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APPENDICES



APPENDIX A

Foreign Trade Statistics of Gelatin * (12)

B.E.		Quantity (kg)	C.I.F Value (Baht)
2516	Gelatin Edible Coloured or not	33,221	1,076,442
	Gelatin and Gelatin derivatives	39,530	1,189,500
2517	Gelatin Edible Coloured or not	67,690	4,190,654
	Gelatin and Gelatin derivatives	30,278	1,092,450
2518	Gelatin Edible Coloured or not	79,539	5,188,032
	Gelatin and Gelatin derivatives	3,084	235,391
2519	Gelatin Edible Coloured or not	93,659	5,084,299
	Gelatin and Gelatin derivatives	9,648	327,460
2520	Gelatin Edible Coloured or not	171,665	7,612,299
	Gelatin and Gelatin derivatives	11,434	486,717
2521	Gelatin Edible Coloured or not	133,894	7,355,055
	Gelatin and Gelatin derivatives	60	14,716

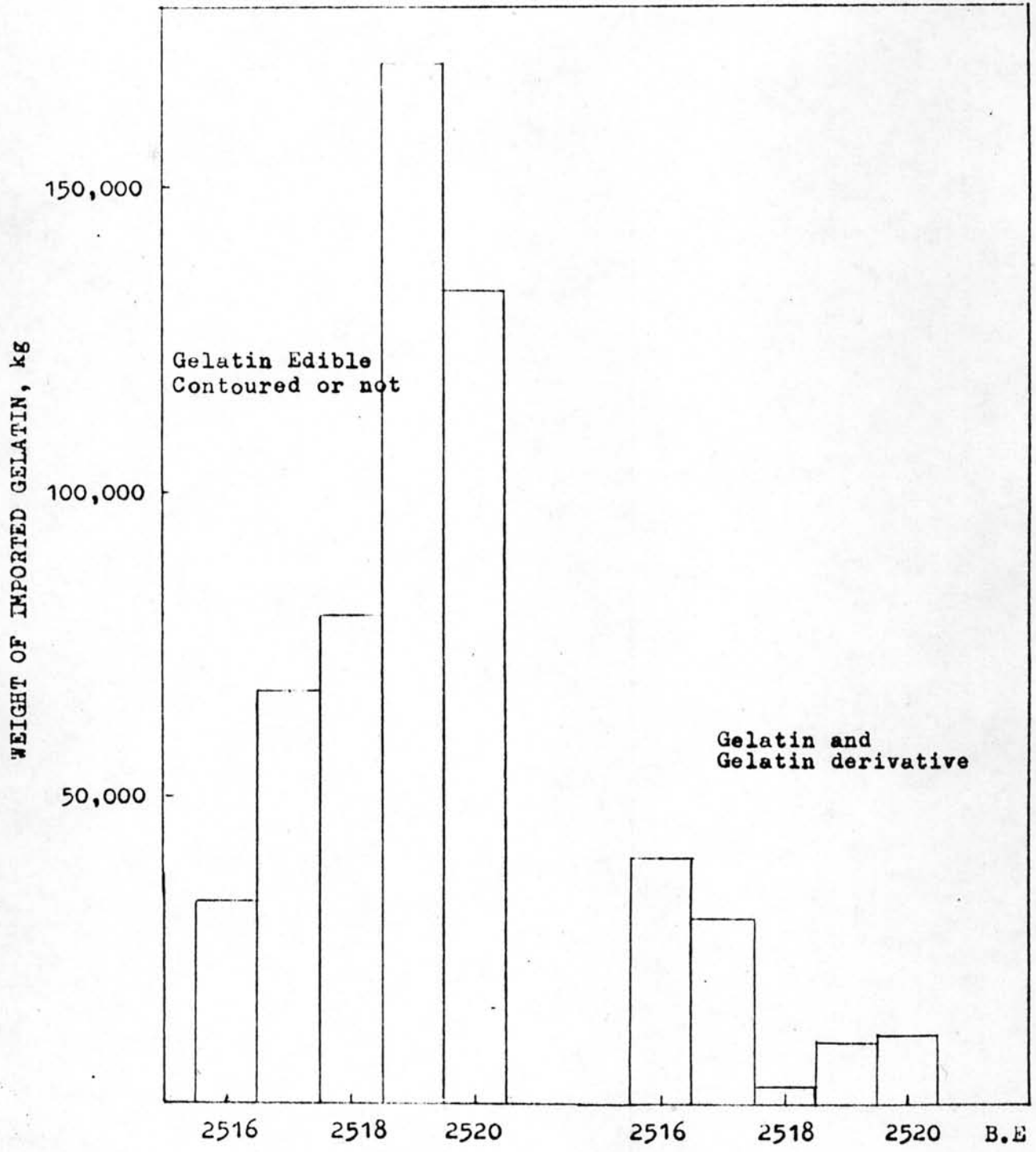


Figure A.1 Foreign Trade Statistics of Gelatin Quantity v.s B.E

APPENDIX BTable B.1Experimental Data and Results for Run No.1Drying conditions:

Temp. of air	=	76.0 °C	Air flow rate	=	2.16 m/sec
Dry bulb temp.	=	30.5 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	27 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	12.91 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	69.35	1.0000	4.37			
10	62.75	0.9048	3.86			1.1432
30	50.90	0.7348	2.94			1.1432
50	39.15	0.5645	2.03			1.1432
70	30.10	0.4340	1.33	51.02	1.40	0.6234
90	24.60	0.3547	0.90	25.47	0.97	0.4330
110	21.65	0.3122	0.67	21.70	0.68	0.2867
130	19.35	0.2790	0.50	19.28	0.49	0.1789
150	18.25	0.2632	0.41	17.81	0.38	0.1043
160	17.80	0.2567	0.38	17.33	0.34	0.0777
245	15.25	0.2199	0.18			
270	14.95	0.2156	0.16			
285	14.85	0.2141	0.15			
310	14.70	0.2120	0.14			

• by equation;

$$W = 72.000 - 0.907t + 0.557 \times 10^{-2} t^2 - 0.151 \times 10^{-4} t^3 + 0.151 \times 10^{-7} t^4$$

Table B.2

Experimental Data and Results for Run No.2Drying conditions:

Temp. of air	=	76.0 °C	Air flow rate	=	3.86 m/sec
Dry bulb temp.	=	28.5 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	24.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.29 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	69.30	1.0000	4.21			
10	63.40	0.9149	3.77			
20	57.60	0.8312	3.33			1.0883
50	40.55	0.5851	2.05			1.0883
105	22.20	0.3203	0.67	22.85	0.72	1.0883
120	20.25	0.2922	0.52	20.26	0.52	0.3744
140	17.80	0.2568	0.34	17.82	0.34	0.2824
160	16.60	0.2395	0.25	16.29	0.22	0.1839
200	15.20	0.2193	0.14	14.99	0.13	0.1104
240	14.70	0.2121	0.11			0.0247
290	14.30	0.2063	0.08			
320	14.20	0.2049	0.07			

* by equation;

$$W = 71.800 - 0.828t + 0.443 \times 10^{-2} t^2 - 0.103 \times 10^{-4} t^3 + 0.857 \times 10^{-8} t^4$$

Table B.3

Experimental Data and Results for Run No.3Drying conditions:

Temp. of air	=	76.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	25.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.36 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	67.20	1.0000	4.03			1.1025
20	54.90	0.8170	3.11			1.1025
40	43.90	0.6533	2.29			1.1025
60	33.70	0.5015	1.52	33.80	1.53	0.9777
80	26.40	0.3928	0.98	25.56	0.91	0.6012
110	20.30	0.3021	0.52	19.20	0.44	0.2335
140	17.80	0.2649	0.33	17.17	0.28	0.0526
160	16.90	0.2515	0.26	16.89	0.26	
180	16.20	0.2411	0.21			
210	15.75	0.2344	0.18			
250	15.20	0.2262	0.14			
295	14.95	0.2225	0.12			
320	14.75	0.2195	0.10			

• by equation;

$$W = 92.000 - 0.154 \times 10^{-1} t + 0.117 \times 10^{-1} t^2 - 0.383 \times 10^{-4} t^3 + 0.455 \times 10^{-7} t^4$$

Table B.4

Experimental Data and Results for Run No.4Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	2.72 m/sec
Dry bulb temp.	=	29.5 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	23.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.30 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	70.85	1.0000	4.33			
10	64.50	0.9104	3.85			1.1183
30	51.90	0.7325	2.90			1.1183
40	46.30	0.6535	2.48			1.1183
60	35.40	0.4996	1.66			1.1183
80	27.80	0.3924	1.09	29.00	1.18	0.5501
90	25.30	0.3571	0.90	26.33	0.98	0.4611
120	21.50	0.3034	0.62	20.79	0.56	0.2526
150	18.80	0.2653	0.41	17.94	0.35	0.1194
180	16.90	0.2385	0.27	16.69	0.25	0.0462
240	15.25	0.2152	0.15	15.98	0.20	0.0176
300	14.60	0.2061	0.10			
360	14.20	0.2004	0.07			
390	14.10	0.1990	0.06			

• by equation;

$$W = 73.500 - 0.985t + 0.523 \times 10^{-2} t^2 - 0.135 \times 10^{-4} t^3 + 0.127 \times 10^{-7} t^4$$

Table B.5

Experimental Data and Results for Run No.5Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	3.37 m/sec
Dry bulb temp.	=	30.5 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	25.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	14.39 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	72.70	1.0000	4.05			
10	65.20	0.8968	3.53			1.3319
20	58.19	0.8004	3.04			1.3319
40	44.55	0.6128	2.10			1.3319
60	33.60	0.4622	1.33	33.56	1.33	0.7724
75	28.75	0.3955	1.00	28.64	0.99	0.4862
120	22.00	0.3109	0.57	22.41	0.56	0.1409
150	20.30	0.2792	0.41	20.29	0.41	0.1399
170	19.05	0.2620	0.32	18.74	0.30	0.1478
180	18.20	0.2503	0.26	17.99	0.25	0.1367
215	17.20	0.2366	0.20			
220	17.05	0.2345	0.18			

• by equation;

$$W = 91.400 - 1.740t + 0.174 \times 10^{-1} t^2 - 0.775 \times 10^{-4} t^3 + 0.129 \times 10^{-6} t^4$$

Table B.6

Experimental Data and Results for Run No.6Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	3.84 m/sec
Dry bulb temp.	=	30.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	25.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.77 gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	70.80	1.0000	4.14			
10	62.70	0.8856	3.55			1.4442
25	50.20	0.7090	2.64			1.4442
40	39.20	0.5537	1.85			1.4442
50	32.65	0.4612	1.37			1.4442
60	27.50	0.3884	1.00	28.41	1.06	0.7787
70	24.40	0.3446	0.77	24.76	0.80	0.6079
80	22.45	0.3171	0.63	21.95	0.59	0.4583
120	17.40	0.2458	0.26	16.91	0.23	0.0790
130	16.90	0.2387	0.23	16.60	0.20	0.0413
140	16.35	0.2309	0.19	16.43	0.19	0.0274
150	15.55	0.2196	0.13			
180	14.70	0.2076	0.07			

* by equation;

$$W = 74.100 - 1.170t + 0.784 \times 10^{-2} t^2 - 0.158 \times 10^{-4} t^3 - 0.978 \times 10^{-8} t^4$$

Table B.7

Experimental Data and Results for Run No.7Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	32.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	26.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.51 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	69.70	1.0000	4.16			
10	62.50	0.8967	3.63			1.2997
20	55.50	0.7963	3.11			1.2997
30	49.00	0.7030	2.63			1.2997
40	42.20	0.6054	2.12			1.2997
50	35.50	0.5093	1.63			1.2997
60	28.50	0.4088	1.11	28.64	1.12	1.0378
70	25.00	0.3578	0.85	24.99	0.85	0.5803
90	19.50	0.2798	0.44	19.59	0.45	0.3015
130	15.40	0.2209	0.14	15.53	0.15	0.1185
200	14.00	0.2009	0.04			

* by equation;

$$W = 84.600 - 1.530t + 0.126 \times 10^{-1} t^2 - 0.455 \times 10^{-4} t^3 + 0.610 \times 10^{-7} t^4$$

Table B.8

Experimental Data and Results for Run No.8Drying conditions:

Temp. of air	=	30.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	30.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	24.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.47 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	71.30	1.0000	4.29			
40	67.60	0.9481	4.02			0.2140
80	63.55	0.8913	3.72			0.2140
140	56.60	0.7938	3.20			0.2140
180	51.60	0.7237	2.83			0.2140
220	46.50	0.6522	2.45			0.2140
240	44.50	0.6241	2.30			0.2140
320	35.10	0.4923	1.60			0.2140
340	33.10	0.4642	1.46	34.10	1.53	0.1609
380	29.25	0.4102	1.17	30.87	1.29	0.1440
400	27.80	0.3899	1.06	29.39	1.18	0.1360
600	21.80	0.3058	0.62	19.30	0.43	0.0571
800	17.00	0.2384	0.26			
900	16.00	0.2244	0.19			

* by equation;

$$W = 75.000 - 0.151t + 0.738 \times 10^{-4} t^2 + 0.678 \times 10^{-7} t^3 - 0.470 \times 10^{-10} t^4$$

Table B.9

Experimental Data and Results for Run No.9Drying conditions:

Temp. of air	=	57.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	25.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	12.60 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	67.60	1.0000	4.36			
20	59.70	0.8831	3.74			0.7066
45	50.10	0.7411	2.98			0.7066
60	44.20	0.6538	2.51			0.7066
90	34.00	0.5029	1.70			0.7066
135	23.15	0.3424	0.84	24.08	0.91	0.3171
160	19.80	0.2929	0.57	20.50	0.63	0.2273
180	18.45	0.2729	0.46	18.43	0.46	0.1663
210	16.90	0.2500	0.34	16.41	0.30	0.0920
240	16.25	0.2404	0.29			
300	15.45	0.2286	0.23			
330	15.20	0.2248	0.21			
400	14.95	0.2211	0.19			

* by equation;

$$W = 71.300 - 0.577t + 0.203 \times 10^{-2} t^2 - 0.273 \times 10^{-5} t^3 + 0.935 \times 10^{-9} t^4$$

Table B.10

Experimental Data and Results for Run No.10Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	98.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	48.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.53 gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	68.20	1.0000	4.04			
20	51.70	0.7581	2.82			
40	37.00	0.5425	1.73			1.4764
60	27.60	0.4047	1.04	28.62	1.12	1.4764
90	21.10	0.3094	0.56	20.67	0.53	0.6981
110	18.90	0.2771	0.40	18.03	0.33	0.3335
185	15.20	0.2229	0.12	15.99	0.18	0.1779
220	14.70	0.2155	0.09			
260	14.30	0.2097	0.06			
280	14.15	0.2075	0.04			
290	14.10	0.2067	0.04			

* by equation;

$$W = 69.600 - 1.080t + 0.802 \times 10^{-2} t^2 - 0.261 \times 10^{-4} t^3 + 0.308 \times 10^{-7} t^4$$

Table B.11

Experimental Data and Results for Run No.11Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	3.86 m/sec
Dry bulb temp.	=	98.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	43.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.12 gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	67.70	1.0000	4.16			
20	47.95	0.7083	2.65			1.5794
45	30.15	0.4453	1.30			1.5794
75	20.10	0.2969	0.53	20.37	0.55	0.4074
105	17.20	0.2541	0.31	16.44	0.20	0.0350
120	15.80	0.2334	0.20	15.74	0.14	0.0454
170	14.15	0.2090	0.08	14.96	0.12	
180	13.95	0.2060	0.06			
200	13.85	0.2046	0.06			
220	13.75	0.2031	0.05			
240	13.70	0.2024	0.04			
260	13.65	0.2016	0.04			

* by equation;

$$W = 69.100 - 1.280t + 0.114 \times 10^{-1} t^2 - 0.449 \times 10^{-4} t^3 + 0.646 \times 10^{-7} t^4$$

Table B.12

Experimental Data and Results for Run No.12Drying conditions:

Temp. of air	=	32.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	32.0 °C	Thickness of sol	=	1.5 mm
Wet bulb temp.	=	26.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	9.01 gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	49.60	1.0000	4.50			
20	47.25	0.9526	4.24			
40	44.85	0.9042	3.98			0.2160
60	42.85	0.8629	3.75			0.2160
90	39.30	0.7923	3.36			0.2160
130	34.90	0.7036	2.87			0.2160
155	32.15	0.6482	2.57			0.2160
265	19.35	0.3901	1.15			0.2160
355	13.00	0.2621	0.44	13.28	0.47	0.2160
435	11.10	0.2238	0.23	11.05	0.23	0.0879
455	10.90	0.2198	0.21	10.89	0.21	0.0214
470	10.80	0.2177	0.20	10.84	0.20	0.0009
						0.0002

* by equation;

$$W = 48.300 - 0.637 \times 10^{-1} t - 0.489 \times 10^{-3} t^2 + 0.151 \times 10^{-5} t^3 - 0.114 \times 10^{-8} t^4$$

Table B.13

Experimental Data and Results for Run No.13Drying conditions:

Temp. of air	=	32.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	32.0 °C	Thickness of sol	=	3.5 mm
Wet bulb temp.	=	27.0 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	20.27 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	109.45	1.0000	4.40			
40	105.33	0.9625	4.20			0.2082
90	100.50	0.9182	3.96			0.2082
110	98.30	0.8981	3.85			0.2082
150	94.25	0.8611	3.65			0.2082
180	90.65	0.8282	3.47			0.2082
240	84.25	0.7698	3.16			0.2082
300	77.25	0.7058	2.81			0.2082
390	66.65	0.6090	2.29			0.2082
450	59.95	0.5477	1.96			0.2082
530	51.50	0.4705	1.54	51.77	1.55	0.1869
590	46.35	0.4235	1.29	46.10	1.27	0.1705
685	38.45	0.3513	0.90	38.29	0.89	0.1397
830	29.55	0.2700	0.46	29.62	0.46	0.0859

* by equation;

$$W = 109.000 - 0.822 \times 10^{-1} t - 0.126 \times 10^{-3} t^2 + 0.175 \times 10^{-6} t^3 - 0.499 \times 10^{-10} t^4$$

Table B.14

Experimental Data and Results for Run No. 14

Drying conditions:

Temp. of air	=	32.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	32.0 °C	Thickness of sol	=	4.5 mm
Wet bulb temp.	=	23.5 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	26.54 gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	146.35	1.0000	4.51			
30	141.55	0.9672	4.33			
60	137.20	0.9375	4.17			0.3052
100	131.40	0.8978	3.95			0.3052
120	128.45	0.8777	3.84			0.3052
150	123.50	0.8439	3.65			0.3052
240	108.10	0.7386	3.07			0.3052
305	96.80	0.6614	2.65			0.3052
360	87.75	0.5996	2.31			0.3052
440	76.05	0.5196	1.86	76.46	1.88	0.3052
530	65.15	0.4452	1.45	64.97	1.45	0.2699
650	53.60	0.3662	1.02	53.09	1.00	0.2171
770	44.60	0.3047	0.68	45.02	0.70	0.1544
890	39.20	0.2678	0.48	39.78	0.50	0.1003
						0.0680

* by equation;

$$W = 146.000 - 0.126t - 0.220 \times 10^{-3} t^2 + 0.415 \times 10^{-6} t^3 - 0.179 \times 10^{-9} t^4$$

Table B.15

Experimental Data and Results for Run No.15Drying conditions:

Temp. of air	=	57.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	28.5 °C	Thickness of sol	=	1.5 mm
Wet bulb temp.	=	24.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	9.17 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	47.20	1.0000	4.15			
20	40.60	0.8602	3.43			0.6516
40	32.90	0.6970	2.59			0.6516
70	23.10	0.4894	1.52			0.6516
100	15.80	0.3347	0.72	16.33	0.78	0.2991
120	13.10	0.2775	0.43	13.70	0.49	0.2018
150	11.50	0.2436	0.25	11.40	0.24	0.0956
185	10.96	0.2309	0.19	10.39	0.13	0.0225
215	10.60	0.2246	0.16			
246	10.45	0.2214	0.14			
306	10.10	0.2140	0.10			
340	9.95	0.2108	0.08			

* by equation;

$$W = 52.400 - 0.628t + 0.339 \times 10^{-2} t^2 - 0.778 \times 10^{-5} t^3 + 0.633 \times 10^{-8} t^4$$

Table B.16

Experimental Data and Results for Run No.16Drying conditions:

Temp. of air	=	57.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	30.0 °C	Thickness of sol	=	3.5 mm
Wet bulb temp.	=	24.0 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	19.82 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	103.45	1.0000	4.22			
40	89.85	0.8685	3.53			0.6249
100	68.30	0.6602	2.45			0.6249
150	53.45	0.5167	1.70			0.6249
180	45.65	0.4413	1.30	46.99	1.37	0.3674
210	39.65	0.3833	1.00	41.68	1.10	0.2989
270	33.15	0.3204	0.67	33.99	0.72	0.1863
360	28.65	0.2769	0.44	28.04	0.41	0.0717
420	26.95	0.2605	0.36			
450	26.35	0.2547	0.33			
480	25.85	0.2499	0.30			
600	23.80	0.2301	0.20			
800	22.00	0.2127	0.11			

* by equation;

$$W = 109.000 - 0.522t + 0.119 \times 10^{-2} t^2 - 0.113 \times 10^{-5} t^3 + 0.372 \times 10^{-9} t^4$$

Table B.17

Experimental Data and Results for Run No.17Drying conditions:

Temp. of air	=	57.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	30.0 °C	Thickness of sol	=	4.5 mm
Wet bulb temp.	=	25.5 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	27.58 gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	145.93	1.0000	4.29			
105	106.05	0.7266	2.84			
180	81.40	0.5577	1.95			0.6724
240	63.75	0.4368	1.31			0.6724
270	57.05	0.3909	1.07	62.99	1.28	0.4173
300	52.00	0.3563	0.88	56.85	1.06	0.3510
360	45.70	0.3131	0.66	51.71	0.87	0.2929
390	41.10	0.2816	0.49	43.94	0.59	0.1972
430	39.05	0.2676	0.42	41.09	0.49	0.1589
490	36.80	0.2521	0.33	38.17	0.38	0.1169
540	35.65	0.2443	0.29	35.21	0.28	0.0769
660	33.10	0.2268	0.20			
785	31.85	0.2182	0.15			
840	31.75	0.2175	0.15			

* by equation;

$$W = 165.000 - 0.681t + 0.133 \times 10^{-2} t^2 - 0.117 \times 10^{-5} t^3 + 0.383 \times 10^{-9} t^4$$

Table B.18

Experimental Data and Results for Run No.18Drying conditions:

Temp. of air	=	76.0 °C	Air flow rate	=	4.39	m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	1.5	mm
Wet bulb temp.	=	25.0 °C	Surface area	=	0.0317	m ²
			Bone dry solid	=	9.74	gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	47.00	1.0000	3.82			
20	35.20	0.7489	2.61			1.0410
40	25.00	0.5319	1.57			1.0410
60	18.10	0.3851	0.86	18.73	0.92	0.4789
80	14.85	0.3160	0.52	14.86	0.53	0.2632
100	13.55	0.2886	0.39	12.96	0.33	0.1074
120	12.80	0.2723	0.31			
140	12.30	0.2617	0.26			
180	11.55	0.2457	0.18			
200	11.15	0.2372	0.14			

* by equation;

$$W = 48.400 - 0.785t + 0.562 \times 10^{-2} t^2 - 0.132 \times 10^{-4} t^3$$

Table B.19

Experimental Data and Results for Run No. 19Drying conditions:

Temp. of air	=	76.0 °C	Air flow rate	=	4.39	m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	3.5	mm
Wet bulb temp.	=	26.0 °C	Surface area	=	0.0320	m ²
			Bone dry solid	=	18.80	gm

t	Experimental Data			Calculated Data *		R
	W	W _f	X	W _c	X _c	
0	102.40	1.0000	4.45			
10	96.00	0.9375	4.11			1.0688
30	84.40	0.8242	3.49			1.0688
50	71.60	0.6992	2.81			1.0688
80	54.20	0.5293	1.88			1.0688
100	45.40	0.4434	1.41	45.91	1.44	0.6653
135	33.85	0.3306	0.80	35.78	0.90	0.4309
165	29.40	0.2871	0.56	30.15	0.60	0.2790
200	26.20	0.2559	0.39	26.21	0.39	0.1515
240	25.05	0.2446	0.33	24.04	0.28	0.0607
270	24.30	0.2373	0.29			
320	22.95	0.2241	0.22			
420	21.70	0.2112	0.15			
520	20.90	0.2041	0.11			

* by equation;

$$W = 107.000 - 0.934t + 0.384 \times 10^{-2} t^2 - 0.688 \times 10^{-5} t^3 + 0.450 \times 10^{-8} t^4$$

Table B.20

Experimental Data and Results for Run No.20Drying conditions:

Temp. of air	=	76.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	4.5 mm
Wet bulb temp.	=	25.5 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	27.31 gm

t	Experimental Data			Calculated Data *		R
	W	W _f	X	W _c	X _c	
0	145.75	1.0000	4.34			
20	134.75	0.9245	3.93			1.0181
60	111.65	0.7660	3.09			1.0181
100	91.45	0.6274	2.35			1.0181
155	67.35	0.4621	1.47	67.89	1.48	0.6369
180	58.45	0.4010	1.14	60.06	1.20	0.5386
210	51.10	0.3506	0.87	52.33	0.92	0.4296
240	46.35	0.3186	0.70	46.25	0.69	0.3315
270	42.75	0.2933	0.56	41.66	0.52	0.2452
305	38.25	0.2624	0.40	37.90	0.39	0.1600
360	34.95	0.2398	0.28	34.75	0.27	0.0681
400	33.75	0.2316	0.24			
480	32.05	0.2199	0.17			

* by equation;

$$W = 150 - 0.734t + 0.243 \times 10^{-2} t^2 - 0.540 \times 10^{-6} t^3 - 0.628 \times 10^{-9} t^4$$

Table B.21

Experimental Data and Results for Run No.21Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	33.0 °C	Thickness of sol	=	1.5 mm
Wet bulb temp.	=	23.5 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	8.96 gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	47.40	1.0000	4.29			
10	39.30	0.8291	3.39			
30	25.50	0.5380	1.84			1.3816
45	18.00	0.3797	1.01			1.3816
60	14.20	0.2996	0.58	18.52	1.07	0.6942
80	12.45	0.2626	0.39	14.47	0.61	0.3346
150	10.20	0.2152	0.14			0.1640
						0.0603

* by equation;

$$W = 48.000 - 0.908t + 0.431 \times 10^{-2} t^2 + 0.415 \times 10^{-4} t^3 - 0.271 \times 10^{-6} t^4$$

Table B. 22

Experimental Data and Results for Run No.22Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	3.5 mm
Wet bulb temp.	=	24.8 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	20.16 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	102.95	1.0000	4.11			
10	93.80	0.9111	3.65			
20	85.75	0.8329	3.25			1.4515
40	70.25	0.6824	2.48			1.4515
60	56.50	0.5488	1.80			1.4515
80	45.15	0.4386	1.24	46.10	1.29	1.4515
105	35.80	0.3477	0.78	37.26	0.85	0.7981
140	30.00	0.2914	0.49	29.79	0.48	0.5393
160	27.85	0.2705	0.38	27.37	0.36	0.2800
180	26.35	0.2559	0.31	25.87	0.28	0.1786
200	25.45	0.2472	0.26			0.1064
260	23.20	0.2254	0.15			
320	22.45	0.2181	0.11			

* by equation;

$$W = 106.000 - 1.140t + 0.595 \times 10^{-2} t^2 - 0.135 \times 10^{-4} t^3 + 0.111 \times 10^{-7} t^4$$

Table B.23

Experimental Data and Results for Run No.23

Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39	m/sec
Dry bulb temp.	=	30.0 °C	Thickness of sol	=	4.5	mm
Wet bulb temp.	=	25.5 °C	Surface area	=	0.0320	m ²
			Bone dry solid	=	2524	gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	142.45	1.0000	4.64			
10	132.75	0.9319	4.64			
20	123.55	0.8673	3.89			1.7352
55	91.55	0.6472	2.63			1.7352
80	75.60	0.5307	2.00			1.7352
100	65.65	0.4609	1.60	77.01	2.05	1.0336
135	55.00	0.3961	1.18	67.00	1.66	0.8299
160	49.70	0.3489	0.97	54.41	1.16	0.5437
190	44.60	0.3131	0.77	48.24	0.91	0.3882
235	39.40	0.2766	0.56	43.21	0.71	0.2489
285	35.75	0.2510	0.42	38.93	0.54	0.1219
360	31.65	0.2222	0.25			
450	28.75	0.2018	0.14			
620	27.55	0.1934	0.09			

* by equation;

$$W = 144.000 - 1.170t + 0.484 \times 10^{-2} t^2 - 0.896 \times 10^{-5} t^3 + 0.59 \times 10^{-8} t^4$$

Table B.24

Experimental Data and Results for Run No.24Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	25.5 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	13.00 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	67.50	1.0000	4.19			
22	48.85	0.7237	2.76			1.4791
45	32.00	0.4741	1.46			1.4791
70	22.70	0.3363	0.75	22.64	0.74	0.4978
90	19.15	0.2837	0.47	18.77	0.44	0.2487
120	16.25	0.2407	0.25	16.49	0.27	0.0690
150	15.25	0.2259	0.17	15.75	0.21	0.0400
190	14.40	0.2133	0.11			
255	13.80	0.2044	0.06			

* by equation;

$$W = 73.800 - 1.390t + 0.127 \times 10^{-1} t^2 - 0.513 \times 10^{-4} t^3 + 0.758 \times 10^{-7} t^4$$

Table B.25

Experimental Data and Results for Run No.25Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	26.5 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	1252 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	69.40	1.0000	4.53			
10	61.10	0.8804	3.87			
40	35.80	0.5158	1.85			1.5750
85	17.45	0.2514	0.39	17.71	0.41	1.5750
130	13.70	0.1974	0.09	13.49	0.08	0.3886
155	13.05	0.1880	0.04			0.0298
190	12.80	0.1844	0.02			

* by equation;

$$W = 72.800 - 1.260t + 0.934 \times 10^{-2} t^2 - 0.273 \times 10^{-4} t^3 + 0.227 \times 10^{-7} t^4$$

Table B.26

Experimental Data and Results for Run No. 26Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	31.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	26.5 °C	Surface area	=	0.0320 m ²
			Bone dry solid	=	13.74 gm

t	Experimental Data			Calculated Data		R
	W	W _f	X	W _c	X _c	
0	69.50	1.0000	4.06			
10	60.35	0.8683	3.39			1.7156
50	37.14	0.5344	1.70			1.7156
70	21.10	0.3036	0.54	21.10	0.54	0.5357
110	16.05	0.2309	0.17	16.05	0.17	0.2021
220	14.70	0.2115	0.07	14.07	0.07	0.0532

• by equation;

$$W = 72.200 - 1.280t + 0.937 \times 10^{-2} t^2 - 0.215 \times 10^{-4} t^3$$

Table B.27

Experimental Data and Results for Run No.27Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	98.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	55.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.83 gm

t	Experimental Data			Calculated Data*		R
	W	W _f	X	W _c	X _c	
0	68.70	1.0000	3.97			
10	62.50	0.9097	3.52			
30	47.95	0.6980	2.47			1.2050
45	37.90	0.5517	1.74			1.2050
60	30.50	0.4439	1.20	30.80	1.23	1.2050
80	23.30	0.3392	0.68	24.01	0.74	0.7848
120	18.50	0.2693	0.34	17.72	0.28	0.5082
140	16.90	0.2460	0.22	16.93	0.22	0.1276
180	15.90	0.2314	0.15			0.0332
200	15.45	0.2249	0.12			

* by equation;

$$W = 72.300 - 1.000t + 0.574 \times 10^{-2} t^2 - 0.808 \times 10^{-5} t^3 - 0.132 \times 10^{-7} t^4$$

Table B. 28

Experimental Data and Results for Run No. 28Drying conditions:

Temp. of air	=	98.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	98.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	64.0 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.85 gm

t	Experimental Data			Calculated Data *		R
	W	W _f	X	W _c	X _c	
0	69.40	1.0000	4.01			
10	63.00	0.9078	3.25			
20	56.70	0.8170	3.09			1.0562
50	41.50	0.5980	2.00			1.0562
60	36.80	0.5303	1.66	36.81	1.66	1.0562
80	29.20	0.4207	1.11	29.20	1.11	0.8068
100	23.55	0.3393	0.70	23.48	0.70	0.6316
130	18.20	0.2622	0.31	18.33	0.32	0.4514
160	16.65	0.2399	0.20	16.49	0.32	0.2073
180	16.25	0.2341	0.17		0.19	0.0434

* by equation;

$$W = 68.800 - 0.603t + 0.416 \times 10^{-3}t^2 + 0.153 \times 10^{-4}t^3 - 0.445 \times 10^{-7}t^4$$

Table B.29

Experimental Data and Results for Run No.29Drying conditions:

Temp. of air	=	25.0 °C	Air flow rate	=	4.39 m/sec
Dry bulb temp.	=	21.0 °C	Thickness of sol	=	2.2 mm
Wet bulb temp.	=	14.5 °C	Surface area	=	0.0317 m ²
			Bone dry solid	=	13.27 gm

t	Experimental Data			Calculated Data *		R
	W	W _f	X	W _c	X _c	
0	67.92	1.0000	4.12			
30	59.72	0.8793	3.50			0.5142
60	50.72	0.7468	2.82			0.5142
90	42.62	0.6275	2.21			0.5142
120	35.32	0.5200	1.66			0.5142
150	29.52	0.4346	1.22	29.75	1.24	0.3215
210	21.92	0.3227	0.65	21.89	0.65	0.1780
270	18.42	0.2712	0.39	18.08	0.36	0.0705
300	17.42	0.2565	0.31	17.25	0.30	0.0377
330	16.72	0.2462	0.26	16.79	0.26	0.0230
360	16.22	0.2388	0.22			
390	16.02	0.2359	0.21			

* by equation;

$$W = 70.200 - 0.360t + 0.480 \times 10^{-3} t^2 + 0.117 \times 10^{-5} t^3 - 0.244 \times 10^{-8} t^4$$

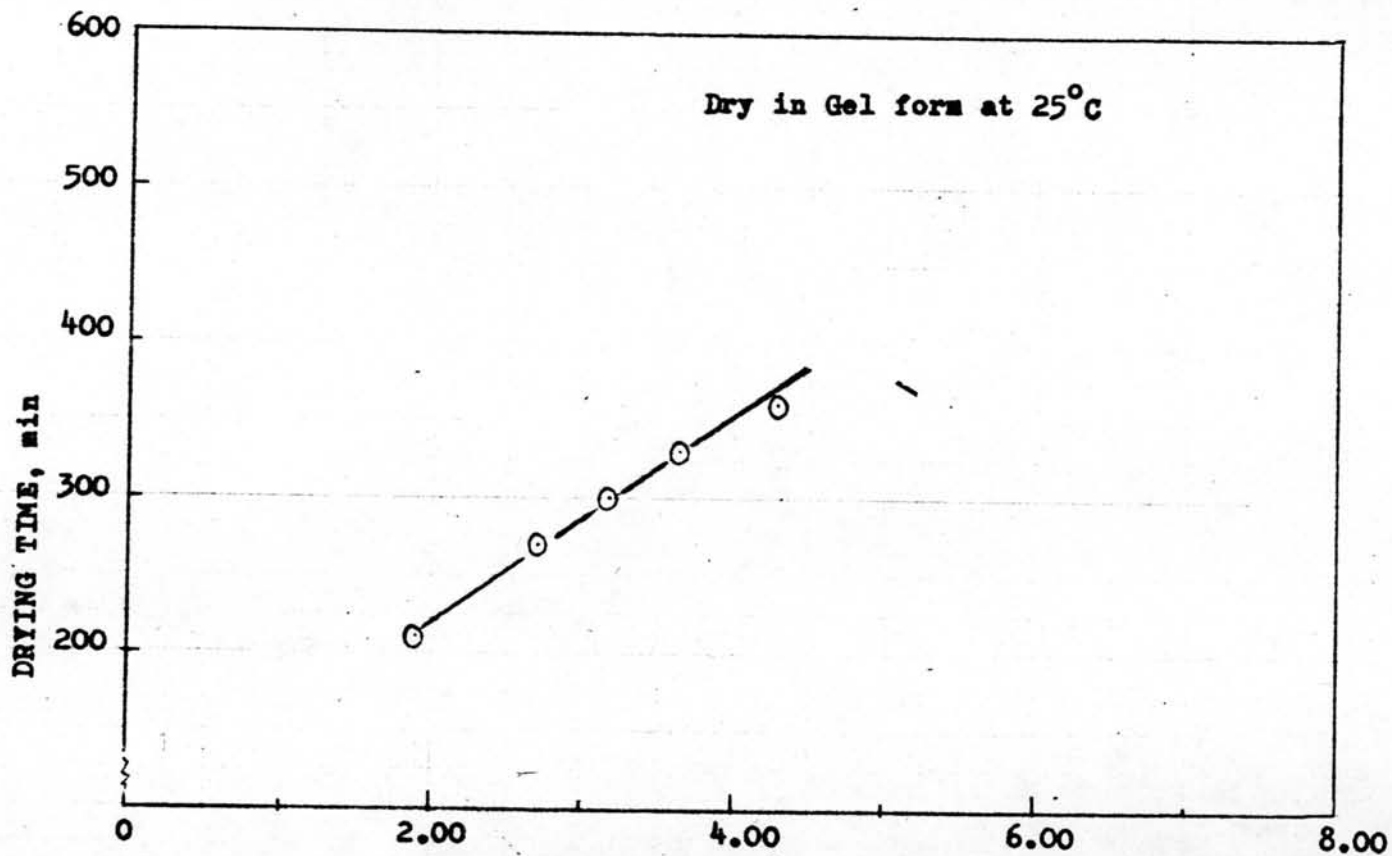
APPENDIX C
COMPUTER PROGRAM

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DCS FORTRAN IV 300N-FC-479 3-8          MAINPOM

C      METHOD OF LEAST SQUARE FOR CURVE FITTING
C      M=NUMBER OF PLOTTED
C      N-1=DEGREE OF POLYNOMIAL
C      MS=NUMBER OF SET OF DATA
0001      DIMENSION X(20),Y(30),SUM(20),A(20,21),B(30),C(30)
0002      READ(1,996)N,MS
0003      996 FORMAT(2I2)
0004      DO10 M=1,MS
0005      READ(1,997)M
0006      997 FORMAT(I2)
0007      READ(1,998)(X(I),Y(I),I=1,M)
0008      998 FORMAT(8(F5.0,F5.2))
C      COMPUTE SUMS FOR MATRIX
C      SUMS=SIGMA(X**(K-1))
0009      NN=2*N-1
0010      DO6 K=1,NN
0011      KK=K-1
0012      SUM(K)=0.0
0013      DO6 J=1,M /
0014      6 SUM(K)=SUM(K)+X(J)**(KK)
C      COMPUTE SUMS FOR LAST COLUMN
L=N+1
0015      DO18 I=1,N
0016      A(I,L)=0.0
0017      XI=I-1
0018      DO9 J=1,M
0019      9 A(I,L)=A(I,L)+Y(J)*X(J)**XI
0020      C      PUT SUMS INTO MATRIX
0021      DO18 J=1,N
0022      JK=I+J-1
0023      18 A(I,J)=SUM(JK)
C      APPLY GAUSS JORDAN METHOD FOR SOLVING UNKNOWNNS
C      CALL SOLEQN(A,N,L)
0024      C      COMPARE THE VALUE BETWEEN CALCULATED AND EXPERIMENTAL VALUE
0025      DO15 J=1,M
0026      B(J)=0.0
0027      DO15 I=1,N
0028      15 B(J)=B(J)+A(I,L)*X(I)**(J-1)
C      FIND THE SLOPE OF THE GIVEN VALUE
0029      DO35 I=1,M
0030      C(I)=0.0
0031      DO35 J=2,N
0032      Z=J-1
0033      35 C(I)=C(I)+2*A(J,L)*X(I)**(J-2)
0034      WRITE(3,100)
0035      100 FORMAT(////,T10,'DATA SET NUMBER',10X,'N',10X,'M',//)
0036      WRITE(3,101)M,N,M
0037      101 FORMAT(T15,I3,I5X,I3,8X,I3,////////)
0038      WRITE(3,102)
0039      102 FORMAT(T25,'DATA',12X,'CALCULATED VALUE',12X,'SLOPE',//)
0040      DO1001 I=1,M
0041      1001 WRITE(3,103)X(I),Y(I),I(I),C(I)
0042      103 FORMAT(10X,4(E12.5,5X))
0043      WRITE(3,104)(A(I,1),I=1,N)
0044      104 FORMAT(////,T20,'COEFFICIENTS',//,8(E12.3))
0045      10 CONTINUE
0046      STOP
0047      END

```

$$\ln \frac{8(x_1 - x^*)}{\pi^2(x - x^*)}$$

APPENDIX D. Drying time vs. $\ln \frac{8(x_1 - x^*)}{\pi^2(x - x^*)}$

APPENDIX E

Table E.1 Normalized Data, X^* and X_{cr}
 Thickness of sol = 1.5 mm

Temp.	32°C		57°C		76°C		98°C	
X^*	0.125		0.100		0.085		0.075	
X_{cr}	1.000		1.525		1.575		1.850	
	f	Φ	f	Φ	f	Φ	f	Φ
	1.00	4.70	1.00	2.84	1.00	2.51	1.00	2.37
	1.00	4.40	1.00	2.34	1.00	1.69	1.00	1.87
	1.00	4.14	1.00	1.75	1.00	1.10	1.00	0.99
	1.00	3.70	1.00	0.10	0.46	0.52	0.59	0.53
	1.00	3.14	0.46	0.44	0.25	0.29	0.24	0.28
	1.00	2.79	0.31	0.23	0.10	0.20	0.20	0.18
	1.00	1.17	0.15	0.10				
	0.41	0.36	0.02	0.06				
	0.10	0.12						
	0.04	0.10						

Table E.2 Thickness of sol = 2.2 mm

Temp.	32°C		57°C		76°C		98°C	
x^*	0.125		0.100		0.085		0.075	
x_{cr}	1.550		1.700		1.650		1.650	
	r	Φ	r	Φ	r	Φ	r	Φ
	1.00	2.92	1.00	2.66	1.00	2.52	1.00	2.59
	1.00	2.73	1.00	2.28	1.00	1.93	1.00	2.26
	1.00	2.52	1.00	1.80	1.00	1.41	1.00	1.93
	1.00	2.16	1.00	1.51	0.89	0.92	1.00	1.62
	1.00	1.90	1.00	1.00	0.41	0.57	1.00	1.30
	1.00	1.63	0.45	0.46	0.26	0.28	1.00	0.99
	1.00	1.53	0.32	0.29	0.17	0.16	0.80	0.66
	1.00	1.04	0.24	0.22	0.16	0.11	0.45	0.49
	0.75	0.94	0.13	0.15			0.23	0.23
	0.67	0.73					0.09	0.04
	0.63	0.66						
	0.24	0.35						

Table E.3 Thickness of sol = 3.5 mm

Temp.	32°C		57°C		76°C		98°C	
x^*	0.125		0.100		0.085		0.075	
x_{cr}	1.550		1.700		1.875		0.183	
	f	Φ	f	Φ	f	Φ	f	Φ
	1.00	3.00	1.00	2.56	1.00	2.44	1.00	2.30
	1.00	2.86	1.00	2.14	1.00	2.25	1.00	2.04
	1.00	2.69	1.00	1.47	1.00	1.90	1.00	1.81
	1.00	2.61	1.00	1.00	1.00	1.52	1.00	1.37
	1.00	2.47	0.59	0.75	1.00	1.00	1.00	0.98
	1.00	2.35	0.48	0.56	0.62	0.79	0.55	0.66
	1.00	2.13	0.30	0.36	0.40	0.40	0.37	0.40
	1.00	1.88	0.11	0.21	0.26	0.26	0.19	0.24
	1.00	1.52			0.14	0.17	0.12	0.17
	1.00	1.29			0.07	0.14	0.07	0.13
	0.90	0.99						
	0.82	0.82						
	0.67	0.54						
	0.41	0.24						

Table E.4 Thickness of sol = 4.5 mm

Temp.	32°C		57°C		76°C		98°C	
X^*	0.125		0.100		0.085		0.075	
X_{cr}	1.825		1.950		2.350		2.625	
	f	Φ	f	Φ	f	Φ	f	Φ
			/					
	1.00	2.58	1.00	2.26	1.00	1.88	1.00	1.79
	1.00	2.47	1.00	1.48	1.00	1.70	1.00	1.64
	1.00	2.38	1.00	1.00	1.00	1.33	1.00	1.50
	1.00	2.25	0.62	0.65	1.00	1.00	1.00	1.00
	1.00	2.18	0.52	0.52	0.62	0.61	0.60	0.75
	1.00	2.07	0.44	0.42	0.53	0.46	0.48	0.60
	1.00	1.73	0.29	0.30	0.42	0.35	0.31	0.43
	1.00	1.48	0.24	0.21	0.32	0.27	0.22	0.35
	1.00	1.28	0.17	0.17	0.24	0.21	0.14	0.27
	0.85	1.02	0.10	0.12	0.16	0.14	0.07	0.19
	0.71	0.78			0.06	0.09		
	0.51	0.52						
	0.33	0.33						
	0.22	0.21						

APPENDIX FNomenclature

A	=	Surface area of gelatin	, m ²
a	=	The surface area of the drying gelatin per unit volume	, m ⁻¹
B	=	Bloom strength	, gm
B ₁	=	Bloom strength at percent moisture content M ₁	, gm
D' _v	=	Diffusivity	, cm ² /sec
f	=	Relative drying rate	
K _o	=	Mass transfer coefficient characterising the operating of the drying equipment	, kg/m ² s
M	=	Percent moisture content	, %
R	=	Drying rate	, kg water/hr.m ²
R _c	=	Constant drying rate	, kg water/hr.m ²
% RH	=	Percent relative humidity	
S	=	One - half slab thickness	, cm
T	=	Air temperature	, °C
t	=	Elapse drying time	, hr
t _c	=	time of constant rate drying	, hr
W	=	Weight of sample	, gm
W ₁	=	Weight of dry gelatin	, gm
W _f	=	Weight fraction	
W _c	=	Weight fraction from calculated equation	, gm

X	=	Average moisture content	,
		kg water/kg dry gelatin	
X^*	=	Equilibrium moisture content	,
		kg water/kg dry gelatin	
X_1	=	Initial moisture content at start of drying when $t = 0$	
X_c	=	Average moisture (water) content from calculated equation	,
		kg water/kg dry gelatin	
X_{cr}	=	Average moisture content at the end of the constant rate period	,
		kg water/kg dry gelatin	
Y_w	=	Wet - bulb humidity	,
		kg water/kg dry air	
Y_G	=	Bulb - gas humidity	,
		kg water/kg dry air	
Z	=	Slab thickness	, cm
η	=	Viscosity of gelatin solution	, cp
η_1	=	Viscosity at moisture content M_1	, cp
ρ_s	=	bulk density of the bone-dry gelatin	, kg/m ³
θ	=	Time	, hr
ϕ	=	humidity potential coefficient	
Φ	=	characteristic moisture content	

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