LAMPIRAN A

DATA-DATA

KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI
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SURAT VALIDASI DATA

Berikut ini merupakan data hasil penelitian mahasiswa semester akhir DIV Teknologi Kimia Industri:

Nama : Ester Necessary
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Judul Penelitian : Prototipe Alat Evaporator Vakum (Efektivitas Temperatur dan Waktu Evaporasi Terhadap Tekanan Vakum dan Laju Evaporasi pada Pembuatan Sirup Buah Mengkudu).

Penelitian dilaksanakan di Laboratorium Mikrobiologi Politeknik Negeri Sriwijaya. Data-data yang didapatkan dari hasil penelitian antara lain:

1. **Pengamatan Tekanan Vakum**

Tabel A.1 Data Hasil Pengamatan Tekanan Vakum

Temperatur (°C)	Waktu (menit)	Tekanan (cmHg)
Pengujian Awal	10	15
	20	14
	30	14
	40	13
	50	14
50	10	16
	20	18
	30	18
	40	19
	50	18
60	10	18
	20	17
	30	17
	40	17
	50	19

2. Pengukuran Viskositas

Tabel A.2 Data Hasil Pengukuran Viskositas

No.	Temperatur Evaporasi (°C)	Waktu (Menit)	Lama Bola Turun (Detik)	Berat Piknometer + Sirup (gr)	Berat Jenis (gr/cm^3)	Viskositas (cP)
1.	50	10	7,5	17,6498	1,1128	4,7164
		20	9,5	17,7112	1,1248	5,9638
		30	9,8	17,7345	1,1293	6,1482
		40	10,2	17,7561	1,1335	6,3952
		50	10,4	17,7970	1,1415	6,5132
2.	60	10	9,7	17,8498	1,1518	6,0658
		20	10,6	17,8775	1,1572	6,6234
		30	11,3	17,9076	1,1631	7,0548
		40	12,4	17,9369	1,1688	7,7352
		50	13,6	17,9944	1,1800	8,4701

3. Pengukuran Kadar Air

Tabel A.3 Data Hasil % Kadar Air

No.	Temperatur Evaporasi (°C)	Waktu (Menit)	Berat Cawan Kosong (gr)	Berat Cawan Kosong+Sampel Sesudah di Oven (gr)	Berat Sampel (gr)	Kadar Air (%)
1.	50	10	71,8120	72,4700	2,0242	82,26
		20	30,3948	31,1300	2,1488	80,16
		30	28,3493	29,14	2,1693	70,05
		40	76,7631	77,5120	2,0100	67,49
		50	64,0482	74,8854	2,1755	63,16
2.	60	10	74,0520	74,9119	2,0291	77,95
		20	30,3930	31,2568	2,0822	74,45
		30	28,3457	29,2688	2,0939	63,55
		40	77,6421	78,6970	2,2547	58,52
		50	64,0476	65,1598	2,1870	57,62

4. Pengukuran Laju Evaporasi

Tabel A.4 Data Hasil Laju Evaporasi

No.	Temperatur Evaporasi (°C)	Waktu (Menit)	Ulangan Ke-	Kadar Air Sebelum Evaporasi (%)	Kadar Air Setelah Evaporasi (%)	Laju Evaporasi (gr uap/menit)
1	50	40	I	95	67,49	0,688
			II		63,16	0,796
2	60		I		58,52	0,912
			II		55,24	0,994

Palembang, Juli 2019

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Table of F-statistics P=0.05

t-statistics
F-statistics with other P-values: P=0.01 | P=0.001
Chi-square statistics

df2\df1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.76	8.74	8.73	8.71	8.70
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.94	5.91	5.89	5.87	5.86
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.70	4.68	4.66	4.64	4.62
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.03	4.00	3.98	3.96	3.94
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.60	3.57	3.55	3.53	3.51
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.31	3.28	3.26	3.24	3.22
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.10	3.07	3.05	3.03	3.01
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.94	2.91	2.89	2.86	2.85
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.82	2.79	2.76	2.74	2.72
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.72	2.69	2.66	2.64	2.62
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.63	2.60	2.58	2.55	2.53
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.57	2.53	2.51	2.48	2.46
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.51	2.48	2.45	2.42	2.40
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.46	2.42	2.40	2.37	2.35
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.41	2.38	2.35	2.33	2.31
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.37	2.34	2.31	2.29	2.27
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.34	2.31	2.28	2.26	2.23
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.31	2.28	2.25	2.23	2.20
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.26	2.23	2.20	2.17	2.15
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.22	2.18	2.15	2.13	2.11
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.18	2.15	2.12	2.09	2.07
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.15	2.12	2.09	2.06	2.04
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.13	2.09	2.06	2.04	2.01
35	4.12	3.27	2.87	2.64	2.49	2.37	2.29	2.22	2.16	2.11	2.08	2.04	2.01	1.99	1.96
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.04	2.00	1.97	1.95	1.92
45	4.06	3.20	2.81	2.58	2.42	2.31	2.22	2.15	2.10	2.05	2.01	1.97	1.94	1.92	1.89
50	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.03	1.99	1.95	1.92	1.89	1.87
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.95	1.92	1.89	1.86	1.84
70	3.98	3.13	2.74	2.50	2.35	2.23	2.14	2.07	2.02	1.97	1.93	1.89	1.86	1.84	1.81
80	3.96	3.11	2.72	2.49	2.33	2.21	2.13	2.06	2.00	1.95	1.91	1.88	1.84	1.82	1.79
100	3.94	3.09	2.70	2.46	2.31	2.19	2.10	2.03	1.97	1.93	1.89	1.85	1.82	1.79	1.77
200	3.89	3.04	2.65	2.42	2.26	2.14	2.06	1.98	1.93	1.88	1.84	1.80	1.77	1.74	1.72
500	3.86	3.01	2.62	2.39	2.23	2.12	2.03	1.96	1.90	1.85	1.81	1.77	1.74	1.71	1.69

Table 5.4. Dimensions of Standard Flanged-only Heads for All Diameters

(Courtesy of Lukens Steel Company)

Gage (Thickness) t	Standard Straight Flange (in.) sf	Inside-corner Radius (in.) icr
3/16	1 1/2–2	9/16
1/4	1 1/2–2 1/2	3/4
5/16	1 1/2–3	15/16
3/8	1 1/2–3	1 1/8
7/16	1 1/2–3 1/2	1 5/16
1/2	1 1/2–3 1/2	1 1/2
5/8	1 1/2–3 1/2	1 7/8
3/4	1 1/2–3 1/2	2 1/4
7/8	1 1/2–4	2 5/8
1	1 1/2–4	3
1 1/8	1 1/2–4 1/2	3 3/8
1 1/4	1 1/2–4 1/2	3 3/4
1 3/8	1 1/2–4 1/2	4 1/8
1 1/2	1 1/2–4 1/2	4 1/2
1 3/4	1 1/2–4 1/2	5 1/4
2	1 1/2–4 1/2	6

Table 13.2. Maximum Allowable Efficiencies for Arc- and Gas-welded Joints (11)

From the 1956 ASME Unfired-Pressure-Vessel Code with Permission of the American Society of Mechanical Engineers

Type of Joint	Limitations	Basic Joint Efficiency, per cent	Radiographed	Thermally Stress Relieved	Maximum Joint Efficiency, per cent
Double-welded butt joint	None		No	No	80
Single-welded butt joint with backing strip	Longitudinal joints not over 1¼ in. thick. No thickness limitation on circumferential joints.	80	No	Yes	85
			Yes	No	90
			Yes	Yes	95
Single-welded butt joint without backing strip	Circumferential joints only, not over ⅝ in. thick.	70	No	No	70
			No	Yes	75
Double full-fillet lap joint	Longitudinal joints not over ⅜ in. thick. Circumferential joints not over ⅝ in. thick.	65	No	No	65
			No	Yes	70
Single full-fillet lap joint with plug welds	Circumferential joints only, not over ⅝ in. thick; attachment of heads not over 24 in. in outside diameter to shells not over ½ in. thick.	60	No	No	60
			No	Yes	65
Single full-fillet lap joint without plug welds	Only for attachment of heads convex to pressure to shells not over ⅝ in. thick, and for attachment of heads concave to pressure not over 24 in. in outside diameter to shells not over ¼ in. thick.	50	No	No	50
			No	Yes	55

Table 5.7. Dimensions of ASME Code Flanged and Dished Heads
(Courtesy of Lukens Steel Company)

OD	12		14		16		18		20		22		24	
t	*icr*	*r*	*icr*	*r*	*icr*	*r*	*icr*	*r*	*icr*	*r*	*icr*	*r*	*icr*	*r*
3/16	3/4	12	7/8	14	1	15	1 1/8	18	1 1/4	20	1 3/8	21	1 1/2	24
1/4	3/4		7/8	14	1					20				
5/16	15/16		15/16	14	1					18				
3/8	1 1/8			12			1 1/8	18	1 1/4			21		
7/16	1 5/16							16	1 5/16		1 3/8	20		
1/2	1 1/2					15		16					1 1/2	
5/8	1 7/8					14		15					1 7/8	
3/4	2 1/4			12				15					2 1/4	
7/8	2 5/8			14				18					2 5/8	
1	3												3	
1 1/8	3 3/8												3 3/8	
1 1/4	3 3/4	12											3 3/4	
1 3/8			4 1/8										4 1/8	
1 1/2			4 1/2	14	4 1/2	14	4 1/2	18	4 1/2				4 1/2	
1 5/8									4 7/8				4 7/8	
1 3/4									5 1/4				5 1/4	
1 7/8									5 5/8				5 5/8	
2									6				6	
2 1/4									6 3/4	18	6 3/4	20	6 3/8	24
2 1/2														
2 3/4														
3														

TABLE 6

Rules of thumb for use in preliminary estimates of costs for pressure vessels

Costs for vessel (January, 1990—Including nozzles, manholes, and saddle or skirt but no special internals such as trays or agitators) as dollars per pound of weight of fabricated unit f.o.b. with carbon steel as the cost basis = $80(W_v)^{-0.34}$ where W_v is the total weight in pounds (applicable in W_v range of 800 lb to 100,000 lb).

To account for the extra weight due to nozzles, manholes, and skirts or saddles, increase the weight calculated for the smooth vessel including top and bottom by 1.5% for vessels to be installed in a horizontal position and by 20% for vessels to be installed in a vertical position.

Steel density can be taken as 489 lb/ft^3 or 0.283 lb/in^3.

Cost factors to convert from carbon steel as the material of construction for the fabricated unit follow:

	Shell-material cost factors
Carbon steel	1.0 (basis)
Stainless steel 304	2.0 to 3.5
Stainless steel 316	2.3 to 4.3
Monel	4.5 to 9.8
Titanium	4.9 to 10.6

Cost factors to convert from an internal pressure of up to 50 psig for carbon steel at temperatures below 800°F†

Pressure	Pressure factor	Pressure	Pressure factor
up to 50 psig	1.0 (basis)	800 psig	3.8
loo	1.3	900	4.0
200	1.6	1000	4.2
300	2.0	1500	5.4
400	2.4	2000	6.5
500	2.8	3000	8.8
600	3.0	4000	11.3
700	3.3	5000	13.8

In general, the minimum wall thickness, not including allowances for corrosion, for any plate subject to pressure should not be less than $\frac{3}{32}$ in. for welded or brazed construction and not be less than $\frac{3}{16}$ in. for riveted construction except that the thickness of walls for unfired steam boilers should not be less than $\frac{1}{4}$ in.

A corrosion allowance of 0.010 to 0.015 in./yr, or about $\frac{1}{8}$ in. for a lo-year life is a reasonable value.

For high-pressure vessels, hemispherical heads are usually the most economical.

Lang factors to convert from the base cost of the delivered vessel (costed as if it were of carbon-steel material of construction so that weight becomes the primary measure of installation cost) to the cost of the vessel installed with all necessary auxiliaries except special internals such as trays or agitators are 3.0 for vessels installed in a horizontal position and 4.0 for vessels installed in a vertical position.

LAMPIRAN B

PERHITUNGAN

LAMPIRAN B
URAIAN PERHITUNGAN

1. Perhitungan Desain Evaporator Vakum

a. Desain Proses

Diketahui :

Volume tangki (Presto) = 8 dm^3

Diameter = 24 cm = 2,4 dm

Maka,

$V = \frac{\pi}{4} D^2 H$

$8000 \text{ cm}^3 = \frac{3{,}14}{4} (2{,}4 \text{ cm})^2 . H$

$H = 17{,}6929 \text{ cm} = 6{,}9657 \text{ in}$

Jadi,

Tangki dirancang sehingga 80% volumenya berisi reaktan.

$V \text{ cairan} = \frac{V \text{ tangki}}{20\%}$

$V \text{ cairan} = \frac{8 \text{ dm}^3}{\frac{100}{80}}$

$V \text{ cairan} = \frac{640 \text{ dm}^3}{100}$

$V \text{ cairan} = 6{,}4 \text{ dm}^3$

Jadi, tinggi tangki (H) sebesar 17,6929 cm dan volume cairan sebesar 6,4 dm^3.

Tinggi cairan

$HL = \frac{V \text{ cairan}}{\frac{\pi D^2}{4}}$

$V \text{ cairan} = \frac{\pi}{4} D^2 HL$

$6{,}4 \text{ dm}^3 = \frac{3{,}14}{4} \times (2{,}4 \text{ dm})^2 \times HL$

HL = 1,41543 dm

HL = 14,1543 cm = 5,5726 in = 0,4644 ft

b. Desain Mekanikal

Reaktor beroperasi pada tekanan di bawah atmosferis.

Asumsi :

$$\rho = \frac{m}{v} = \frac{8000 \text{ gr}}{8000 \text{ cm}^3} = 1 \text{ gr/cm}^3 = 62{,}428 \text{ lb/ft}^3$$

Tekanan hidrostatis di dasar evaporator disebabkan oleh adanya cairan di dalam evaporator.

Ph = ρgh

Dimana:

Ph = tekanan hidrostatis dalam reaktor, Psi

ρ = massa jenis cairan dalam reaktor, lb/ft^3

h = tinggi *level* cairan dalam reaktor, ft

$$g = \frac{g}{gc} = \frac{32{,}179 \text{ ft/det}^2}{32{,}1740 \text{ lbft/lbs}^2} = 1$$

Ph = ρgh = $62{,}428 \text{ lb/ft}^3$ x 1 x 0,4644 ft = 28,9916 lb/ft^2

= 0,20133 Psi

P diasumsikan = 0,6 atm = 8,8176 Psi

P operasi = P_h + P

= 0,20133 Psi + 8,8176 Psi

= 9,01893 Psi = 0,613701 atm

Tekanan desain 5-10% di atas tekanan kerja absolut (*Coulson, 1988:637*)

Desain Tekanan di *set* 10 % di atas tekanan operasi.(*Walas, 1988:xviii*)

P desain = (110%)(9,01893 Psi)

= 9,9208 Psi = 68,4015 KN/m^2

Tebal *Shell*

Untuk mencari tebal *shell*, digunakan persamaan berikut.

$$t_s = \frac{P.ri}{f.E - 0{,}6\,P} + C$$ (Rase *and* Barrow, 1957)

Dengan,

t_s = Tebal *shell*

P = Tekanan desain

ri = jari-jari

f = *Allowable working stress*

E = *joint efficiency*

C = *Corrosion allowance*

Material = *Stainless Steel*

Working Stress, (f) = 129276,7 KN/m^2.

Joint Efficiency, (E) = 0,8

(Tabel 13.2, Brownell, 1959:254)

Internal Radius, (ri) = D/2 =8,35 in/2 = 4,175 in

=0,106045 m

Corrosion allowance = 0,125 in = 0,003175 m

(Tabel 6, Timmerhaus, 1991:542)

$$t_s = \frac{P\,.\,ri}{f.E - 0{,}6\ P} + C$$

$$= \frac{68{,}4015\frac{KN}{m^2}\ x\ 0{,}12\ m}{\left(129276{,}7\frac{KN}{m^2 x}0{,}8\right) - \left(0{,}6\ x 68{,}4015\frac{KN}{m^2}\right)} + 0{,}003175\ m$$

= 0,0032544 m =3,2544 mm = 0,12813 in

maka *outside diameter* (OD) = $D_i + 2t_s$

= 9,4488 in + (2 x 0,12813in)

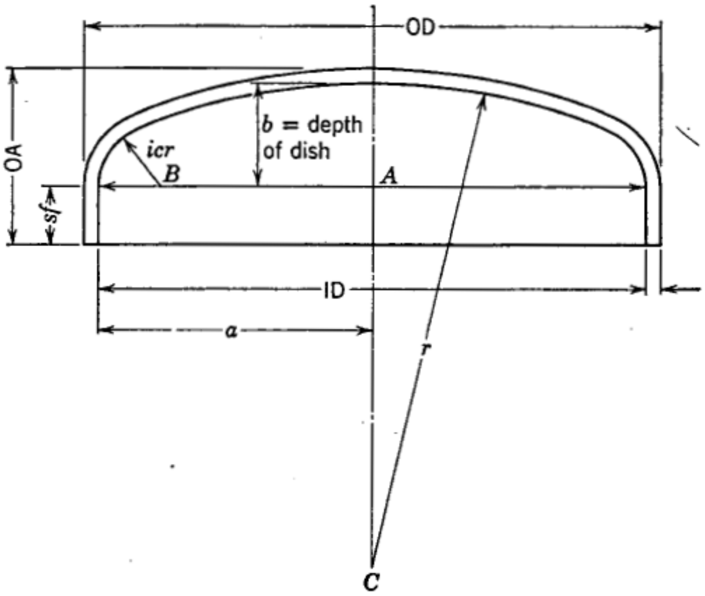
= 9,70508 in = 24,6509 cm

Diambil OD standar = 12 in (Brownell *and* Young, 1959:91)

c. Perancangan *Head* Tangki

Bentuk : *Flanged and Standard Dished Head*

Dasar Pemilihan : Digunakan untuk tangki vertikal bertekanan rendah (< 1 atm), terutama untuk tangki penyimpanan horizontal, serta menyimpan fluida yang volatil (Brownell *and* Young, 1959:91).



Menentukan dimensi tutup atas dan bawah

$th = \frac{P.r_c.W}{2f.E-0,2P} + C$ (Brownell *and* Young, 1959:91)

Ketebalan = OD – ID

= 9,70508 – 9,4488

= 0,25626 in

= 6,5090 mm

Sehingga diperoleh:

r = 12 in (jari-jari *dish*, in)

icr = ¾ (jari-jari sudut dalam, in) (Tabel 5.7, Brownell, 1959:89)

$$W = \frac{1}{4} x \left(3 + \sqrt{\frac{rc}{icr}}\right)$$

$$W = \frac{1}{4} x \left(3 + \sqrt{\frac{12}{3/4}}\right)$$

$W = 1,75$ in = 0,04445 m

maka,

$$th = \frac{P.r_c.W}{2f.E - 0,2P} + C$$

$$th = \frac{9{,}9208 \text{ psi x } 1{,}75 \text{ in}}{(2 \text{ x } 18750 \text{ x } 0{,}8) - (0{,}2 \text{ x } 9{,}9208)} + 0{,}125 \text{ in}$$

$$th = \frac{68{,}4015 \text{ KN/m}^2 \text{ x } 0{,}04445 \text{ m}}{(2 \text{ x } 69{,}3169 \text{ KN/m}^2 \text{ x } 0{,}8) - (0{,}2 \text{ x } 68{,}4015 \text{ KN/m}^2)} + 0{,}003175 \text{ m}$$

$$th = 0{,}031272 + 0{,}003175 \text{ m}$$

$$th = 0{,}03445 \text{ m}$$

$$th = 1{,}3563 \text{ inci}$$

Dipakai plat dengan tebal standar 1 3/8 in

sehingga didapat nilai Sf standar = 3,5 in (Tabel 5.4, Brownell, 1959:87)

$$a = \frac{ID}{3{,}5} = \frac{9{,}4488 \text{ in}}{3{,}5} = 2{,}6997 \text{ in}$$

$$AB = \frac{ID}{3{,}5} - \text{ irc} = \frac{9{,}4488 \text{ in}}{3{,}5} - \frac{3}{4}$$

$$= 1{,}9497 \text{ in}$$

$$BC = r - irc = 12 - \frac{3}{4} = \frac{48 - 3}{4} = 11{,}25 \text{ in}$$

$$AC = \sqrt{BC^2 - AB^2}$$

$$AC = \sqrt{11{,}25^2 - 1{,}9497^2}$$

$$AC = 11{,}0798 \text{ in}$$

b = r – AC = 12 in – 11,0798 in = 0,9202 in

$$OA = b + th + Sf$$

$$OA = 0{,}9202 + 1{,}3563 + 3{,}5$$

$$OA = 5{,}7765 \text{ in}$$

jadi,

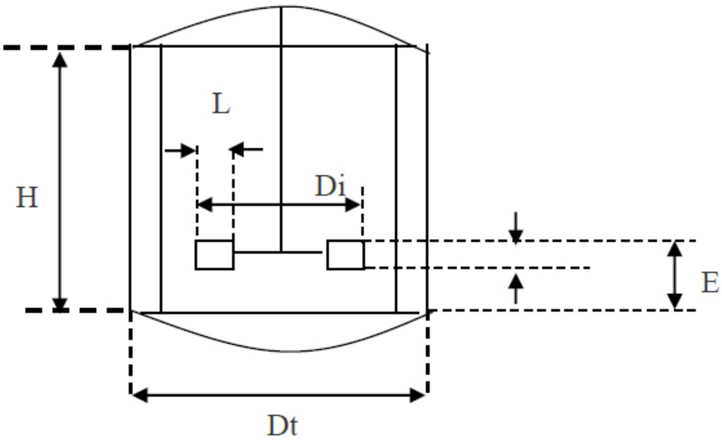
$$\text{Tinggi Evaporator} = \text{Tinggi } head + \text{Tinggi } shell$$

$$= 5{,}7765 \text{ in} + 6{,}9657 \; in$$

$$= 12{,}7422 \; in$$

$$= 32{,}3652 \; cm$$

d. Perancangan Pengaduk



Data pengadukan diperoleh dari Brown "*Unit Operation*" hal 507:

Di/ID = 1/3

B/ID = 1/12

W/Di = 1/5

E/Di = 1

L/Di = 1/4

Ukuran Pengaduk:

- Diameter Pengaduk (Di)

$$\mathrm{Di} = \frac{\mathrm{ID}}{3} = \frac{24\ \mathrm{cm}}{3} = 8\ \mathrm{cm}$$

- Lebar Padel (W)

$$\mathrm{W} = \frac{\mathrm{Di}}{5} = \frac{8\ \mathrm{cm}}{5} = 1{,}6\ \mathrm{cm}$$

- Panjang Padel (L)

$$\mathrm{L} = \frac{\mathrm{Di}}{4} = \frac{8\ \mathrm{cm}}{4} = 2\ \mathrm{cm}$$

- Lebar *Baffle* (B)

$$\mathrm{B} = \frac{\mathrm{ID}}{12} = \frac{24\ \mathrm{cm}}{12} = 2\ \mathrm{cm}$$

- Jarak Pengaduk dengan Dasar (E)

$\frac{\mathrm{E}}{\mathrm{Di}} = 0{,}75 - 1{,}3$: dipilih 1

$\mathrm{E} = 1 \times \mathrm{Di} = 1 \times 8\ \mathrm{cm} = 8\ \mathrm{cm}$

2. **Perhitungan Kadar Air**

Rumus yang digunakan untuk menentukan kadar air :

Kadar air = $\frac{W-(W1-W2)}{W}$ x 100 ...... (AOAC, 1995)

Keterangan :

W = bobot sampel sebelum dikeringkan (gr)

W1 = bobot sampel dan cawan kering (gr)

W2 = bobot cawan kosong (gr)

Waktu pengeringan = 5 jam

a. Sampel 1 (T= 50℃, 10 menit)

W = 4,7164 gr, W1 = 59,3761 gr, W2 = 58,5392 gr

Kadar air $= \frac{4,7164-(59,3761-58,5392)}{4,7164}$ x 100 = $\frac{4,7164 - 0,8369}{4,7164}$ x 100 = 82,26%

b. Sampel 2 (T= 50℃, 20 menit)

W = 2,0715 gr, W1 = 50,8662 gr, W2 = 50,4553 gr

Kadar air $= \frac{2,0715 \ -(50,8662-50,4553)}{2,0715}$ x 100 = $\frac{2,0715 \ - 0,4109}{2,0715}$ x 100 = 80,16%

c. Sampel 3 (T= 50℃, 30 menit)

W = 2,0967 gr, W1 = 59,1806 gr, W2 = 58,5517 gr

$Kadar\ air = \frac{2,0967-(59,1806 \ -58,5517)}{2,0967}$ x 100 = $\frac{2,0967 - 0,6289}{2,0967}$ x 100 = 70,05%

d. Sampel 4 (T= 50℃, 40 menit)

W = 2,1558 gr, W1 = 71,6561 gr, W2 = 70,9552 gr

$Kadar\ air = \frac{2,1558-(71,6561-70,9552)}{2,1558}$ x 100 = $\frac{2,1558 - 0,7009}{2,1558}$ x 100 = 67,49%

e. Sampel 5 (T= 50℃, 40 menit)

W = 2,1451 gr, W1 = 76,4908 gr, W2 = 75,7006 gr

$Kadar\ air = \frac{2,1451-(76,4908-75,7006)}{2,1451}$ x 100 = $\frac{2,1451- 0,7902}{2,1451}$ x 100 = 63,16%

f. Sampel 6 (T= 60°C, 10 menit)

W = 2,0258gr, W1 = 70,9112 gr, W2 = 70,4644 gr

$Kadar\ air = \frac{2,0258-(70,9112-70,4644)}{2,0258}$ x 100 = $\frac{2,0258 - 0,4468}{2,0258}$ x 100 = 77,95%

g. Sampel 7 (T= 60°C, 20 menit)

W = 2,1254 gr, W1 = 70,9689 gr, W2 = 70,4258 gr

$$Kadar\ air = \frac{2{,}1254\ -(70{,}9689-70{,}4258)}{2{,}1254}\ x\ 100 = \frac{2{,}1254\ -0{,}5431}{2{,}1254}\ x\ 100 = 74{,}45\%$$

h. Sampel 8 (T= 60℃, 30 menit)

W = 2,1693 gr, W1 = 29,14 gr, W2 = 28,3493 gr

$$Kadar\ air = \frac{2{,}1693\ -(29{,}14\ -28{,}3493)}{2{,}1693}\ x\ 100 = \frac{2{,}1693 - 0{,}7907}{2{,}1693}\ x\ 100 = 63{,}55\%$$

i. Sampel 9 (T= 60℃, 40 menit)

W = 2,0822 gr, W1 = 31,2568 gr, W2 = 30,3930 gr

$$Kadar\ air = \frac{2{,}0822\ -(31{,}2568-30{,}3930)}{2{,}0822}\ x\ 100 = \frac{2{,}0822 - 0{,}8638}{2{,}0822}\ x\ 100 = 58{,}52\%$$

j. Sampel 10 (T= 60℃, 50 menit)

W = 2,0291 gr, W1 = 74,9119 gr, W2 = 74,0520 gr

$$\text{Kadar air} = \frac{2{,}0291\ -(74{,}9119-74{,}0520)}{2{,}0291}\ \text{x}\ 100 = \frac{2{,}0291\ \ - 0{,}8599}{2{,}0291}\ x\ 100 = 57{,}62\%$$

3. Perhitungan Penentuan Viskositas Sirup

Diketahui :

Beratp piknometer kosong = 11,9454 gr

Berat piknometer + Air = 17,0562 gr

ρ. Air = 0,997 gr/cm^3

$$\text{V. piknometer} = \frac{B - A}{\rho.\,Air}$$

$$= \frac{17{,}0562\ gr - 11{,}9454\ gr}{0{,}997\ \ gr/cm^3}$$

$$= 5{,}1262\ cm^3$$

Temperatur (^oC)	Waktu (menit)	Lama Bola Turun (detik)	Berat Piknometer + Sirup (gr)

50	10	7,5	17,6498
	20	9,5	17,7112
	30	9,8	17,7345
	40	10,2	17,7561
	50	10,4	17,7970
60	10	9,7	17,8498
	20	10,6	17,8775
	30	11,3	17,9076
	40	12,4	17,9369
	50	13,6	17,9944

Rumus Viskositas : $\boldsymbol{\mu} = k\,(\boldsymbol{\rho}_1 - \boldsymbol{\rho}_2)\,t$ ......(Metode Hoppler)

a. Sampel 1 (50°C, 10 Menit)

Diketahui : $\boldsymbol{\rho}_1 = 8{,}1\ g/cm^3$

$$\boldsymbol{\rho}_2 = \frac{(17{,}6498 - 11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1128\ g/cm^3$$

$k = 0{,}09\ mPa.s\ cm^3/gr.s$

Viskositas :

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (8{,}1\ g/cm^3 - 1{,}1128\ g/cm^3)(7{,}5\ s)$

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (6{,}9872\ g/cm^3)(7{,}5\ s)$

$\boldsymbol{\mu} = 4{,}7164\ mPa.s = 4{,}7164\ cp$

b. Sampel 2 (50°C, 20 Menit)

Diketahui : $\boldsymbol{\rho}_1 = 8{,}1\ g/cm^3$

$$\boldsymbol{\rho}_2 = \frac{(17{,}7112 - 11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1248\ g/cm^3$$

$k = 0{,}09\ mPa.s\ cm^3/gr.s$

Viskositas :

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (8{,}1\ g/cm^3 - 1{,}1248\ g/cm^3)(9{,}5\ s)$

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (6{,}9752\ g/cm^3)(9{,}5\ s)$

$\boldsymbol{\mu} = 5{,}9638\ mPa.s = 5{,}9638\ cp$

c. Sampel 3 (50°C, 30 Menit)

Diketahui : $\boldsymbol{\rho}_1 = 8{,}1\ g/cm^3$

$$\boldsymbol{\rho}_2 = \frac{(17{,}7345 - 11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1293\ g/cm^3$$

$k = 0{,}09\ mPa.s\ cm^3/gr.s$

Viskositas :

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (8{,}1\ g/cm^3 - 1{,}1293\ g/cm^3)(9{,}8\ s)$

$\mu =$ (0,09 mPa.s cm^3/gr.s) (6,9707 g/cm^3)(9,8s)
$\mu =$ 6,1482 mPa.s = 6,1482 cp

d. Sampel 4 (50^{o}C, 40 Menit)
Diketahui : $\rho_1 = 8{,}1$ g/cm^3

$$\rho_2 = \frac{(17{,}7561 - 11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1335\ g/cm^3$$

k = 0,09 mPa.s cm^3/gr.s

Viskositas :
$\mu =$ (0,09 mPa.s cm^3/gr.s) (8,1 g/cm^3 - 1,1335 g/cm^3)(10,2 s)
$\mu =$ (0,09 mPa.s cm^3/gr.s) (6,9665 g/cm^3)(10,2 s)
$\mu =$ 6,3952 mPa.s = 6,3952 cp

e. Sampel 5 (50^{o}C, 50 Menit)
Diketahui : $\rho_1 = 8{,}1$ g/cm^3

$$\rho_2 = \frac{(17{,}7970 - 11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1415\ g/cm^3$$

k = 0,09 mPa.s cm^3/gr.s

Viskositas :
$\mu =$ (0,09 mPa.s cm^3/gr.s) (8,1 g/cm^3 - 1,1415 g/cm^3)(10,4 s)
$\mu =$ (0,09 mPa.s cm^3/gr.s) (6,9585 g/cm^3)(10,4 s)
$\mu =$ 6,5132 mPa.s = 6,5132 cp.

f. Sampel 6 (60^{o}C, 10 Menit)
Diketahui : $\rho_1 = 8{,}1$ g/cm^3

$$\rho_2 = \frac{(17{,}8498 - 11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1518\ g/cm^3$$

k = 0,09 mPa.s cm^3/gr.s

Viskositas :
$\mu =$ (0,09 mPa.s cm^3/gr.s) (8,1 g/cm^3 - 1,1518 g/cm^3)(9,7 s)
$\mu =$ (0,09 mPa.s cm^3/gr.s) (6,9482 g/cm^3)(9,7 s)
$\mu =$ 6,0658 mPa.s = 6,0658 cp.

g. Sampel 7 (60^{o}C, 20 Menit)
Diketahui : $\rho_1 = 8{,}1$ g/cm^3

$$\rho_2 = \frac{(17{,}8775 - 11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1572\ g/cm^3$$

k = 0,09 mPa.s cm^3/gr.s

Viskositas :
$\mu =$ (0,09 mPa.s cm^3/gr.s) (8,1 g/cm^3 - 1,1572 g/cm^3)(10,6 s)
$\mu =$ (0,09 mPa.s cm^3/gr.s) (6,9428 g/cm^3)(10,6 s)
$\mu =$ 6,6234 mPa.s = 6,6234 cp.

h. Sampel 8 (60^{o}C, 30 Menit)

Diketahui : $\boldsymbol{\rho}_1 = 8{,}1\ g/cm^3$

$$\boldsymbol{\rho}_2 = \frac{(17{,}9076-11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1631\ g/cm^3$$

k = 0,09 mPa.s cm^3/gr.s

Viskositas :

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (8{,}1\ g/cm^3 - 1{,}1631\ g/cm^3)(11{,}3s)$

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (6{,}9369\ g/cm^3)(11{,}3s)$

$\boldsymbol{\mu} = 7{,}0548$ mPa.s = 7,0548 cp.

i. Sampel 9 (60ºC, 40 Menit)

Diketahui : $\boldsymbol{\rho}_1 = 8{,}1\ g/cm^3$

$$\boldsymbol{\rho}_2 = \frac{(17{,}9369-11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1688\ g/cm^3$$

k = 0,09 mPa.s cm^3/gr.s

Viskositas :

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (8{,}1\ g/cm^3 - 1{,}1688\ g/cm^3)(12{,}4s)$

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (6{,}9312\ g/cm^3)(12{,}4s)$

$\boldsymbol{\mu} = 7{,}7352$ mPa.s = 7,7352 cp.

j. Sampel 10 (60ºC, 50 Menit)

Diketahui : $\boldsymbol{\rho}_1 = 8{,}1\ g/cm^3$

$$\boldsymbol{\rho}_2 = \frac{(17{,}9944-11{,}9454)gr}{5{,}1262\ cm^3} = 1{,}1800\ g/cm^3$$

k = 0,09 mPa.s cm^3/gr.s

Viskositas Dinamik

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (8{,}1\ g/cm^3 - 1{,}1800\ g/cm^3)(13{,}6\ s)$

$\boldsymbol{\mu} = (0{,}09\ mPa.s\ cm^3/gr.s)\ (6{,}92\ g/cm^3)(13{,}6\ s)$

$\boldsymbol{\mu} = 8{,}4701$ mPa.s = 8,4701 cp.

4. Perhitungan Penentuan Laju Evaporasi

Laju evaporasi:

$$\frac{\delta M}{\delta T} = \frac{m1-m2}{\theta} \text{ ..... (Ban, 1971)}$$

Keterangan:

$\frac{\delta M}{\delta T}$ = laju evaporasi

m1 = kadar air awal bahan

m2 = kadar air akhir bahan

θ = lamanya/waktu proses evaporasi

Sebelum evaporasi

W = 2,1515 gr, W1 = 71,9049 gr, W2 = 71,7974 gr

$$Kadar\ air = \frac{2{,}1515 - (71{,}9049 - 71{,}7974)}{2{,}1515}\ x\ 100 = \frac{2{,}1515 - 0{,}1075}{2{,}1515}\ x\ 100 = 95\%$$

Setelah evaporasi

Ulangan I
T= 50℃, 40 menit
W = 2,0242 gr, W1 = 72,47 gr, W2 = 71,8120 gr

$$Kadar\ air = \frac{2{,}0242 - (72{,}47 - 71{,}8120)}{2{,}0242}\ x\ 100 = \frac{2{,}0242 - 0{,}658}{2{,}0242}\ x\ 100 = 67{,}49\%$$

M1 = 95%
M2 = 67,49%

$$\frac{\delta M}{\delta T} = \frac{95 - 67{,}49}{40} = 0{,}68775\ \text{gr uap/menit} = 41{,}0597\ \text{gr uap/jam}$$

Ulangan II
T= 50℃, 40 menit
W = 2,1451 gr, W1 = 76,4908 gr, W2 = 75,7006 gr

$$Kadar\ air = \frac{2{,}1451 - (76{,}4908 - 75{,}7006)}{2{,}1451}\ x\ 100 = \frac{2{,}1451 - 0{,}7902}{2{,}1451}\ x\ 100 = 63{,}16\%$$

M1 = 95%
M2 = 63,16%

$$\frac{\delta M}{\delta T} = \frac{95 - 63{,}16}{40} = 0{,}796\ \text{gr uap/menit} = 47{,}52\ \text{gr uap/jam}$$

Sebelum evaporasi

W = 2,1515 gr, W1 = 71,9049 gr, W2 = 71,7974 gr

$$Kadar\ air = \frac{2{,}1515 - (71{,}9049 - 71{,}7974)}{2{,}1515}\ x\ 100 = \frac{2{,}1515 - 0{,}1075}{2{,}1515}\ x\ 100 = 95\%$$

Setelah evaporasi

Ulangan I
T= 60℃, 40 menit
W = 2,0822 gr, W1 = 31,2568 gr, W2 = 30,3930 gr

$$Kadar\ air = \frac{2{,}0822 - (31{,}2568 - 30{,}3930)}{2{,}0822}\ x\ 100 = \frac{2{,}0822 - 0{,}8638}{2{,}0822}\ x\ 100 = 58{,}52\%$$

M1 = 95%
M2 = 58,52%

$$\frac{\delta M}{\delta T} = \frac{95 - 58{,}52}{40} = 0{,}912\ \text{gr uap/menit} = 54{,}4478\ \text{gr uap/jam}$$

Ulangan II
T= 60℃, 40 menit
W = 2,0587 gr, W1 = 29,1759 gr, W2 = 28,2545 gr

$$Kadar\ air = \frac{2{,}0587 - (29{,}1759 - 28{,}2545)}{2{,}0587}\ x\ 100 = \frac{2{,}0587 - 0{,}9214}{2{,}0587}\ x\ 100 = 55{,}24\%$$

M1 = 95%
M2 = 55,24%

$$\frac{\delta M}{\delta T} = \frac{95 - 55{,}24}{40} = 0{,}994\ \text{gr uap/menit} = 59{,}34\ \text{gr uap/jam}$$

5. Organoleptik (Uji Kesukaan)

Perhitungan organoleptik berdasarkan ANOVA:

A. Organoleptik Terhadap Rasa

Diketahui :

N = 250

k = 10

n = 25

Ditanya : F tabel

Penyelesaian :

dbK = k – 1

= 10 – 1

= 9

dbG = N – k

= 250 – 10

= 240

dbT = N – 1

= 250 – 1

= 249

$$JKK = \frac{(\Sigma Yt)^2}{n} - \frac{(\Sigma Y)^2}{N}$$

$$= (\frac{85^2}{25} + \frac{80^2}{25} + \frac{73^2}{25} + \frac{68^2}{25} + \frac{73^2}{25} + \frac{82^2}{25} + \frac{75^2}{25} + \frac{69^2}{25} + \frac{64^2}{25} + \frac{72^2}{25}) - \frac{731^2}{250}$$

$$= 20,8360$$

$$JKT = \Sigma Y^2 - \frac{(\Sigma Y)^2}{N}$$

$$= 2237 - (\frac{731^2}{250})$$

$$= 99,560$$

$$JKG = JKT - JKK$$

$$= 99,560 - 20,8360$$

$$= 78,7200$$

$$KTK = \frac{JKK}{dbK}$$

$$= \frac{20,8360}{9}$$

$$= 2,3151$$

$$\text{KTG} = \frac{\text{JKG}}{\text{dbG}}$$

$$= \frac{78,7200}{240}$$

$$= 0,3280$$

$$\text{F hitung} = \frac{\text{KTK}}{\text{KTG}}$$

$$= \frac{2,3151}{0,3280}$$

$$= 7,06$$

F tabel = 1,915 (diperoleh dari tabel F)

F hitung $> F\ tabel$

B. Organoleptik Terhadap Warna

Diketahui :

N = 250

k = 10

n = 25

Ditanya : F tabel

Penyelesaian :

dbK = k – 1

= 10 – 1

= 9

dbG = N – k

= 250 – 10

= 240

dbT = N – 1

= 250 – 1

= 249

$$JKK = \frac{(\Sigma Yt)^2}{n} - \frac{(\Sigma Y)^2}{N}$$

$$= \left(\frac{73^2}{25} + \frac{68^2}{25} + \frac{62^2}{25} + \frac{59^2}{25} + \frac{57^2}{25} + \frac{70^2}{25} + \frac{60^2}{25} + \frac{63^2}{25} + \frac{58^2}{25} + \frac{55^2}{25}\right) - \frac{630^2}{250}$$

$$= 12{,}8000$$

$$JKT = \Sigma Y^2 - \frac{(\Sigma Y)^2}{N}$$

$$= 1730 - \left(\frac{630^2}{250}\right)$$

$$= 142{,}4000$$

$$JKG = JKT - JKK$$

$$= 142{,}4000 - 12{,}8000$$

$$= 129{,}6000$$

$$KTK = \frac{JKK}{dbK}$$

$$= \frac{12{,}8000}{9}$$

$$= 1{,}4222$$

$$KTG = \frac{JKG}{dbG}$$

$$= \frac{129{,}6000}{240}$$

$$= 0{,}5400$$

$$F\ hitung = \frac{KTK}{KTG}$$

$$= \frac{1{,}4222}{0{,}5400}$$

$$= 2{,}63$$

F tabel $= 1{,}915$ (diperoleh dari tabel F)

F hitung $> F\ tabel$

C. Organoleptik Terhadap Bau

Diketahui :

N = 250

k = 10

n = 25

Ditanya : F tabel

Penyelesaian :

dbK = k – 1

= 10 – 1

= 9

dbG = N – k

= 250 – 10

= 240

dbT = N – 1

= 250 – 1

= 249

$$JKK = \frac{(\Sigma Yt)^2}{n} - \frac{(\Sigma Y)^2}{N}$$

$$= (\frac{76^2}{25} + \frac{75^2}{25} + \frac{69^2}{25} + \frac{65^2}{25} + \frac{62^2}{25} + \frac{72^2}{25} + \frac{71^2}{25} + \frac{68^2}{25} + \frac{63^2}{25} + \frac{61^2}{25}) - \frac{682^2}{250}$$

$$= 10{,}3040$$

$$JKT = \Sigma Y^2 - \frac{(\Sigma Y)^2}{N}$$

$$= 1992 - (\frac{682^2}{250})$$

$$= 131{,}5040$$

$$JKG = JKT - JKK$$

$$= 131{,}5040 - 10{,}3040$$

$$= 121{,}200$$

$$KTK = \frac{JKK}{dbK}$$

$$= \frac{10,3040}{9}$$

$$=1,1449$$

$$\text{KTG} = \frac{\text{JKG}}{\text{dbG}}$$

$$= \frac{121,200}{240}$$

$$=0,5050$$

$$\text{F hitung} = \frac{\text{KTK}}{\text{KTG}}$$

$$= \frac{1,1449}{0,5050}$$

$$= 2,27$$

F tabel = 1,915 (diperoleh dari tabel F)

F hitung $> F\ tabel$

LAMPIRAN C

DOKUMENTASI

LAMPIRAN C
DOKUMENTASI

Buah Mengkudu

Gula

Buah Mengkudu yang telah di potong

Penghalusan Buah Mengkudu

Penyaringan Sari Buah Mengkudu

Sari buah mengkudu yang telah disaring

Pengentalan dengan alat evaporator

Persiapan sampel untuk uji kadar air

Sampel yang akan diuji kadar air dimasukkan kedalam oven

Pengamatan Tekanan

Uji Organoleptik

Sirup Buah Mengkudu