

1. Metabolic Stoichiometry

Component	Type	Purpose
Ascorbic Acid	Other	Also known as Vitamic C, this functions in formation of collagen Detoxifier
Beta Carotene	Fatty acid/other	Coloring 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 Binder and filler 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 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 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 Antioxidant
Vitamin B12	Nucleotide derivative/other	Hematopoietic vitamin
Vitamin D	Other	Calcium and phosphorus metabolism
Vitamin E Acetate		Source of Vitamin E Antioxidant
Zinc Oxide	Inorganic	Source of zinc

2. Metabolic Stoichiometry

a) Since we are finding the stoichiometric formula for the fertilizer, we 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, $(\text{NH}_4)_2\text{HPO}_4$. The formula for ammonium nitrate is NH_4NO_3 . Thus,



$$A * (2\text{N} + 9\text{H} + \text{P} + 4\text{O}) + B * (2\text{N} + 4\text{H} + 3\text{O})$$

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

$$\begin{array}{ll} A * P * (m_w P) = 8 & \text{and} \quad (2 * A * N + 2 * B * N) * (m_w N) = 28 \\ A * (30.974) = 8 & \text{and} \quad (2 * A + 2 * B) * (14.007) = 28 \end{array}$$

$$A = 0.25828$$

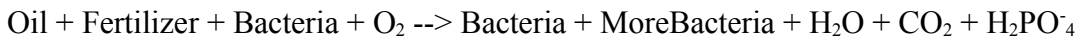
$$B = 0.74121$$

so

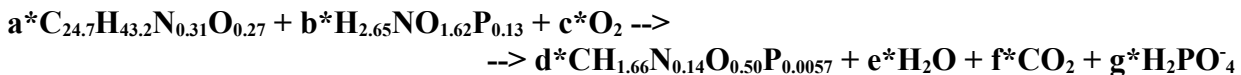
$$\begin{aligned} 0.25828 * (2\text{N} + 9\text{H} + \text{P} + 4\text{O}) + 0.74121 * (2\text{N} + 4\text{H} + 3\text{O}) &= \\ &= 1.9990\text{N} + 5.2894\text{H} + 0.25828\text{P} + 3.2568\text{O} \end{aligned}$$

So now, knowing that we want one N in the formula we get $\text{H}_{2.65}\text{NO}_{1.62}\text{P}_{0.13}$.

b) For inorganic phosphate we use H_2PO_4^- .
The reaction that takes place is something like:



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



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

$$\begin{array}{ll} \text{C, eq1:} & 24.7a = d + f \\ \text{H, eq2:} & 43.2a + 2.65b = 1.66d + 2e + 2g \\ \text{N, eq3:} & 0.31a + b = 0.14d \\ \text{O, eq4:} & 0.27a + 1.62b + 2c = 0.50d + e + 2f + 4g \\ \text{P, eq5:} & 0.13b = 0.0057d + g \end{array}$$

We 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:

$$\mathbf{a = 0.096}$$

$$\mathbf{b = 0.110}$$

$$\mathbf{c = 2.241}$$

$$\mathbf{d = 1.000}$$

$$\mathbf{e = 1.389}$$

$$\mathbf{f = 1.381}$$

$$\mathbf{g = 0.0086}$$

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

$$\begin{aligned} \text{molec. weight } \text{CH}_{1.66}\text{N}_{0.14}\text{O}_{0.50}\text{P}_{0.0057} &= \\ &= 12.011 + 1.66*1.008 + 0.14*14.007 + 0.50*15.999 + 0.0057*30.974 = 23.82 \text{ g/mol} \end{aligned}$$

$$\begin{aligned} \text{molec. weight } \text{C}_{24.7}\text{H}_{43.2}\text{N}_{0.31}\text{O}_{0.27} &= \\ &= 24.7*12.011 + 43.2*1.008 + 0.31*14.007 + 0.27*15.999 = 348.88 \text{ g/mol} \end{aligned}$$

$$\text{molec. weight } \text{H}_{2.65}\text{NO}_{1.62}\text{P}_{0.13} = 2.65*1.008 + 14.007 + 1.62*15.999 + 0.13*30.974 = 46.62 \text{ g/mol}$$

$$Y_{x/S} = (d*23.82) / (a*348.88) = \mathbf{0.71}$$

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