the coefficients a-f using the mole balance.

| | |
|---|---|
| C, eq1: | 24.7a = d+f |
| H, eq2: | 43.2a+ 2.65b = 1.66d + 2e + 2g |
| N, eq3: | 0.31a + b = 0.14d |
| O, eq4: | 0.27a + 1.62b + 2c = 0.50d + e + 2f + 4g |
| P, eq5: | 0.13b = 0.0057d + g |

W have five equations and two unknown variables. But we know that 42% substrate carbon (the substrate is the oil) is converted into carbon in bacteria. Therefore, we come up with a sixth

equation, 0.42 = d/(24.7a). Additionally, let us assume that we are producing one mole of bacteria, therefore, d=1. So now, with six equations and six unknown variables, we can solve for each coefficient:

**a = 0.096**
**b = 0.110**
**c = 2.241**
**d = 1.000**
**e = 1.389**
**f = 1.381**
**g = 0.0086**

d) The respiratory quotient is the ratio of volume of $CO_2$ produced to the volume of $O_2$ consumed. Since $CO_2$ and $O_2$ are both gasses and we are taking their ratio, dividing f/c gives us RQ. Thus, we get **RQ = 0.616**.

To solve the yield coefficients, we identify the dry biomass as the bacteria, the substrate as the oil, and the N-source as the fertilizer. We find that

molec. weight $CH_{1.66}N_{0.14}O_{0.50}P_{0.0057}$ =
= 12.011 + 1.66*1.008 + 0.14*14.007 + 0.50*15.999 + 0.0057*30.974 = 23.82 g/mol
molec. weight $C_{24.7}H_{43.2}N_{0.31}O_{0.27}$ =
= 24.7*12.011 + 43.2*1.008+0.31*14.007+0.27*15.999 = 348.88 g/mol
molec. weight $H_{2.65}NO_{1.62}P_{0.13}$ = 2.65*1.008 + 14.007 + 1.62*15.999 + 0.13*30.974 = 46.62 g/mol

$Y_{x/S}$ = (d*23.82) / (a*348.88) = **0.71**
$Y_{x/N\text{-}source}$ = (d*23.82) / (b*46.62) = **4.64**