TABLE 7.1 Growth Parameters of Some Organisms Growing Anaerobically in a Chemostat

Organism	Growth-limiting Factor	m_{ATP}	$Y^M_{X/ATP}$
Lactobacillus casei	Glucose	1.5	24.3
Enterobacter aerogenes	Glucose[a]	6.8	14.0
	Glucose[b]	2.3	17.6
	Tryptophan	38.7	25.4
	Citrate	2.2	9.0
Escherichia coli	Glucose	18.9	10.3
		6.9	8.5
Saccharomyces cerevisiae	Glucose	0.5	11.0
		0.25	13.0
Saccharomyces cerevisiae (petite)	Glucose	0.7	11.3
Candida parapsilosis	Glucose	0.2	12.5
Clostridium acetobutylicum	Glucose	—	23.8
Streptococcus cremoris	Lactose[c]	2.3	12.6

[a]Minimal medium. [b] Complex medium. [c] In the presence of a high extracellular lactate concentration.

(With permission, from B. Atkinson and F. Mavituna, *Biochemical Engineering and Biotechnology Handbook*, Macmillan, Inc., New York, 1983.)

Two other yield and maintenance coefficients of importance are related to ATP consumption and oxygen. The ATP yield coefficient, $Y_{X/ATP}$, represents the amount of biomass synthesized per mole of ATP generated. Surprisingly, it has been observed that for many substrates and organisms $Y^M_{X/ATP}$ is nearly constant at 10 to 11 g dry weight/mol ATP for heterotrophic growth under anaerobic conditions. The ATP yield for many autotrophic organisms (recall that autotrophic organisms fix CO_2) is $Y^M_{X/ATP} \approx 6.5$ g/mol ATP. Under aerobic conditions, the values for $Y^M_{X/ATP}$ are usually greater than 10.5 (see Table 7.1). Table 7.2 shows calculated ATP yields (maximum theoretical values) for a variety of media. A maintenance coefficient can also be estimated using an equation analogous to the one we developed for substrate yield coefficient in a chemostat:

$$\frac{1}{Y^{AP}_{X/ATP}} = \frac{1}{Y^M_{X/ATP}} + \frac{m_{ATP}}{D} \tag{7.1}$$

where $Y^{AP}_{X/ATP}$ is the "apparent" yield of biomass and m_{ATP} is the rate of ATP consumption for maintenance energy.

Similarly, yields based on oxygen consumption can be defined and calculated.

$$\frac{1}{Y^{AP}_{X/O_2}} = \frac{1}{Y^M_{X/O_2}} + \frac{m_{O_2}}{D} \tag{7.2}$$

TABLE 7.2 ATP Yields in Various Growth Media

Growth Medium	$Y_{X/ATP}$ (g cells/mol ATP)
Glucose + amino acids + nucleic acids	31.9
Glucose + inorganic salts	28.8
Pyruvate + amino acids + nucleic acids	21
Pyruvate + inorganic salts	13.5
CO_2 + inorganic salts (autotrophic growth)	6.5