

APPENDICES

Bioethanol production from rambutan

Table 1: Fermentation at different PH

PH		PH		TSS %		Glucose mg/ml		Ethanol (v/v)%
		<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>After</i>
4pH	R1	4.0	3.05	10.0	1.7	6.0	4.5	3.5
	R2	4.0	3.13	10.0	2.5	6.2	4.6	3.5
	R3	4.0	3.06	10.0	2.3	6.2	4.7	3.5
	Ave	4.0	3.06	10.0	2.17	6.2	4.7	3.17
5pH	R1	5.0	3.39	10.3	1.5	6.4	4.5	7.0
	R2	5.0	3.09	10.3	1.4	6.4	4.4	7.5
	R3	5.0	3.29	10.3	0.9	6.4	4.4	7.0
	Ave	5.0	3.24	10.3	2.29	6.2	4.44	7.5
6pH	R1	6.0	3.43	12.1	3.2	6.1	5.4	4.0
	R2	6.0	3.37	12.1	2.3	6.1	5.5	4.0
	R3	6.0	3.54	12.1	2.7	6.1	5.3	4.5
	Ave	6.0	3.4	12.1	2.74	6.1	5.4	4.16

Table 2: Fermentation at different yeast concentration

yeast concentration g/L		PH		TSS %		Glucose mg/ml		Ethanol (v/v)%
		<i>before</i>	<i>after</i>	<i>before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>After</i>
2g/L	R1	5.8	3.95	11.1	2.5	4.2	2.6	8.0
	R2	5.8	3.83	11.1	2.9	4.2	2.6	8.5
	R3	5.8	3.93	11.1	2.3	4.2	2.6	8.0
	Ave	5.8	3.90	11.1	2.57	4.2	2.6	8.17
3g/L	R1	5.8	3.37	11.1	2.5	4.2	2.5	7.0
	R2	5.8	3.62	11.1	3.0	4.2	2.6	7.5
	R3	5.8	3.45	11.1	2.9	4.2	2.3	8.0
	Ave	5.8	3.48	11.1	2.8	4.2	2.46	7.5
4g/L	R1	5.8	3.93	11.1	3.0	4.2	2.3	7.5
	R2	5.8	3.51	11.1	2.5	4.2	2.3	7.5
	R3	5.8	3.69	11.1	2.6	4.2	2.9	6.0
	Ave	5.8	3.71	11.1	2.7	4.2	2.17	7.0

Table 3: Fermentation at different temperature

Temperature		PH		TSS %		Glucose mg/ml		Ethanol (v/v)%
		<i>before</i>	<i>After</i>	<i>before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>After</i>
28°C	R1	5.8	3.90	12.0	3.3	6.3	4.2	8.5
	R2	5.8	3.90	12.0	3.2	6.3	3.7	8.5
	R3	5.8	3.90	12.0	3.0	6.3	4.0	8.5
	Ave	5.8	3.90	12.0	3.17	6.3	3.79	8.5
30°C	R1	5.8	3.81	12.0	4.6	6.3	3.2	10.0
	R2	5.8	3.81	12.0	4.3	6.3	3.7	8.5
	R3	5.8	3.81	12.0	4.5	6.3	3.6	9.0
	Ave	5.8	3.81	12.0	4.47	6.3	3.3	9.17
35°C	R1	5.8	3.75	12.0	4.2	6.3	3.4	7.5
	R2	5.8	3.7	12.0	4.2	6.3	3.7	8.0
	R3	5.8	3.75	12.0	4.0	6.3	3.7	8.0
	Ave	5.8	3.75	12.0	4.2	6.3	3.6	7.8

Table 4: Fermentation at different fruit condition

Fruit condition		PH		TSS %		Glucose mg/ml		Ethanol (v/v)%
		<i>Before</i>	<i>After</i>	<i>before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>After</i>
Fresh	R1	5.3	3.93	12.0	2.5	4.4	2.6	5.5
	R2	5.2	3.98	12.0	3.0	4.4	2.6	5.5
	R3	5.5	3.93	12.0	1.9	4.4	2.6	5.5
	Ave	5.3	3.94	12.0	2.8	4.4	2.6	5.5
Rotten	R1	5.3	3.82	12.0	2.0	4.2	2.6	7.0
	R2	5.3	3.72	12.0	2.2	4.2	2.1	6.5
	R3	5.3	3.85	12.0	1.9	4.2	2.5	8.0
	Ave	5.3	3.79	12.0	2.04	4.2	2.4	7.17

Table 5: Fermentation at different days.

Days		PH		TSS %		Glucose mg/ml		Ethanol (v/v)%
		<i>Before</i>	<i>After</i>	<i>before</i>	<i>after</i>	<i>Before</i>	<i>After</i>	<i>After</i>
1day	R1	5.2	4.24	12.0	3.2	6.0	3.2	8.5
	R2	5.2	4.27	12.0	4.1	6.0	3.9	8.5
	R3	5.2	4.14	12.0	3.2	6.0	4.3	8.0
	Ave	5.2	4.22	12.0	3,5	6.0	3.5	8.4
2days	R1	5.2	4.13	12.0	3.0	6.0	3.8	9.5
	R2	5.2	4.05	12.0	4.0	6.0	3.8	9.5
	R3	5.2	4.40	12.0	3.0	6.0	3.8	9.0
	Ave	5.2	4.19	12.0	3,0	6.0	3.8	9.4
3days	R1	5.2	3.75	12.0	3.3	6.0	3.4	8.5
	R2	5.2	3.95	12.0	3.2	6.0	3.7	8.5
	R3	5.2	3.73	12.0	3.0	6.0	3.7	8.5
	Ave	5.2	3.81	12.0	3.17	6.0	3.6	8.5
4days	R1	5.2	3.90	12.0	3.2	6.0	3.6	8.0
	R2	5.2	3.91	12.0	3.0	6.0	3.3	7.0
	R3	5.2	3.92	12.0	3.3	6.0	3.2	7.5
	Ave	5.2	3.91	12.0	3.17	6.0	3.36	7.5

Table 6: Fermentation with enzymatic hydrolysis

Enzyme		PH		TSS %		Glucose mg/ml		Ethanol (v/v)%
		<i>before</i>	<i>After</i>	<i>before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>After</i>
Yeast	R1	5.2	3.20	12.0	3.6	6.2	4.1	9.11
	R2	5.2	3.24	12.0	4.0	6.2	4.5	9.7
	R3	5.2	3.25	12.0	4.0	6.2	4.4	9.9
	Ave	5.2	3.23	12.0	3.8	6.2	4.4	9.9
cellulase	R1	5.2	3.61	12.0	3.1	6.2	4.8	9.9
	R2	5.2	3.58	12.0	3.3	6.2	4.8	9.5
	R3	5.2	3.54	12.0	3.9	6.2	4.3	9.7
	Ave	5.2	3.57	12.0	3.4	6.2	4.6	9.7
amylase	R1	5.2	3.78	12.0	3.7	6.2	4.1	9.7
	R2	5.2	3.76	12.0	3.9	6.2	4.3	9.8
	R3	5.2	3.80	12.0	4.0	6.2	4.1	9.9
	Ave	5.2	3.78	12.0	3.8	6.2	4.1	9.8

Table 7: Fermentation of different fruit parts.

Fruit Part		PH		TSS %		Glucose mg/ml		Ethanol (v/v)%
		<i>before</i>	<i>after</i>	<i>Before</i>	<i>After</i>	<i>Before</i>	<i>After</i>	<i>After</i>
Skin	R1	5.8	3.02	11.0	2.8	5.2	3.9	7.5
	R2	5.8	3.05	11.0	2.8	5.2	4.1	7.12
	R3	5.8	3.06	11.0	2.3	5.2	4.0	7.75
	Ave	5.8	3.04	11.0	2.81	5.2	4.04	7.46
Pulp	R1	5.8	3.23	12.3	3.2	5.2	2.9	10.25
	R2	5.8	3.26	12.3	2.6	5.2	2.8	9.0
	R3	5.8	3.29	12.3	3.3	5.2	3.4	10.6
	Ave	5.8	3.26	12.3	3.6	5.2	3.06	9.96
Maxi	R1	5.8	3.24	12.2	2.8	6.3	3.7	8.12
	R2	5.8	3.26	12.2	2.6	6.1	3.5	7.25
	R3	5.8	3.28	12.2	3.3	6.2	3.3	7.5
	Ave	5.8	3.26	12.2	2.96	6.2	3.4	7.6

A comparison of ethanol production from different fruits by fermentation

Table 8: Effect of pH to produce ethanol from fruits (Rembutan, mango, banana, pineapple)

Fruits Ph	Rembutan	Mango	Banana	Pineapple
4ph	After	After	after	After
R1	5.5	4.3	5.7	5.2
R2	5.5	4.3	5.7	5.2
R3	5.5	4.3	5.7	5.2
Average	5.5	4.3	5.7	5.2
5ph	After	After	After	After
R1	7.5	6.2	6.3	6.6
R2	7.5	6.1	6.2	6.6
R3	7.5	6.3	6.4	6.6
Average	7.5	6.3	6.3	6.6
6ph	After	After	after	After
R1	6.1	5.0	5.8	5.4
R2	6.0	5.0	5.8	5.4
R3	6.0	5.0	5.8	5.4
Average	6.1	5.0	5.8	5.4

**Table 9: Effect of pH for different parameters from fruits
(Rambutan, mango, banana, pineapple)**

Fruits Parameters		Rembutan	Mango	Banana	Pineapple
		After fermentation	After fermentation	After fermentation	After fermentation
TSS %	PH 4	2.17	2.18	2.12	2.15
	PH 5	2.29	2.30	2.20	2.19
	PH 6	2.74	2.62	2.80	2.72
Glucose mg/ml	PH 4	4.7	4.5	5.0	4.8
	PH 5	4.44	4.26	4.18	4.23
	PH 6	5.5	5.0	5.2	5.4
pH	PH 4	3.06	3.05	3.12	3.11
	PH 5	3.24	3.35	3.41	3.45
	PH 6	3.4	3.21	3.13	3.36

Table10: Effect of yeast concentration to produce ethanol production from fruits (Rembutan, mango, banana, pineapple)

Fruits Yeast concentration	Rembutan	Mango	Banana	Pineapple
2g/m	After	After	After	After
R1	7.0	5.6	5.0	7.2
R2	7.0	5.6	5.0	7.2
R3	7.0	5.6	5.0	7.2
Average	7.0	5.8	5.0	7.2
3g/m	After	After	After	After
R1	7.0	5.2	5.3	7.6
R2	7.5	5.1	5.2	7.6
R3	7.0	5.3	5.4	7.6
Average	7.5	5.9	5.8	7.5
4g/m	After	After	After	After
R1	8.1	7.3	6.0	7.8
R2	8.1	7.3	6.0	7.8
R3	8.1	7.0	6.0	7.8
Average	8.1	7.2	6.0	7.8

Table 11: Effect of yeast concentration for different parameters from fruits (Rambutan, mango, banana, and pineapple)

Fruits		Rembutan	Mango	Banana	Pineapple
Parameters		After fermentation	After fermentation	After fermentation	After fermentation
TSS %	2 g/L	2.5	3.0	2.9	2.1
	3 g/L	2.7	2.6	2.0	2.3
	4 g/L	2.8	2.3	2.8	2.9
Glucose mg/ml	2 g/L	2.6	2.5	2.1	3.0
	3 g/L	2.4	2.9	2.4	2.2
	4 g/L	2.1	2.7	2.5	2.2
pH	2 g/L	3.8	3.4	3.6	4.0
	3 g/L	3.8	3.9	3.3	3.8
	4 g/L	3.8	3.7	4.0	3.2

**Parameter112: Effect of Temperature on ethanol production from fruits
(Rembutan, mango, banana, pineapple)**

Fruits \ Temperature	Rembutan	Mango	Banana	Pineapple
28^oC	After	After	after	After
R1	8.5	6.4	5.6	7.2
R2	8.5	6.5	5.4	7.2
R3	8.5	6.3	5.5	6.2
Average	8.5	6.6	5.5	6.9
30^oC	After	After	after	After
R1	9.1	7.2	6.0	8.6
R2	9.1	7.1	6.0	8.6
R3	9.1	7.3	6.0	8.0
Average	9.1	7.2	6.0	8.4
35^oC	After	After	after	After
R1	7.8	7.0	5.8	7.1
R2	7.8	7.0	5.8	7.1
R3	7.8	7.0	5.8	7.1
Average	7.8	7.0	5.8	7.1

**Table13: Effect of Temperature for different parameters from fruits
(Rambutan, mango, banana, pineapple)**

Fruits		Rembutan	Mango	Banana	Pineapple
Parameters		After fermentation	After fermentation	After fermentation	After fermentation
TSS %	28^oC	3.17	3.16	3.11	3.18
	30^oC	4.4	4.5	4.4	4.7
	35^oC	4.2	4.3	4.8	4.1
Glucose mg/ml	28^oC	3.7	3.6	3.5	3.6
	30^oC	3.3	3.2	3.1	3.5
	35^oC	3.6	3.5	3.6	3.3
pH	28^oC	3.9	3.4	3.4	3.7
	30^oC	3.8	3.6	3.2	3.6
	35^oC	3.7	3.6	3.1	3.2

Table 14: Comparison of fresh and rotten fruit for ethanol production from fruits (Rembutan, mango, banana, pineapple)

Fruits Condition	Rembutan	Mango	Banana	Pineapple
Fresh	After	After	after	After
R1	5.6	4.4	5.7	5.9
R2	5.4	4.5	5.0	5.8
R3	5.5	4.0	5.3	5.10
Average	5.5	4.3	5.5	5.9
Rotten	After	After	after	After
R1	7.1	6.2	5.8	6.10
R2	7.2	6.1	5.7	6.12
R3	7.0	6.3	5.9	6.5
Average	7.1	6.3	5.8	6.9

Table 15: Comparison of fresh and rotten fruit for different parameters from fruits (Rambutan, mango, banana, pineapple)

Fruits		Rembutan	Mango	Banana	Pineapple
Parameters		After fermentation	After fermentation	After fermentation	After fermentation
TSS %	Fresh	2.8	2.5	2.6	2.3
	Rotten	2.04	2.4	2.7	2.6
Glucose mg/ml	Fresh	2.6	2.7	2.9	2.1
	Rotten	2.4	2.03	2.6	2.4
pH	Fresh	3.3	3.5	3.7	3.4
	Rotten	3.3	3.6	3.4	3.2

**Table 16: Effect of retention time on ethanol production from fruits
(Rembutan, mango, banana, pineapple)**

Fruits Days	Rembutan	Mango	Banana	Pineapple
1 day	After	After	After	After
R1	8.5	6.47	5.58	8.3
R2	8.5	6.16	5.58	7.9
R3	8.0	6.32	5.37	8.3
Average	8.4	6.32	5.51	8.23
3 days	After	After	After	After
R1	9.5	7.2	5.86	8.12
R2	9.5	7.1	5.93	8.44
R3	9.0	7.6	5.79	9.34
Average	9.4	7.3	5.86	8.64
5days	After	After	After	After
R1	8.5	8.15	6.14	7.62
R2	8.5	8.15	6.07	7.53
R3	8.5	7.92	6.07	7.20
Average	8.5	8.07	6.09	7.46

**Table 17: Effect of retention time for different parameters from fruits
(Rambutan, mango, banana, pineapple)**

Fruits		Rembutan	Mango	Banana	Pineapple
Parameters		After fermentation	After fermentation	After fermentation	After fermentation
TSS %	1day	3.17	3.16	3.11	3.18
	3days	3.4	3.5	3.4	3.7
	5days	3.2	3.3	3.8	3.1
Glucose mg/ml	1day	3.5	3.6	3.7	3.9
	3days	3.8	3.4	3.3	3.2
	5days	3.3	3.6	3.8	3.3
pH	1day	4.9	4.4	4.4	4.7
	3days	4.8	4.6	4.2	4.6
	5days	3.7	3.6	3.1	3.2

Table 18: Effect of enzymatic pretreatment on ethanol production from fruits (Rembutan, mango, banana, pineapple)

Fruits enzymatic	Rembutan	Mango	Banana	Pineapple
Yeast	After	After	after	After
R1	9.10	7.1	5.6	8.3
R2	9.9	7.2	5.10	8.6
R3	9.8	7.3	5.8	8.9
Average	9.9	7.2	5.8	8.6
Cellulose	After	After	after	After
R1	9.7	5.9	5.9	8.0
R2	9.5	5.9	5.6	8.6
R3	9.9	5.7	5.9	8.0
Average	9.7	5.9	5.8	8.2
Amylase	After	After	after	After
R1	9.8	5.10	5.8	7.4
R2	9.8	5.8	5.5	7.5
R3	9.8	5.6	5.8	7.3
Average	9.8	5.8	5.7	7.4

Table 19: Effect of enzymatic pretreatment for different parameters from fruits (Rambutan, mango, banana, pineapple)

Fruits		Rembutan	Mango	Banana	Pineapple
Parameters		After fermentation	After fermentation	After fermentation	After fermentation
TSS %	Yeast	3.1	3.6	3.3	3.7
	Cellulose	3.4	3.5	3.4	3.7
	Amylase	3.2	3.3	3.8	3.1
Glucose mg/ml	Yeast	4.5	4.6	4.7	4.9
	Cellulose	4.8	4.4	4.3	4.2
	Amylase	4.3	4.6	4.8	4.3
pH	Yeast	3.9	3.4	3.4	3.7
	Cellulose	3.8	3.6	3.2	3.6
	Amylase	3.7	3.6	3.1	3.2

Table20: Ethanol production from different fruit parts (Rembutan, mango, banana, pineapple)

Fruits Days	Rembutan	Mango	Banana	Pineapple
Skin	After	After	After	After
R1	7.10	5.3	3.2	4.3
R2	7.2	5.8	3.7	4.6
R3	7.0	5.7	3.3	4.0
Average	7.4	5.6	3.7	4.3
Pulp	After	After	After	After
R1	9.8	7.9	5.6	8.6
R2	9.10	7.9	5.9	8.6
R3	9.9	7.7	5.9	8.9
Average	9.9	7.6	5.8	8.7
Maxi	After	After	After	After
R1	7.8	6.5	5.0	8.3
R2	7.5	6.0	5.5	8.0
R3	7.5	6.4	5.1	8.3
Average	7.6	6.3	5.2	8.2

Table 21: Different parameters from different fruit parts

Fruits		Rembutan	Mango	Banana	Pineapple
Parameters		After fermentation	After fermentation	After fermentation	After fermentation
TSS %	Skin	2.1	2.6	3.3	3.7
	Pulp	2.4	3.5	2.4	3.7
	Maxi	2.2	2.3	2.8	3.1
Glucose mg/ml	Skin	4.4	4.8	4.3	4.9
	Pulp	4.8	4.2	4.7	4.2
	Maxi	4.2	4.7	4.2	4.9
pH	Skin	3.1	3.9	3.8	3.3
	Pulp	3.2	3.9	3.7	3.5
	Maxi	3.4	3.8	3.3	3.1

Table 22: Viscosity and acid value

Feedstock	Viscosity (cst)	Acid value (mg KOH/g)
Rambutan	1.23	0.36
Banana	1.58	0.38
Pineapple	1.62	0.48
Mango	1.75	0.49

Table 23 Chemical Analysis

Chemical	Value (ppm)			
	Time (hour)			
	Rambutan	Banana	pineapple	Mango
Fe	1.2	2.5	5.5	3
Pb	0	0	0	0
Cu	0	0.5	0	0
Al	0	0	0	0
Sn	4.2	4.2	4.3	4.15
Mn	6	4	2.5	4.5
Ag	18.5	00.5	20.0	19.65
Zn	9.5	6	7	5
P	91	75.5	70	65
Ca	3.16	5.8	4.25	5.3
Mg	1.67	185	1.72	8.1
Si	1.65	1.65	1.65	18
Na	13.8	14.05	8.75	11.35