Cellular Composition:

To determine a detailed list of the cellular components of *Saccharomyces cerevisiae*, chemical composition of *S. cerevisiae* from a glucose limited continuous culture determined by Schulze was used (Table 8.3, Schulze 1995). Since the optimal solution has shown not to be sensitive to the biomass composition (Varma, 1995), the cellular composition at dilution rate of 0.1 h^{-1} was chosen for this analysis.

Table 1. Cellular composition of S. cerevisiae from a glucose limited anaerobic continuous culture (adopted from Schulze, 1995).

D=0.1	Cellular content %(w/w)
Protein	45.0
Glycogen	8.4
Trehalose	0.8
Mannan	13.1
Other carbohydrates	18.4
RNA	6.3
DNA	0.4
Free amino acids	1.1
Lipid	2.9
Ash	5.0
Sum	101.4

For protein and nucleotide content of the cell, the monomer composition of the cell tabulated by Bruinenberg et. al. (1983) was used. The values are shown in Table 2. Free amino acid composition was not taken into account since it composes a very small portion of the total cell and it is most likely has been already accounted for in the amino acid monomer composition which Bruinenberg has reported in his paper.

Table 2. Amino acid and ribonucleotide monomer composition of *S. cerevisiae* (adopted from Oura, 1972, Bruinenberg, 1983).

Amino acid and RNA monomer compositon

Monomer	mmol/gDW	Monomer	mmol/gDW
ALA	0.459	MET	0.051
ARG	0.161	PHE	0.134
ASN	0.102	PRO	0.165
ASP	0.297	SER	0.185
CYS	0.007	THR	0.191
GLN	0.105	TRP	0.028
GLU	0.302	TYR	0.102
GLY	0.290	VAL	0.265
HIS	0.066	AMP	0.051
ILE	0.193	GMP	0.051
LEU	0.296	UMP	0.067
LYS	0.286	CMP	0.05

The carbohydrate components of the cell are taken to be glycogen, trehalose, mannan, and glucan (see Table 4). The "Other carbohydrates" in this table are assumed to be composed solely of glucan since chitin constitutes a very small portion of the cell composition (Farkas, 1982). Glycogen, mannan, and glucan are taken as polyglucose with a molecular mass of 162 Da (Verduyn, 1990b).

Table 3. Deoxyribonucleotide composition of *S.cerevisiae*. The composition was calculated assuming a G + C content of 40.3. mol % (Vaughan-Martini, 1993).

DNA	Content %(mol/mol)	MW (g/mol)	Content %(w/w)	mmol/gDW
dAMP	0.298	349.23946	0.313	0.0036
dCMP	0.202	307.19926	0.187	0-0024
dGMP	0.202	347.22366	0.211	0.0024
dTMP	0.298	322.21086	0.289	0.0036

Table 4. Carbohydrate composition in *S. cerevisiae* (the first two columns are adopted from Schulze, 1995).

Carbohydrates	Cellular content %(w/w)	MW (g/mol)	mmol/gDW
Glycogen	8.4	162	0.52
Trehalose	0.8	342.3	0.02
Mannan	13.1	162	0.81
Other carbohydrates (glucan)	18.4	162	1.14

The molecular mass of each component of the carbohydrate was calculated as follows:

Carbohydrate content (mmol/gcell) = cellular content of each carbohydrate (g/gcell) * 1/(MW of the carbohydrate (g/mol)) * 1000 mmol/mol

For example:

Glycogen (mmol/gcell) = 0.084 (g/gcell) * 1/162 (g/mol) * 1000 = 0.52 mmol/gcell

The lipid composition is assumed to be as follows (taken from Schulze 1995, Table 3.2):

Table 5. Lipid components of *S. cerevisiae* (the first two columns are adopted from Schulze, 1995).

Lipid	Content %(w/w Lipid)	MW (g/mol)	mmol/gDW
Triacylglycerol	20	867.22	0.0066
Monoacylglycerol (artifact)	8	348.41	0.0066
Sterols (ergosterol)	1	396.66	0.007
Sterol esters (zymestrol)	2	384.00	0.015
Phospholipids	54		

e.g.: Ergosterol: (0.01 g Ergosterol/0.39666 g/mmol)/g Lipid * 2.9 g Lipid/100g DW = 0.0073 mmol Erg/gDW

The monoacylglycerol was not included in the model since Ratledge and Evans (1989) believe that the measurement of this component is most likely an artifact of extraction. The sterols and sterol esters were assumed to be composed solely of ergosterol (Schulze 1995) and zymestrol (Ratledge, 1989), respectively. The molecular weights are estimated using an average value of the cell's fatty acids based on Table 3.3

from Schulze weighted by the percentage content (see Table 5) added to the core structure of the compound.

Table 6. Fatty acid components of *S. cerevisiae* (the first two columns are adopted from Schulze, 1995).

Fatty Acid	Content %(w/w)	Content (w/w)	Avg MW (g/mol)	Average MW (g/mol)
10:0	1.1	0.011	171	1.881
12:0	4.8	0.048	199	9.552
14:0	8.8	0.088	227	19.976
16:0	26.8	0.268	255	68.34
16:1	16.6	0.166	253	41.998
18:0	6.1	0.061	283	17.263
18:1	25.7	0.257	281	72.217
18:2<	10.1	0.101	279	28.179
	100		Average:	259.406

For instance for triacylglycerol, the core structure has a molecular weight of 89 g/mol. It also has 3 fatty acid chains attach to the core structure which makes its average molecular weight to be 867 g/mol (i.e. 89+3*259.406). For phospholipids, the following data from Henry (1982) was used (p.109):

Table 7. Phospholipid content of *S. cerevisiae* (the first two columns are adopted from Henry, 1982).

Phospholipids	phospholipids (%)	Avg MW (g/mol)	mmol/gDW
PA	2.5	672.57	0.0006
PINS	28.7	850.71	0.0053
PS	8.0	760.66	0.0017
PE	20.5	716.65	0.0048
PC	29.2	758.73	0.006

e.g. (2.5 g PA/100 g PL)*(54 g PL/100 g Lipid)*(2.9 g Lipid/100 g DW)*(1/0.74281 g/mmol) = 0.00058

The average molecular weight of fatty acids was also used here to determine the average molecular weight of phospholipids.

Energy required for polymerization of macromolecules was calculated using the macromolecule content of the cell and ATP requirement for biosynthesis of polymers during growth (Verduyn, 1991).

Table 8. Energy requirement for polymerization of macromolecules during growth (Verduyn, 1991).

		Polymerization Energy	
	Cellular content (w/w)	Per Molecule (mmol ATP/g polymer)	Total (mmol ATP/ g cell)
Protein	45	37.7	16.965
Carbohydrates	40.7	12.8	5.2096
RNA	6.3	26.0	1.638
DNA	0.4	26.0	0.104
Sum			23.9166

The overall cell composition is therefore as follows:

Table 9. Cellular components of *S. cerevisiae*

ALA	0.459	CMP	0.05
ARG	0.161	dAMP	0.0036
ASN	0.102	dCMP	0-0024
ASP	0.297	dGMP	0.0024
CYS	0.007	DTMP	0.0036
GLU	0.302	TAGLY	0.007
GLN	0.105	ERGOST	0.0007
GLY	0.290	ZYMST	0.015
HIS	0.066	PA	0.0006
ILE	0.193	PINS	0.005
LEU	0.296	PS	0.002
LYS	0.286	PE	0.005
MET	0.051	PC	0.006
PHE	0.134	GLYCOGEN	0.519
PRO	0.165	TRE	0.023
SER	0.185	Mannan	0.809
THR	0.191	13GLUCAN	1.136
TRP	0.028	SLF	0.02
TYR	0.102	ATP	23.9166
VAL	0.265	ADP	23.9166
AMP	0.051	PI	23.9456
GMP	0.051	Biomass	1
UMP	0.067		

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