CHAPTER 6

RESULTS AND DISCUSSIONS

6.1 THE FLUDIZING VELOCITY

From experimental data of six runs the curve representing pressure drop vs. superficial velocity of air is shown in table 6.1 and fig.6.1, the minimum fluidizing velocity of air for the rice bran is 28 cm/sec. Then treating rice bran air velocity for all procedures was set about two times of minimum fluidizing velocity (56 cm/sec).

6.2 DETERIORATION OF OIL IN RICE BRAN.

Deterioration of rice bran during storage is the result of complex chemical and biological reactions. Deterioration of rice bran and oil is considered the most serious obstacles for economic production of a high quality edible oil as well as the use of rice bran as animal feed.

The FFA content is used as an index of deterioration of oil and oil-containing materials. A high FFA content is considered a serious detriment. FFA content of treated and untreated rice bran at various storage time, extracted by using soxhlet extractor as in appendix A, are shown in table series 6.2 and 6.3 . It is unconvenient to compare the efficiency of stabilization conditions by using the relation of FFA and storage times as shown in fig.6.2.1 and 6.2.2 so the Karon Attachul equation[41,42,43] is used to describe this hydrolysis reaction. The lipolytic rate depends upon the biological system such as temperature, light humidity and exposed surface area. The rate of hydrolysis of rice bran oil can be expressed by the autocatalytic types equation proposed by Karon and Attschull.

$$\frac{d(\%FFA)}{d(t)} = K(\%FFA)(100-\%FFA) \qquad (6.1)$$

where %FFA = percentage of free fatty acid produced based on oleic acid

= 1.99 x A.V

TABLE 6.1 DETERMINATION OF THE MINIMUM FLUIDIZING VELOCITY

Air Vel., U (cm/sec)	Run No.1		Run No.2		Run No.3		Run No.4		Run No.5		Run No.6		Ave. Values	
	ΔP(mm water)		ΔP(mm water)		ΔP(mm water)		ΔP(mm water)		ΔP(mm water)		ΔP(mm water)		ΔP(mm water)	
	incr.	decr.	incr.	decr.	incr.	decr.	incr.	decr.	incr.	decr.	incr.	decr.	incr.	decr.
8.53	3	18	3	14	2	12	2	16	3	22	2	22	2.50	17.33
12.73	5	12	5	20	4	18	4	18	4	12	3	10	4.17	15.00
16.55	6	20	6	12	4	20	6	16	6	16	6	16	5.33	16.00
22.03	14	20	12	14	22	22	6	12	12	17	16	12	13.67	16.17
26.74	18	10	16	16	24	23	20	14	16	20	14	16	18.00	16.50
35.65	20	10	17	20	20	23	20	15	18	20	18	18	18.83	17.67
40.74	20	13	19	18	22	24	21	17	20	20	18	20	20.00	18.67
49.66	20	14	20	22	23	25	22	20	20	18	19	20	20.67	19.83
57.33	22	16	20	20	24	26	23	22	20	20	20	20	21.50	20.67
66.21	22	18	21	22	24	27	23	23	21	21	20	20	21.83	21.83
76.39	23	22	21	22	25	27	24	23	21	21	20	20	22.33	22.50
86.58	24	24	22	22	26	27	25	24	22	21	21	20	23.33	23.50
95.49	24	24	22	22	26	27	25	25	22	22	21	21	23.33	23.50
105.68	25	25	23	23	27	27	25	25	22	22	22	22	24.00	24.00
115.86	26	26	23	23	27	27	25	25	23	23	22	22	24.33	24.33

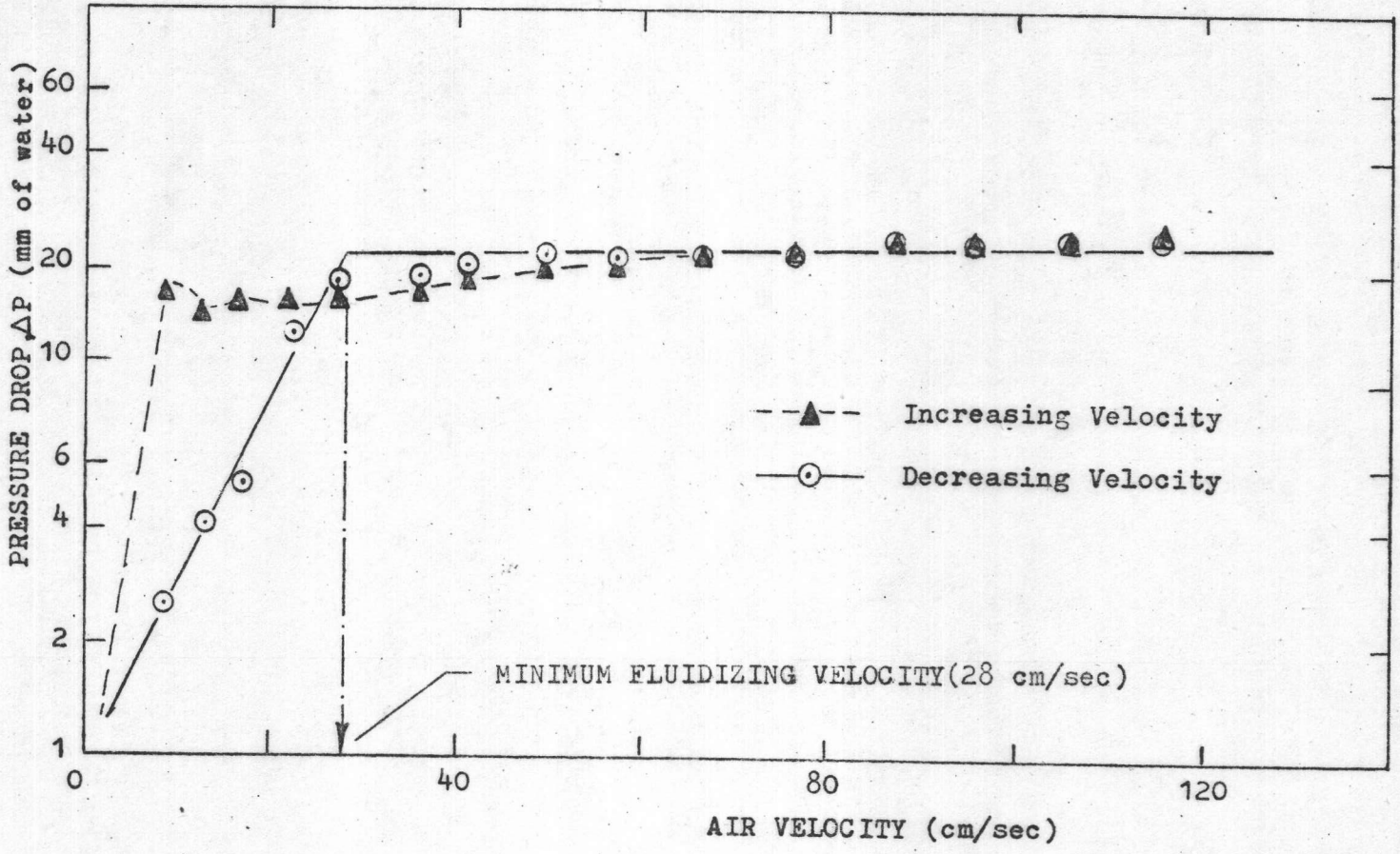

Fig. 6.1 The relation between pressure drop and air velocity

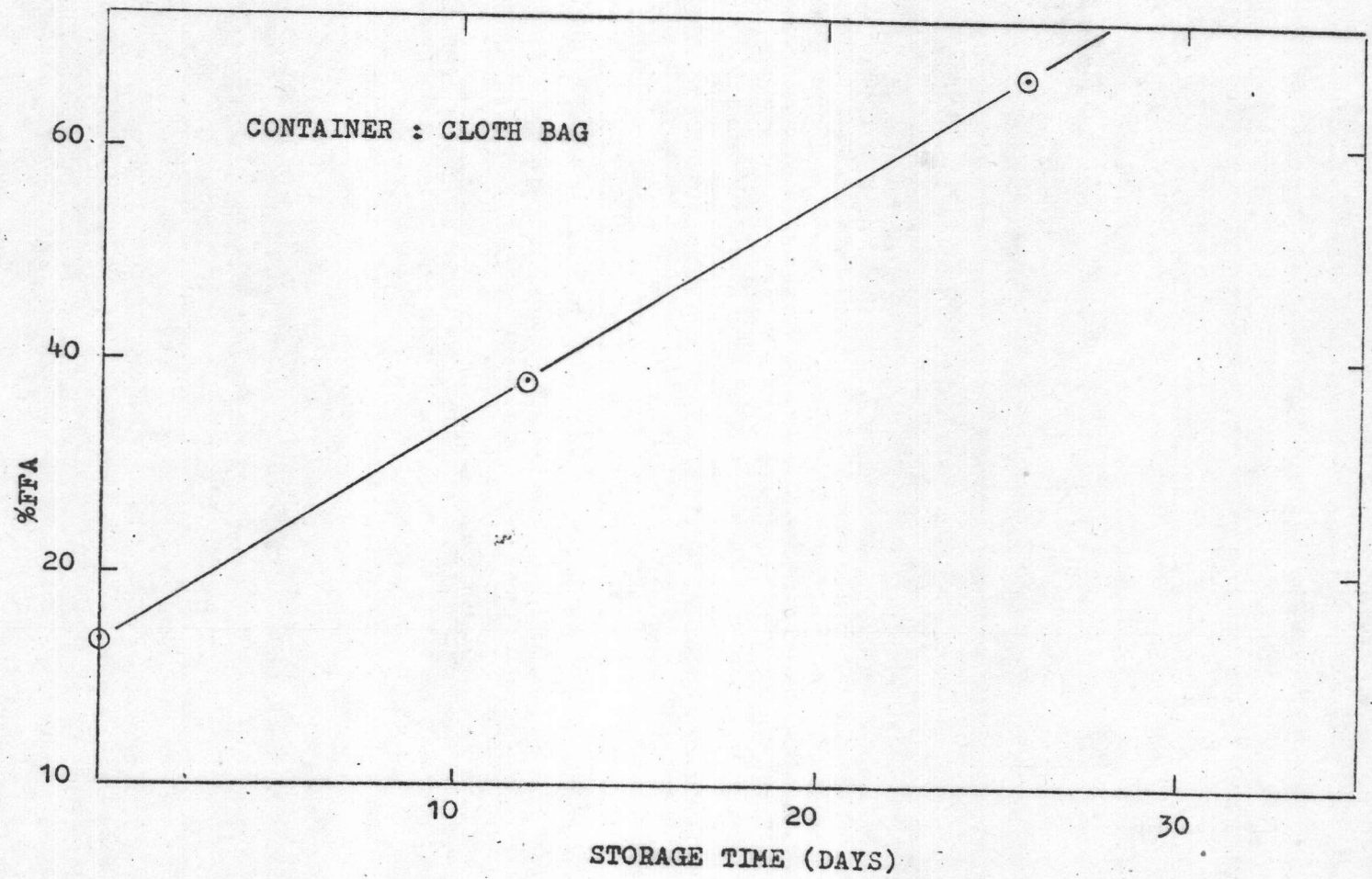

Fig. 6.2.1 The relation of free fatty acid and storage times of untreated rice bran stored in cloth bag.

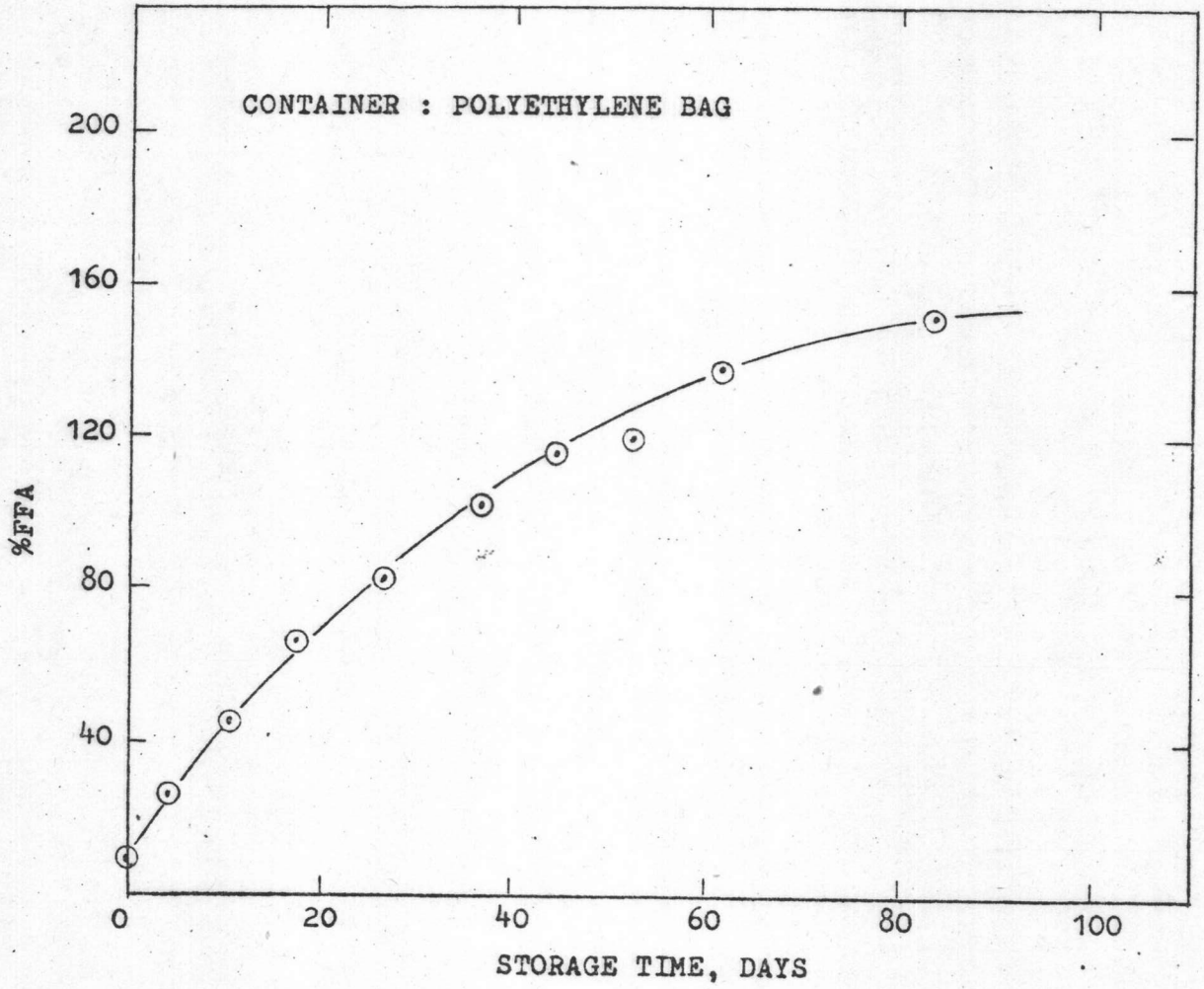

Fig. 6.2.2 The relation of free fatty acid and storage time of untreated rice bran stored in polyethylene bag

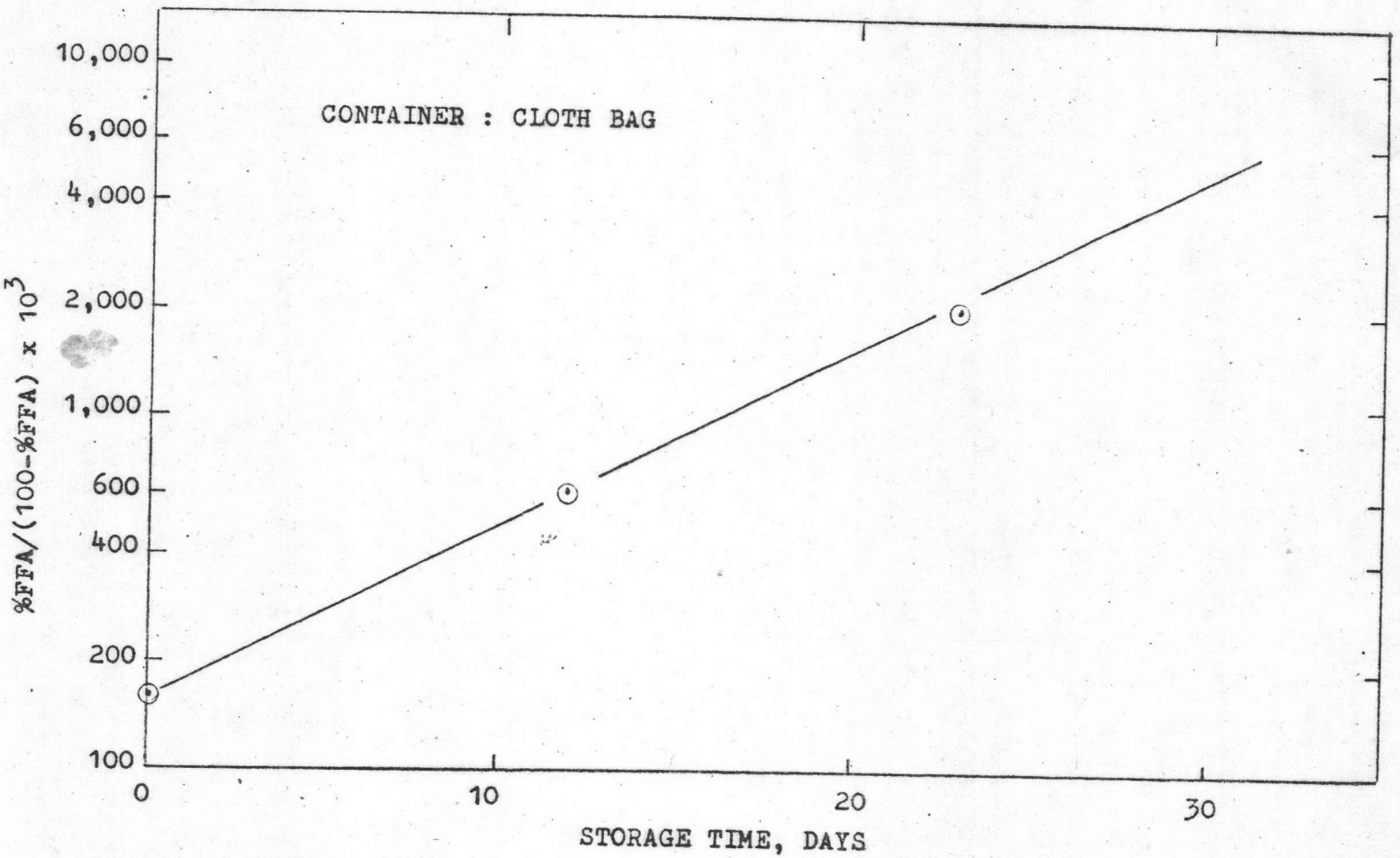

Fig. 6.2.3 The relation between a function of the percentage of FFA formed in the oil of untreated rice bran and storage times

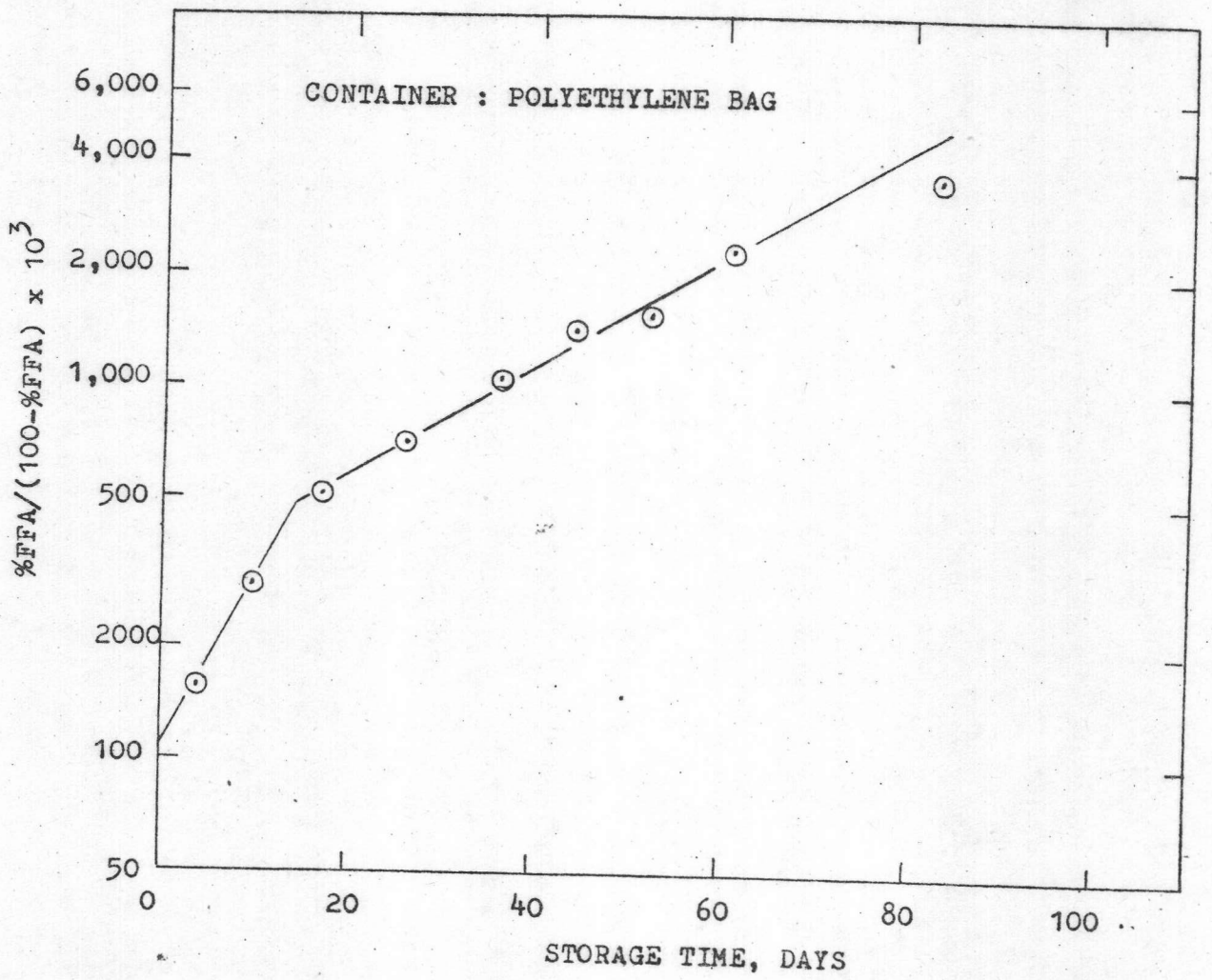

Fig. 6.2.4 The relation between a function of the percentage of FFA formed in the oil of untreated rice bran and storage time

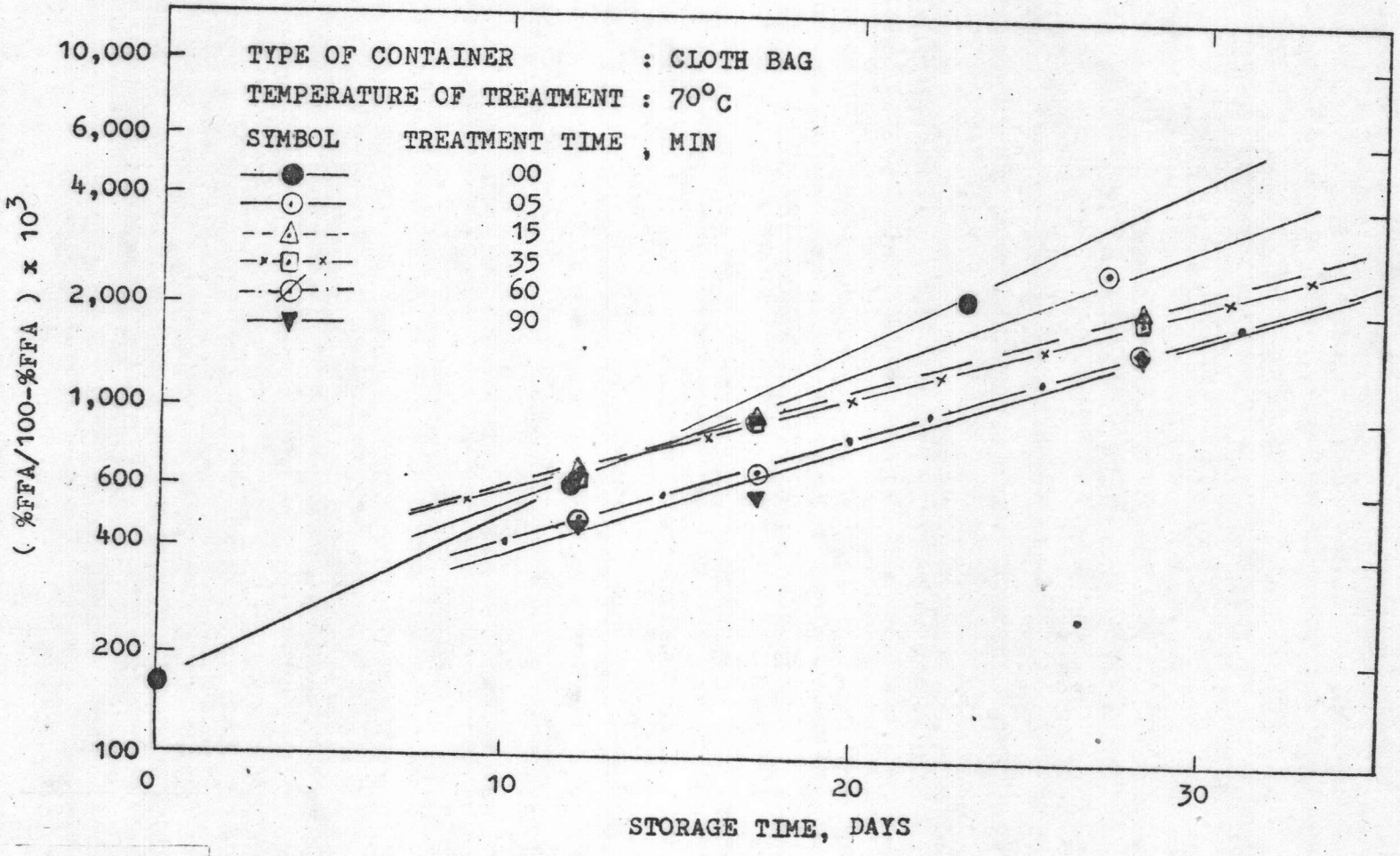

Fig. 6.3.1 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

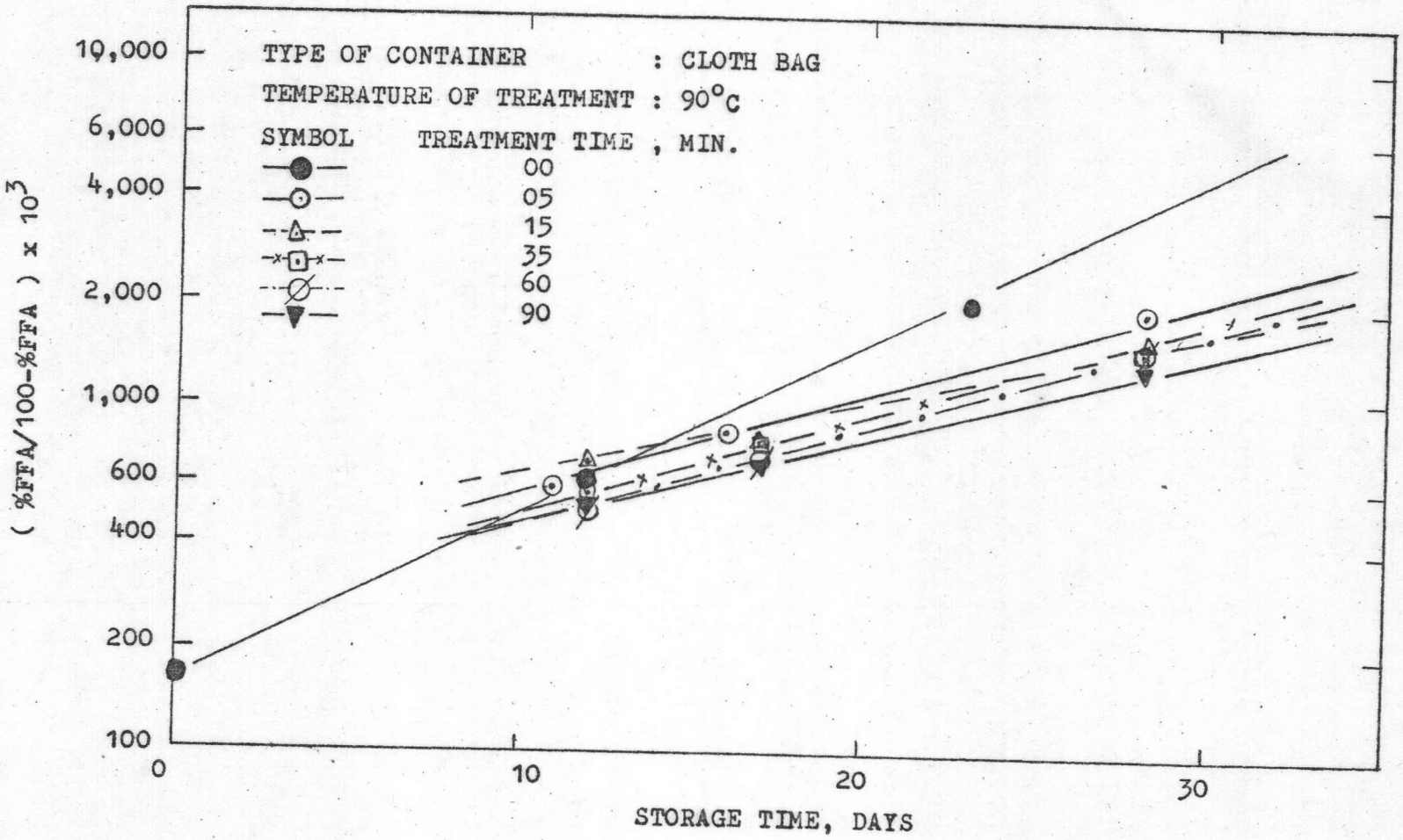

Fig. 6.3.2 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

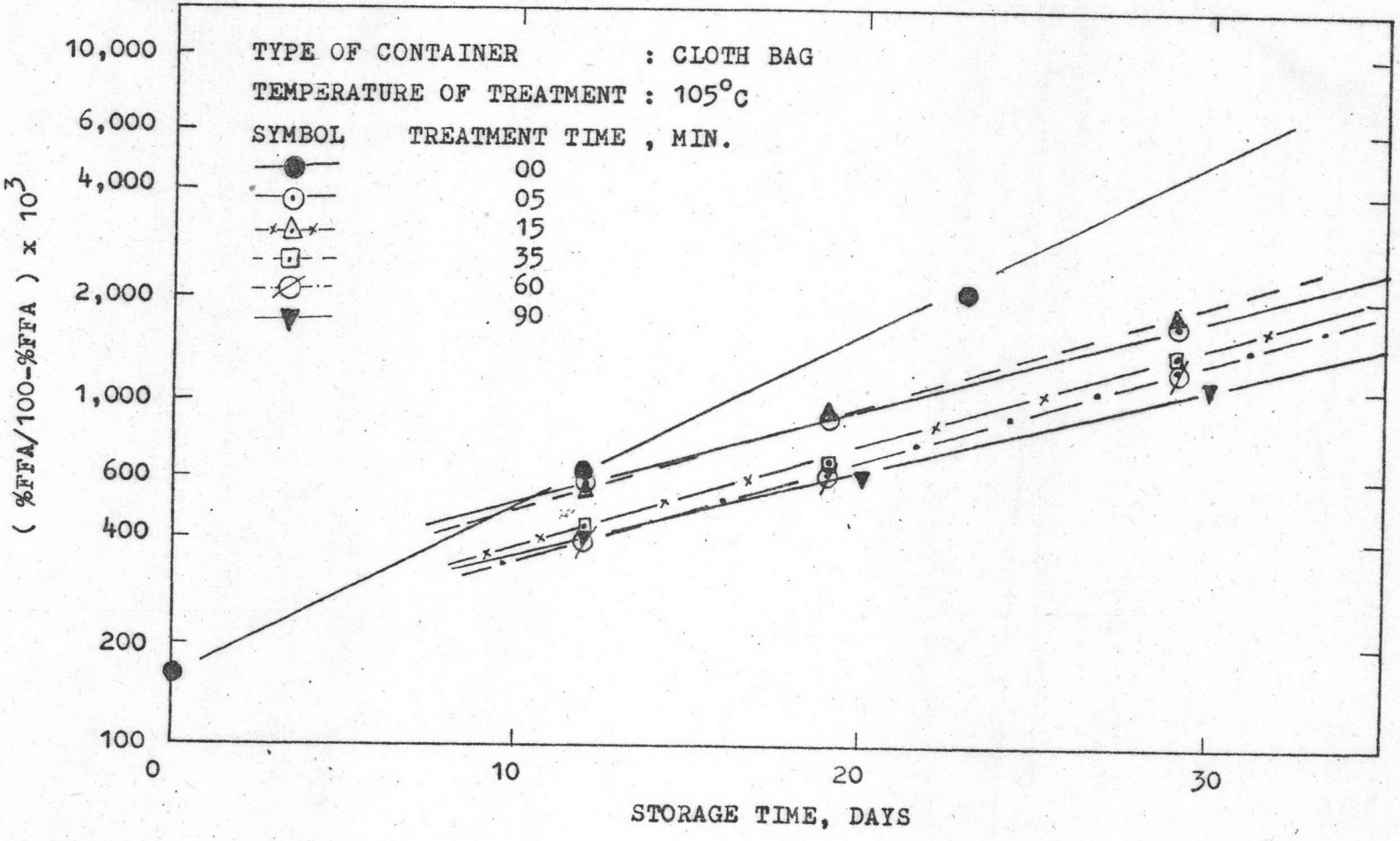

Fig. 6.3.3 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

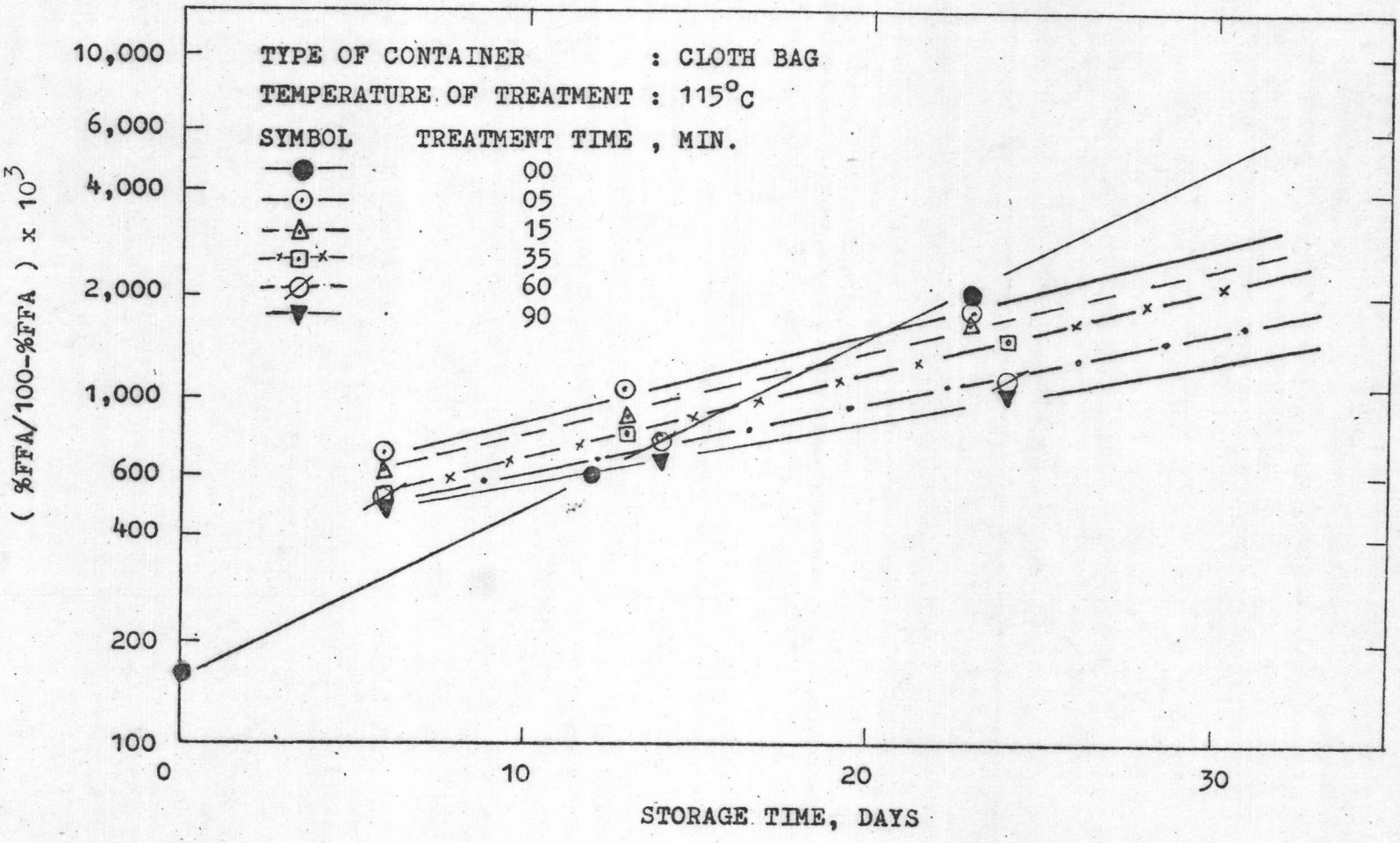

Fig. 6.3.4 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

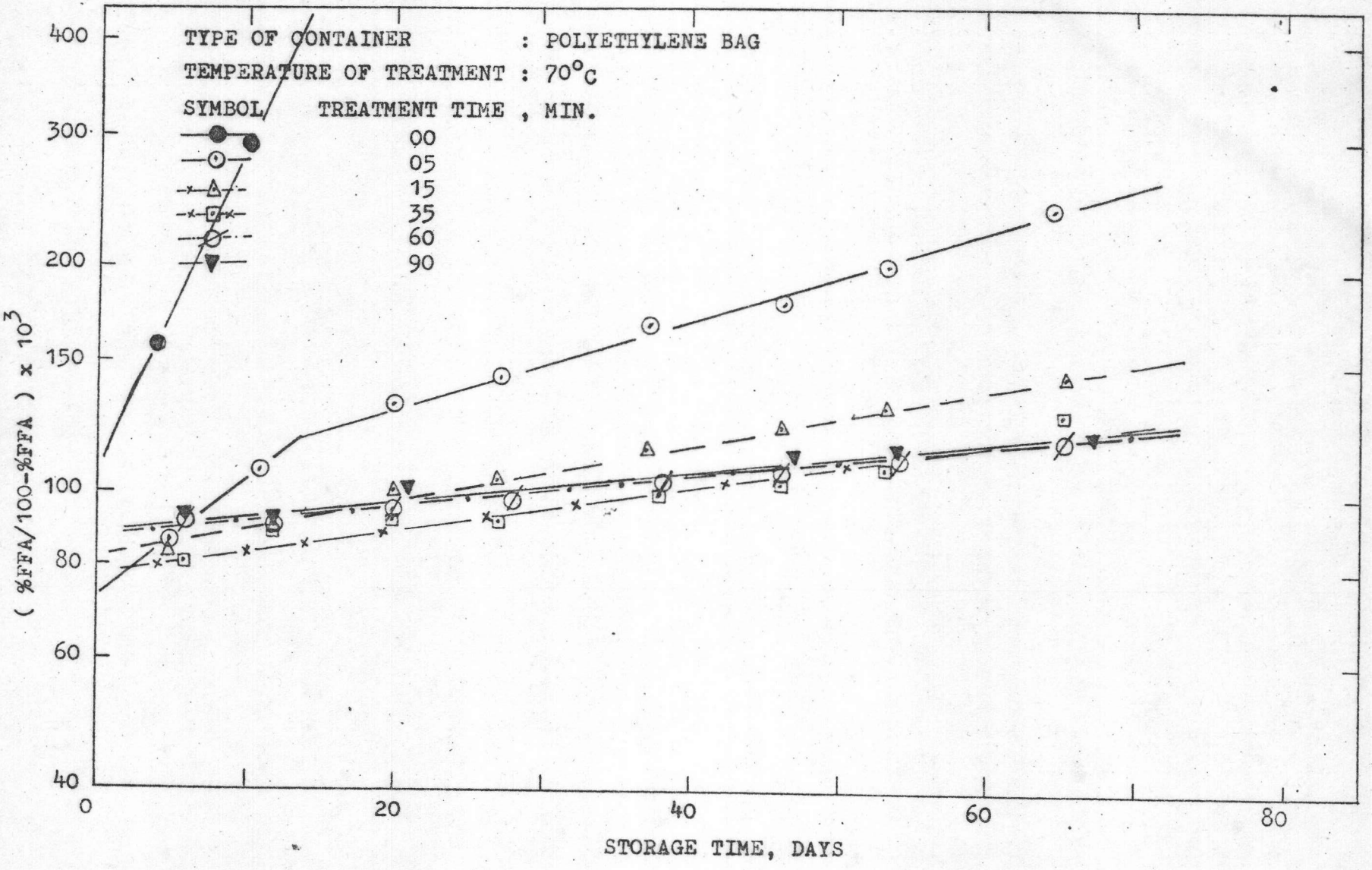

Fig. 6.4.1 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

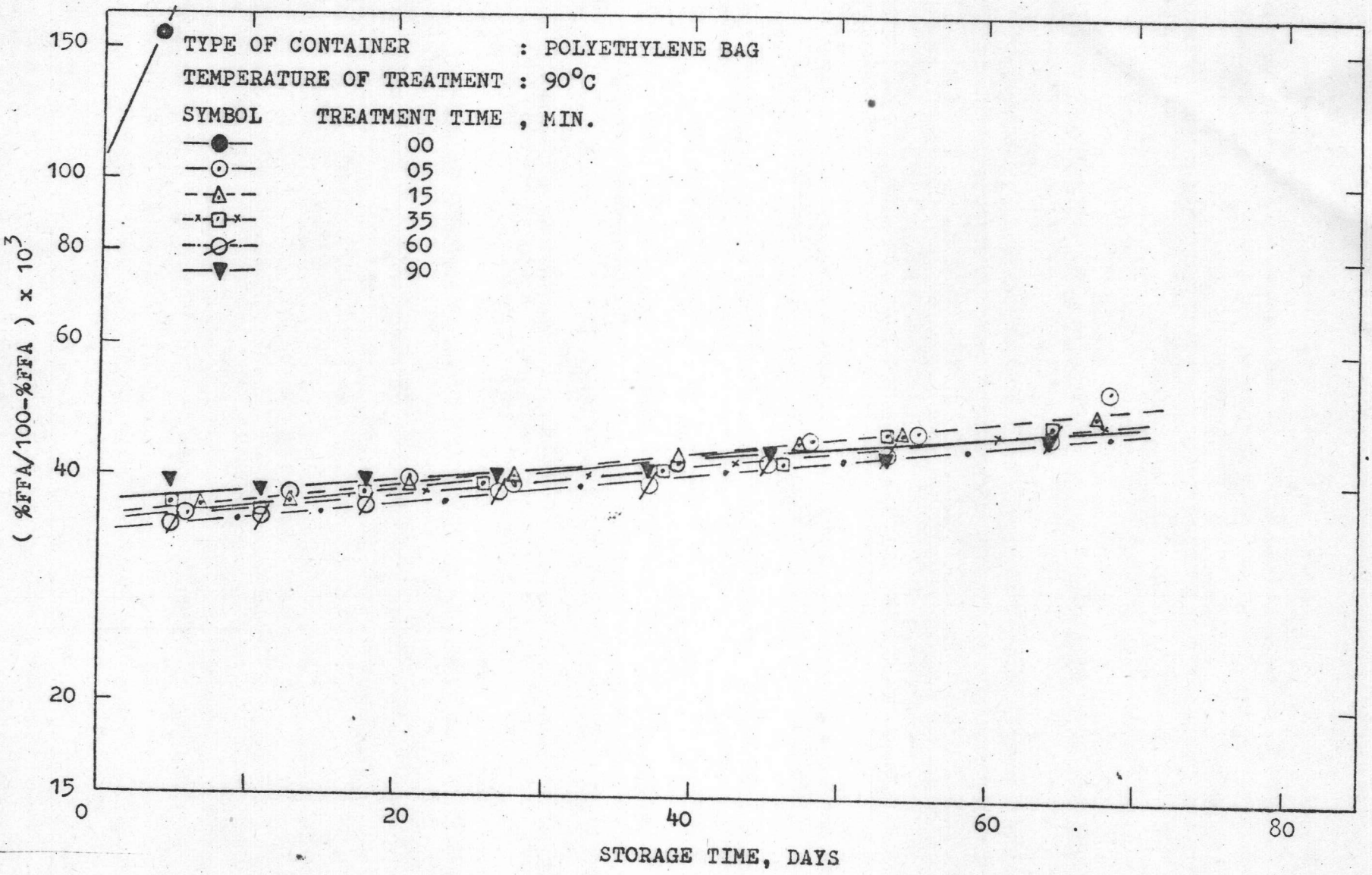

Fig. 6.4.2 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

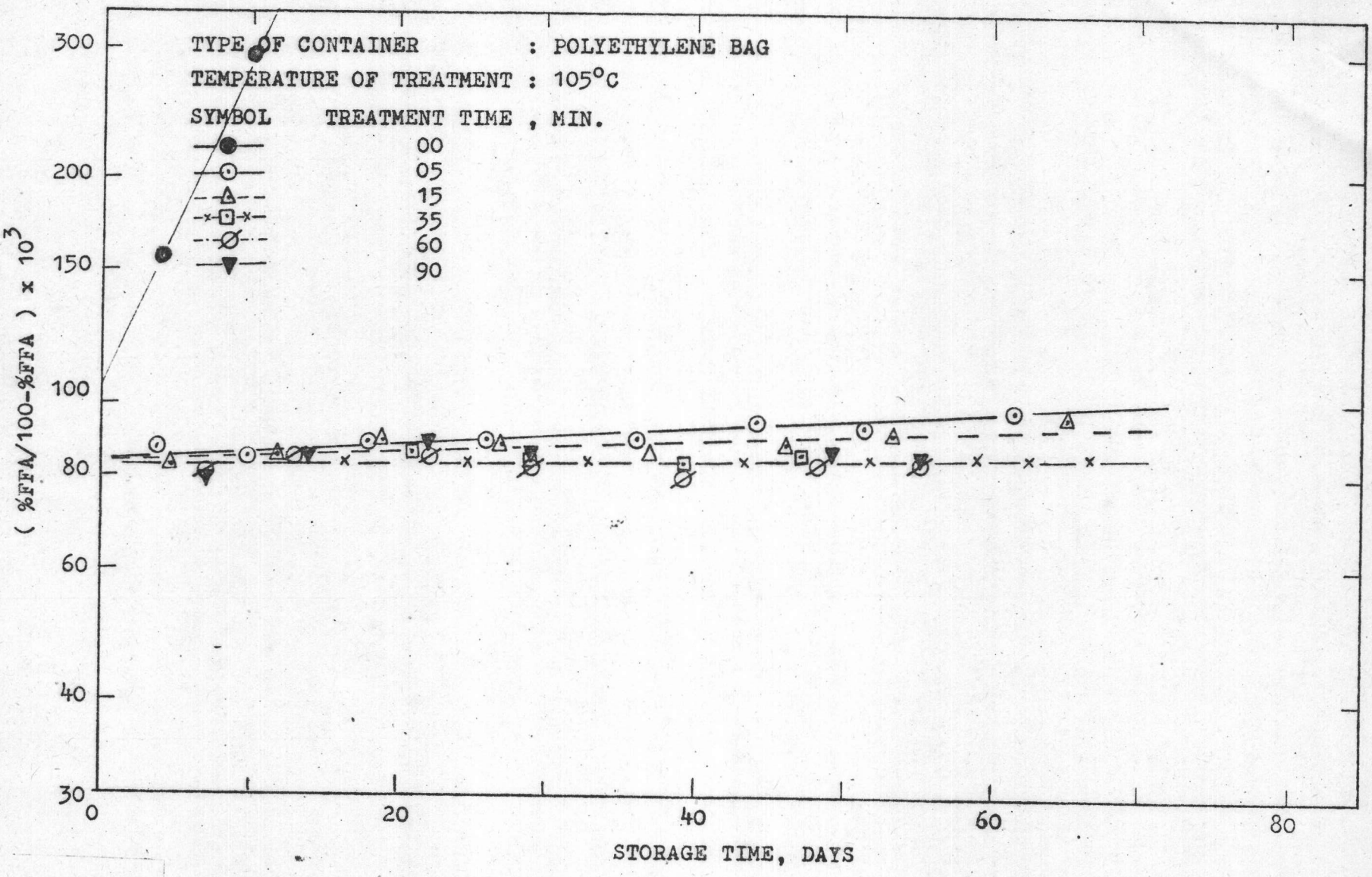

Fig. 6.4.3 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

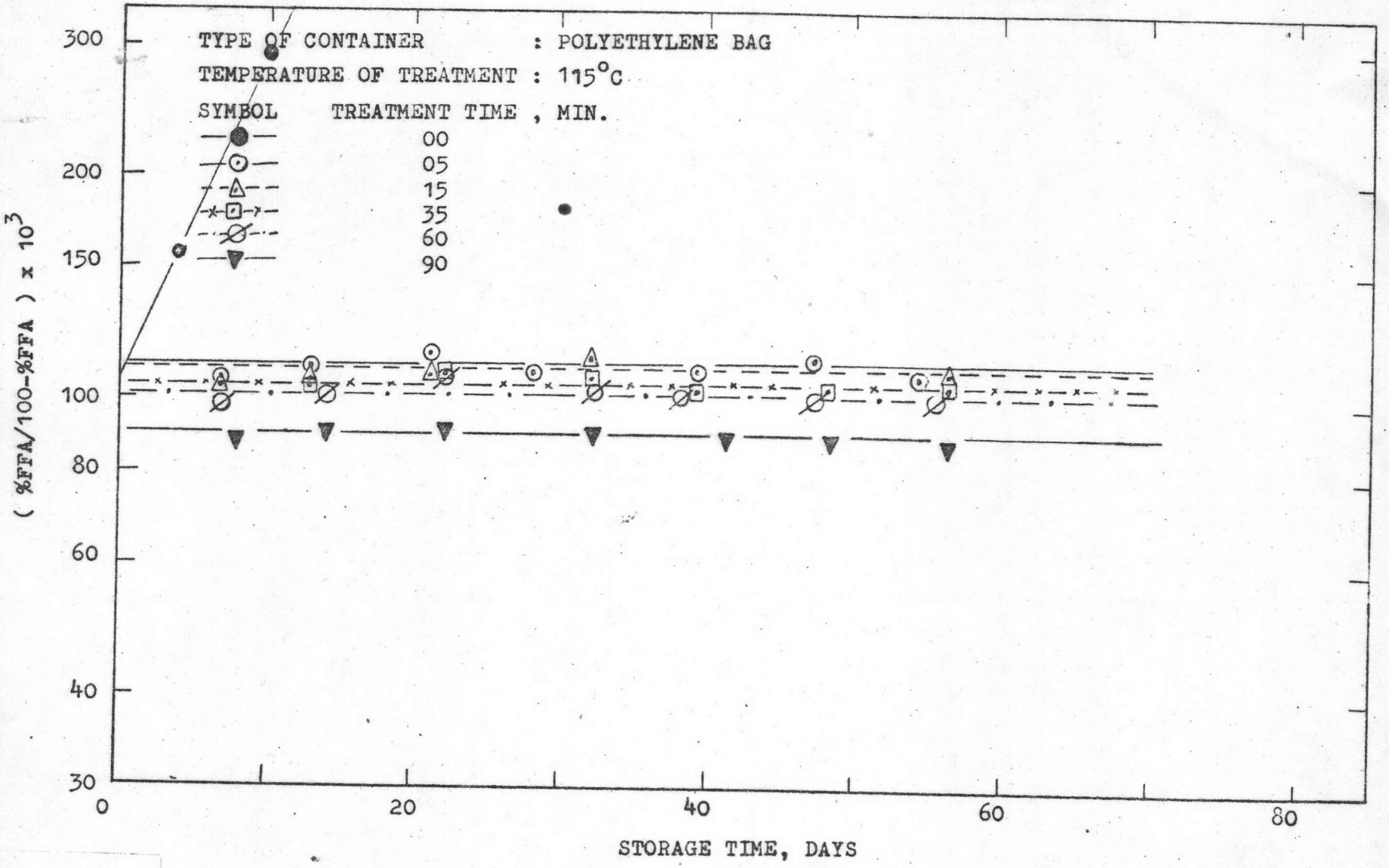

Fig. 6.4.4 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

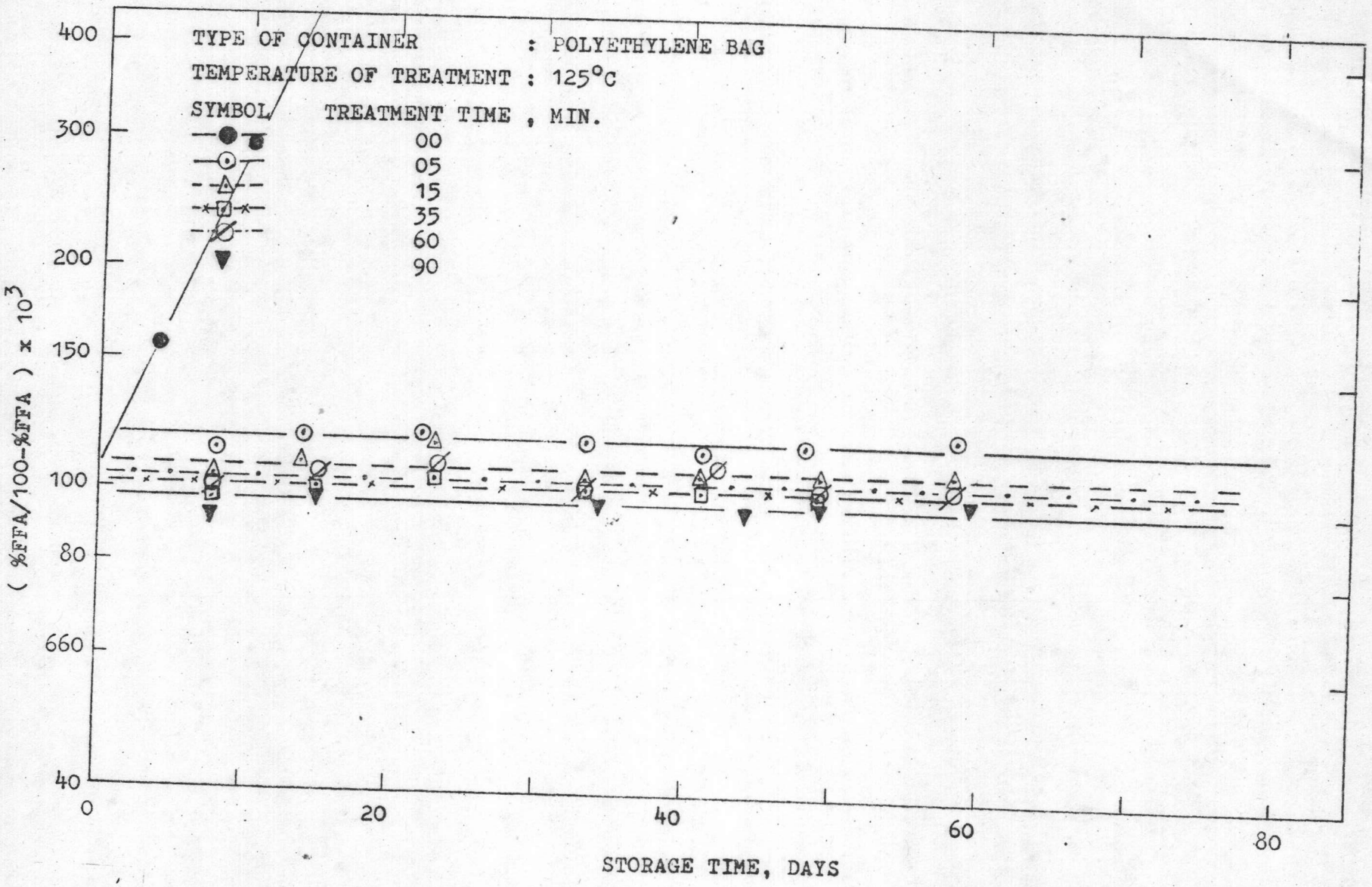

Fig. 6.4.5 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated and untreated rice bran

TABLE 6.2.1 DETERIORATION OF OIL IN UNTREATED RICE BRAN*

TYPE OF CONTAINER : CLOTH BAG

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
—	0	11.02	16.92	19.02	13.47	155.6	K = 111.30
	12	9.06	19.61	21.56	38.11	615.7	r^2 = 0.997
	23	9.17	17.04	18.76	66.79	2011.5	

* at analyzed time

** the value of K is multipied by 10^5

TABLE 6.2.2 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : CLOTH BAG

TEMPERATURE OF TREATMENT : 70°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
5	12	8.96	16.06	17.64	38.94	637.9	K = 93.20
	17	8.17	15.96	17.38	48.09	926.4	r^2 = 0.995
	27	8.84	16.62	18.23	71.71	2534.3	
15	12	8.53	16.12	17.62	40.15	670.9	K = 68.34
	17	7.60	16.75	18.13	48.60	945.5	r^2 = 1.00
	28	8.73	16.62	18.21	66.70	2003.0	
35	12	7.89	16.65	18.07	38.49	625.8	K = 67.56
	17	7.71	16.13	17.48	47.98	922.3	r^2 = 1.00
	28	8.69	16.52	18.09	65.10	1865.3	
60	12	7.39	19.06	20.58	32.91	490.6	K = 71.71
	17	7.34	16.48	17.78	40.15	670.9	r^2 = 0.998
	28	8.55	16.67	18.23	60.47	1529.8	
90	12	7.21	19.28	20.78	32.16	474.1	K = 76.20
	17	7.42	15.97	17.25	36.02	563.0	r^2 = 0.97
	28	8.59	16.85	18.43	60.50	1531.7	

* at analyzed time

** the values of K is multiplied by 10^5

TABLE 6.2.3 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : CLOTH BAG

TEMPERATURE OF TREATMENT : 90°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
5	11	9.06	16.88	18.56	38.09	615.3	K = 69.14
	16	7.90	16.40	17.81	48.98	886.3	r^2 = 1.00
	28	8.93	16.68	18.31	66.69	2002.4	
15	12	8.70	16.72	18.31	41.16	699.4	K = 56.94
	17	7.48	17.04	18.42	46.48	868.5	r^2 = 0.994
	28	8.84	16.75	18.37	63.14	1713.3	
35	12	7.07	16.88	18.16	36.73	580.6	K = 67.79
	17	7.23	16.91	18.23	44.62	805.8	r^2 = 1.00
	28	8.77	16.78	18.39	63.14	1713.3	
60	12	6.84	16.83	18.06	33.77	509.9	K = 68.52
	17	7.19	16.97	18.28	42.38	735.4	r^2 = 1.00
	28	8.69	16.59	18.17	60.54	1534.2	
90	12	6.92	17.20	18.48	34.17	519.1	K = 59.80
	17	7.12	16.79	18.08	41.38	706.0	r^2 = 1.00
	29	8.63	16.68	18.26	58.98	1437.6	

* at analyzed time

** the values of K is multiplied by 10^5

TABLE 6.2.4 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : CLOTH BAG

TEMPERATURE OF TREATMENT : 105°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
5	12	7.25	17.29	18.64	36.73	580.6	K = 63.22
	19	8.09	16.76	18.24	47.53	905.7	r^2 = 1.00
	29	8.54	16.75	18.31	62.98	1701.0	
15	12	6.87	17.52	18.81	36.06	563.2	K = 68.68
	19	7.54	16.79	18.16	47.65	910.3	r^2 = 1.00
	29	8.53	16.60	18.15	64.41	1810.1	
35	12	6.44	17.78	19.00	30.40	436.8	K = 69.23
	19	7.29	16.70	18.01	40.84	690.2	r^2 = 0.998
	29	8.62	16.74	18.32	58.55	1412.7	
60	12	6.26	17.37	18.53	28.54	399.4	K = 65.42
	19	7.24	17.41	18.77	37.92	610.9	r^2 = 1.00
	30	8.56	16.90	18.48	56.36	1290.8	
90	13	6.47	17.18	18.37	29.05	409.3	K = 60.67
	20	7.26	17.18	18.53	38.42	624.0	r^2 = 1.00
	30	8.64	16.94	18.54	59.41	1147.6	

* at analyzed time

** the values of K is multiplied by 10^5

TABLE 6.2.5 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : CLOTH BAG

TEMPERATURE OF TREATMENT : 115°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
5	6	6.66	17.31	18.55	41.36	705.2	K = 53.30 r^2 = 0.995
	13	8.01	16.83	18.30	52.08	1086.8	
	23	8.78	16.67	18.27	63.72	1756.6	
15	6	5.62	17.46	18.50	38.19	617.9	K = 60.52 r^2 = 1.00
	13	7.72	16.62	18.01	47.85	917.7	
	23	8.70	16.73	18.32	63.28	1723.3	
35	6	5.34	17.71	18.71	34.82	534.3	K = 58.22 r^2 = 1.00
	13	7.42	17.29	18.67	44.54	803.2	
	24	8.62	16.43	17.98	60.58	1523.7	
60	6	6.09	16.72	17.81	34.12	517.9	K = 75.51 r^2 = 0.974
	14	7.60	16.93	18.32	43.73	777.3	
	24	8.73	16.45	18.02	66.53	1987.7	
90	6	6.68	18.10	19.40	33.11	494.9	K = 43.58 r^2 = 1.00
	14	7.52	17.12	18.51	40.88	691.4	
	24	8.81	16.66	18.27	52.00	1083.3	

* at analyzed time

** the value of K is multipied by 10^5

TABLE 6.3.1 DETERIORATION OF OIL IN UNTREATED RICE BRAN*

TYPE OF CONTAINER : POLYETHYLENE BAG

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
	0	10.15	18.16	20.21	4.77	50.1	
	4	9.83	18.71	20.75	13.57	157.0	
	10	9.63	19.89	21.30	22.76	294.7	
	17	9.81	19.01	21.08	33.52	504.2	K_1= 104.95
—	26	9.80	19.08	21.15	41.26	702.3	r_1^2= 1.00
	36	9.83	19.36	21.46	51.61	1066.0	K_2= 33.83
	44	9.94	19.43	21.58	58.99	1439.0	r_2^2= 0.98
	52	9.39	20.11	22.19	60.25	1515.8	
	61	9.50	19.10	21.11	70.20	2353.1	
	83	9.35	19.30	21.29	76.07	3179.0	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.2 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : POLYETHYLENE BAG

TEMPERATURE OF TREATMENT : 70°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
5	5	4.03	19.48	20.30	7.94	86.2	
	11	5.91	20.61	21.90	9.70	107.4	
	20	4.52	20.02	20.97	11.56	130.7	K_1= 43.61
	27	4.76	19.97	20.97	12.46	142.4	r_1^2= 0.99
	37	4.49	19.58	20.50	14.47	169.2	
	46	4.67	20.46	21.46	15.38	181.7	K_2= 13.83
	53	4.53	20.09	21.04	16.88	203.1	r_2^2= 0.99
	64	4.89	20.61	21.67	19.55	243.0	
	85	5.28	20.38	21.55	25.36	339.8	
15	5	2.78	20.90	21.50	7.84	83.6	
	12	2.92	20.13	20.74	8.44	92.2	
	20	3.09	20.61	21.25	9.10	100.1	
	27	3.38	20.76	21.46	9.40	103.7	
	37	3.18	19.96	20.61	10.30	114.8	K = 8.86
	46	3.36	20.43	21.14	11.01	123.7	r^2= 0.99
	53	4.72	20.08	21.07	11.61	131.3	
	65	3.76	20.98	21.80	12.62	144.5	
	85	3.86	20.73	21.56	14.62	171.2	

* at analyzed time

** the values of K is multiplied by 10^5

TABLE 6.3.2 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
35	6	1.69	20.72	21.10	7.44	80.4	K = 6.82 r^2 = 0.94
	12	1.99	20.52	20.94	8.09	88.0	
	20	2.36	20.87	21.38	8.44	92.2	
	27	2.63	20.06	20.60	8.39	91.6	
	38	2.60	20.68	21.23	9.00	98.8	
	46	2.66	20.68	21.24	9.35	103.1	
	53	2.61	21.13	21.70	9.85	109.3	
	65	3.16	21.21	21.90	11.40	128.7	
	86	3.73	21.06	21.87	12.53	143.2	
60	6	1.69	20.90	21.26	8.39	91.6	K = 4.75 r^2 = 0.996
	12	1.80	20.96	21.34	8.39	91.6	
	20	2.13	20.94	21.39	8.69	95.2	
	28	2.39	20.56	21.05	8.95	98.2	
	38	2.12	21.03	21.49	9.39	103.6	
	46	2.25	20.71	21.19	9.65	106.8	
	54	2.58	20.54	21.08	10.07	112.0	
	65	2.73	20.24	20.81	10.63	118.9	
	86	3.03	20.62	21.26	11.59	131.1	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.2 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
	6	1.75	20.83	21.20	8.44	92.2	
	12	1.88	20.56	20.95	8.49	92.8	
	21	1.80	21.16	21.54	9.25	101.9	
	28	2.50	20.60	21.12	8.95	98.3	
90	38	2.50	21.15	21.68	9.20	101.3	K = 4.69
	47	2.55	20.77	21.30	10.20	113.6	r^2 = 0.96
	54	2.61	20.38	20.91	10.35	115.5	
	67	2.70	20.54	21.11	10.83	121.5	
	86	2.92	20.40	21.41	11.72	132.8	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.3 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : POLYETHYLENE BAG

TEMPERATURE OF TREATMENT : 90°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
5	6	2.02	20.35	20.77	3.43	35.5	K = 5.85 r^2 = 0.97
	13	2.18	20.81	21.28	3.64	37.8	
	21	1.92	20.93	21.34	3.85	40.0	
	28	2.72	20.93	21.50	3.79	39.4	
	39	2.38	19.64	20.12	4.00	41.7	
	48	2.13	20.72	21.17	4.34	45.4	
	55	2.95	21.38	22.03	4.46	46.7	
	68	2.85	21.52	22.15	5.04	53.1	
	88	2.89	20.97	21.60	5.33	56.3	
15	7	0.09	21.28	21.30	3.53	36.6	K = 5.15 r^2 = 0.99
	13	1.28	21.41	21.69	3.59	37.2	
	21	1.45	21.73	22.05	3.75	39.0	
	28	1.88	21.10	21.50	3.86	40.2	
	39	1.96	21.14	21.56	4.06	42.3	
	47	2.03	21.07	21.50	4.30	44.9	
	54	3.07	20.71	21.41	4.44	46.5	
	67	3.08	21.11	21.76	4.66	48.9	
	87	3.09	21.16	21.84	5.14	54.2	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.3 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
35	5	0.60	21.77	21.90	3.57	37.0	K = 4.86 r^2 = 0.97
	11	0.70	21.37	21.52	3.48	36.1	
	18	1.01	21.67	21.89	3.68	38.2	
	26	1.02	20.90	21.12	3.77	39.2	
	38	1.16	20.86	21.10	3.96	41.2	
	46	1.24	21.11	21.38	4.05	42.2	
	53	1.19	21.43	21.68	4.40	46.1	
	64	1.66	21.78	22.15	4.52	47.4	
	84	1.88	20.82	21.22	5.05	53.2	
60	5	0.60	21.27	21.40	3.32	34.3	K = 4.71 r^2 = 0.99
	11	0.64	21.67	21.81	3.40	35.2	
	18	0.89	21.12	21.31	3.55	36.8	
	27	0.89	21.88	22.08	3.72	38.6	
	37	1.01	21.68	21.90	3.77	39.2	
	45	1.05	20.58	20.80	4.04	42.1	
	53	1.60	21.08	21.42	4.19	43.7	
	64	1.72	21.36	21.73	4.41	46.2	
	84	1.93	21.39	21.81	4.68	49.1	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.3 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
	5	0.40	22.01	22.01	3.78	39.3	
	11	0.46	22.12	22.22	3.73	38.7	
	18	0.69	20.71	20.85	3.82	39.7	
	27	0.74	20.99	21.15	3.87	40.3	
90	37	0.77	21.60	21.77	3.94	41.0	$K = 3.62$ $r^2 = 0.92$
	45	0.95	19.91	20.10	4.12	43.0	
	53	1.38	21.87	22.18	4.15	43.4	
	64	1.52	21.14	21.47	4.43	46.4	
	84	1.57	20.73	21.06	5.00	52.6	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.4 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : POLYETHYLENE BAG

TEMPERATURE OF TREATMENT : 105°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
	4	0.55	20.66	20.77	8.11	88.3	
	10	0.79	21.25	21.42	7.84	89.4	
	18	0.88	20.88	21.07	8.21	89.4	
	26	1.05	21.29	21.52	8.21	89.4	
5	36	1.14	20.76	21.00	8.26	90.0	K = 2.42
	44	1.47	21.16	21.48	8.68	95.1	r^2 = 0.93
	52	1.29	21.83	22.12	8.58	93.9	
	61	1.69	21.34	21.71	8.95	98.3	
	83	2.23	21.15	21.63	9.47	104.6	
	5	0.09	19.68	19.70	7.75	84.0	
	12	0.56	21.83	21.93	8.07	87.8	
	19	0.74	21.15	21.31	8.25	89.9	
	27	0.69	21.08	21.23	8.26	90.0	
15	37	0.69	21.51	21.66	7.90	85.8	K = 0.143
	46	0.97	21.69	21.90	8.01	87.1	r^2 = 0.56
	53	1.53	21.60	21.93	8.36	91.2	
	65	1.57	21.12	21.46	8.78	96.3	
	85	1.64	21.57	21.93	8.63	94.5	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.4 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
	7	0.00	22.07	22.07	7.44	80.4	
	13	0.23	21.73	21.78	7.89	85.7	
	21	0.24	21.84	21.89	8.00	86.8	
	29	0.43	21.09	21.18	7.89	85.7	K = 0.00
35	39	0.57	22.14	22.27	7.64	82.7	
	47	0.74	21.71	21.87	7.89	85.7	
	55	1.21	21.60	21.86	7.79	84.5	
	73	1.16	21.53	21.78	7.69	83.3	
	87	1.51	21.56	21.89	7.77	84.2	
	7	0.00	21.90	21.90	7.50	81.5	
	13	0.25	20.88	20.93	7.84	85.1	
	22	0.35	20.98	21.05	7.89	85.7	
	29	0.87	21.28	21.47	7.64	82.7	K = 0.00
60	39	0.87	21.48	21.67	7.39	79.8	
	48	1.36	20.80	21.09	7.79	84.5	
	55	1.65	21.50	21.86	7.64	84.5	
	73	1.96	21.59	22.02	8.08	87.9	
	88	2.09	21.22	21.67	7.84	85.1	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.4 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
	7	0.00	21.34	21.34	7.54	81.5	
	14	0.22	21.44	21.49	7.89	85.7	
	22	0.39	21.48	21.56	8.14	88.6	
	29	0.62	21.29	21.42	8.00	86.8	
90	39	0.71	21.62	21.78	7.64	82.7	K = 0.00
	48	1.07	21.76	22.00	8.00	86.8	
	55	1.44	21.33	21.64	7.69	83.3	
	73	1.49	20.97	21.28	7.83	85.0	
	88	1.73	21.20	21.57	7.81	84.7	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.5 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : POLYETHYLENE BAG

TEMPERATURE OF TREATMENT : 115°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
5	7	0.00	21.04	21.04	9.65	106.8	K = 0.00
	13	0.72	21.14	21.29	10.00	111.1	
	21	0.66	20.53	20.67	10.40	116.1	
	28	0.95	21.07	21.27	9.85	109.3	
	39	1.05	21.26	21.49	9.90	109.9	
	47	1.36	20.30	20.58	10.25	114.2	
	54	1.74	21.66	22.04	9.80	108.6	
	76	2.58	21.75	22.23	9.63	106.5	
	87	2.63	20.99	21.56	9.90	109.9	
15	7	0.00	21.40	21.40	9.45	104.4	K = 0.00
	13	0.18	19.52	19.56	9.70	107.4	
	21	0.18	20.48	20.52	10.55	118.0	
	32	0.40	20.50	20.58	10.25	114.2	
	39	0.72	21.45	21.61	9.90	109.9	
	47	1.07	20.43	20.65	10.25	114.2	
	56	1.35	21.46	21.75	9.80	108.6	
	76	2.31	22.24	22.76	9.54	105.5	
	88	2.37	21.14	21.65	9.82	108.9	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.5 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
	7	0.00	20.55	20.55	9.25	101.9	
	13	0.10	20.61	20.63	9.70	107.4	
	22	0.25	20.63	20.68	9.75	108.0	
	32	0.40	21.76	21.85	9.70	107.4	
35	39	0.55	21.19	21.31	9.40	103.7	K = 0.00
	48	0.40	21.53	21.62	9.40	103.7	
	56	1.15	21.09	21.33	9.65	106.8	
	76	1.79	22.12	22.52	9.01	99.0	
	88	2.02	20.98	21.41	9.52	105.2	
	7	0.00	20.72	20.72	9.05	99.4	
	14	0.00	21.20	21.20	9.20	101.3	
	22	0.19	20.56	20.60	9.75	108.0	
	32	0.30	21.31	21.37	9.40	103.7	
60	38	0.40	21.52	21.60	9.30	102.5	K = 0.00
	47	0.43	21.17	21.26	9.20	101.3	
	55	1.07	21.37	21.60	9.20	101.3	
	76	1.31	22.08	22.37	7.14	76.8	
	87	1.94	21.08	21.50	9.30	102.5	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.5 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
90	8	0.00	20.64	20.64	8.09	88.0	K = 0.00
	14	0.10	20.80	20.82	8.44	92.2	
	22	0.27	20.38	20.44	8.49	92.8	
	32	0.40	21.24	21.32	8.44	92.2	
	41	0.47	21.02	21.12	8.19	89.2	
	48	0.56	21.44	21.56	8.24	89.8	
	56	1.16	20.86	21.10	8.04	87.4	
	77	1.60	21.41	21.76	6.59	70.6	
	89	1.83	21.17	21.56	8.37	91.3	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.6 DETERIORATION OF OIL IN TREATED RICE BRAN*

TYPE OF CONTAINER : POLYETHYLENE BAG

TEMPERATURE OF TREATMENT : 125°C

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
5	8	0.60	21.39	21.53	10.20	113.6	K = 0.00
	14	0.65	20.88	21.02	10.65	119.2	
	22	0.79	21.12	21.29	10.85	121.8	
	33	1.03	20.70	20.92	10.55	118.0	
	41	1.05	21.57	21.80	10.35	115.5	
	48	1.00	20.55	20.76	10.65	119.2	
	58	2.04	21.53	21.98	10.96	123.2	
	77	2.22	21.08	21.56	10.95	123.0	
	89	2.15	21.29	21.76	10.65	119.2	
15	8	0.16	20.93	20.96	9.65	106.8	K = 0.00
	14	0.27	21.46	21.52	9.90	109.9	
	23	0.45	21.13	21.23	10.55	118.0	
	33	0.50	21.69	21.80	9.55	105.6	
	41	0.83	21.23	21.41	9.80	108.6	
	49	0.97	21.28	21.49	9.70	107.4	
	58	1.73	20.99	21.36	9.90	109.9	
	80	2.54	20.70	21.24	9.98	110.9	
	89	2.34	20.73	21.23	9.93	110.2	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.3.5 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
	8	0.17	21.45	21.49	8.95	98.2	
	15	0.21	21.85	21.90	9.30	102.5	
	23	0.46	20.83	20.93	10.50	107.3	
	33	0.36	21.62	21.70	9.40	103.7	
35	41	0.52	21.85	21.96	9.35	103.1	K = 0.00
	49	0.92	20.30	20.49	9.25	101.9	
	58	1.40	22.01	22.01	9.40	103.7	
	80	2.01	20.92	21.35	9.46	104.5	
	90	2.00	21.02	21.45	9.46	104.5	
	8	0.02	20.18	20.19	9.35	103.1	
	15	0.06	20.29	20.30	9.80	108.6	
	23	0.41	20.60	20.72	9.95	110.5	
	33	0.46	20.76	20.86	9.35	103.1	
60	42	0.83	20.30	20.47	9.90	109.9	K = 0.00
	49	0.59	19.91	20.03	9.35	103.1	
	58	1.41	20.95	21.25	9.50	104.9	
	80	2.02	19.90	20.31	9.59	106.0	
	90	2.02	20.09	20.50	9.59	106.0	

* at analyzed time *

** the values of K is multipied by 10^5

TABLE 6.3.6 (Continue)

TREATMENT TIME(min)	STORAGE DAYS	%MOIST. CONT.	%OIL CONT.	%OIL FRAC.	%FFA IN OIL	$\frac{\%FFA \times 10^3}{(100-\%FFA)}$	REMARK**
90	8	0.00	21.40	21.40	8.63	94.4	K = 0.00
	15	0.01	20.64	20.64	9.08	99.9	
	23	0.09	20.75	20.77	9.61	106.4	
	34	0.16	20.49	20.52	8.96	98.6	
	44	0.52	20.69	20.80	8.74	95.8	
	49	0.59	19.91	20.03	8.95	98.2	
	59	0.98	20.75	20.96	9.20	101.3	
	81	1.53	20.59	20.91	9.12	100.3	
	91	1.33	20.18	20.45	9.16	100.8	

* at analyzed time

** the values of K is multipied by 10^5

TABLE 6.4 COMPARISON THE EFFECTS OF CONTAINER IN STORABILITY OF RICE BRAN

TREATMENT TEMPERATURE	TREATMENT TIME(min)	HYDROLYSIS CONSTANT($K \times 10^5$) CLOTH BAG	POLYETHYLENE BAG
UNTREATED RICE BRAN		111.30	K_1= 104.95, K_2= 33.83
70°C	5	93.2	K = 43.61, K = 13.83
	15	64.34	8.86
	35	67.56	6.82
	60	71.71	4.75
	90	76.20	4.69
		average (K) = 74.60	
90°C	5	69.14	5.85
	15	56.94	5.15
	35	67.79	4.86
	60	68.52	4.71
	90	59.80	3.62
		average (K) = 64.44	
105°C	5	63.22	2.42
	15	68.68	0.14
	35	69.23	0.00
	60	65.42	0.00
	90	60.67	0.00
		average (K) = 65.44	
115°C	5	53.30	0.00
	15	60.52	0.00
	35	58.22	0.00
	60	75.51	0.00
	90	43.58	0.00
		average (K) = 58.23	

A.V = the number of milligrams of potassium hydroxide required to neutralize the fatty acids in each gram of sample

(100-%FFA) = the unhydrolyzed portion of the fat

K = the hydrolysis constant

t = reaction time(storage day)

Integration equation(6.1) and consersion to common logarithms yields the equation

$$\log(\%FFA/(100-\%FFA)) = \frac{100Kt}{2.303} + \log(\%FFA_o/100-\%FFA_o) \quad (6.2)$$

where $\%FFA_o$ is the original percentage of free fatty acid in the oil

A plot of log(%FFA/100-%FFA) against t should give a straight line for an autocatalytic*process, from graph, intercept will be $\log(\%FFA_o/100-\%FFA_o)$ and its slope will be $(\frac{100K}{2.303})$. The slope of this curve which depends on value of K, will present the rate of hydrolysis of oil in rice bran. The higher of the K value means more increasement of undesirable condition. The averaged percentages of free fatty acid formed for each sample of treated and untreated rice bran were substituted in equation(6.2)and plotted against storage times(days) as shown in fig.6.2.3,6.2.4 and fig. series6.3, 6.4,and 6.5 . All figures show the straight lines. The numerical values of the hydrolysis constant(K), evaluated from slope of those curves and experimental data by using least square method curve fitting are presented in table series 6.2, 6.3 and 6.4 .

6.3 DETERIORATION OF OIL FROM RICE BRAN IN CLOTH BAG CONTAINER

The FFA content of the oil obtained from untreated and treated rice bran at 70°C,90°C,105°C,and 115°C, stores for different period of time are given in table 6.2.1,6.2.2,6.2.3,6.2.4 and 6.2.5 respectively.

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autocatalytic process* = the process that product of the process increases the rate of reaction.

6.3.1 Effect of treatment time

From fig. 6.3.2, 6.3.3 and 6.3.4 the effect of variation of treatment time at treatment temperature 90°C, 105°C and 115°C has no clear difference. This may be the result of two lipase enzymes presented in rice bran;

- reversible activity enzyme,
- irreversible activity enzyme.

Irreversible activity enzyme, when treated with the above conditions(90°C, 105°C, 115°C) had completely lost its activity. But reversible activity enzyme, its activity can reverse when moisture content reached the favorable level.(5,12,33)

From fig. 6.3.1 the effect of variation of treatment time at a treatment temperature of 70°C can also be observed, at treatment a time of 5 minutes the K value was high compared to another treatment times. This shows that the activity of irreversible activity enzyme is partially lost . When at a longer period time of treatment, the irreversible activity enzyme is destroyed or decreased, the hydrolysis constant(K) is lowered as compared to that shorter period of treatment time.

6.3.2 Effect of treatment temperature

The average value of K, evaluated at various treatment temperatures as shown in table 6.4 decreases when the treatment temperature increases(K at 70°C = 74.6×10^{-5}, K at 90°C = 64.4×10^{-5}, K at 105°C = 65.4×10^{-5}, K at 115°C = 58.23×10^{-5}). These results indicate that increasing the treatment temperature decreases the FFA formed during storage or in conclusion we could store the rice bran heated at high temperature longer than heated at lower temperature.

6.3.3 Effect of storage time

The results from fig. series 6.3 and table series 6.2 show remarkable increase of FFA when storage time is increased.This shows that the above treatment conditions were not favarable to stabilize the rice bran.

6.3.4 Comparing the results with untreated rice bran

Fig. series 6.3 show the (%FFA/100-%FFA) with storage time of treated and untreated rice bran. From the graph the slope of the curve for treated rise bran is less than for the untreated rice bran. This indicates that the FFA formed in treated rice bran during storage time is less than in untreated rice bran.

6.3.5 The effect of treatment conditions on the quality and quantity of oil and rice bran

The color of oil obtained using higher treatment temperature is darker. Table series 6.2 shows that the treatment conditions do no effect the quantity of oil(see the mention column %oil fraction compared with untreated rice bran). This results is in agreement with manu authors [1,2,5,6,9,16,17,42,43] who studied various processes for stabilizing rice bran.

6.4 DETERIORATION OF OIL FROM RICE BRAN IN POLYETHYLENE BAG CONTAINER

The FFA content of oil from untreated and treated rice bran at various temperature, are given in table series 6.3, the hydrolysis constant(K) were also calculated and presented in those tables.

From fig. 6.2.4, the hydrolysis constant of untreated rice bran in polyethylene bag container show two distinct stages of hydrolysis, during a first stage(3 weeks of storage) the formation rate of FFA increase rapidly with time ($K_1 = 105 \times 10^{-5}$), after 3 weeks of storage or during second stage a subsequent result shows that the formation rate of FFA decreases. Lypolysis of untreated rice bran is due exclusively to enzyme already present in the active state which may undergo a rapid hydrolysis, followed by a slower stage as a result of inhibition of the enzyme formed by the reaction products. [41,42,43] This behaviour also occured in this work(treating temperature 70°C, and treatment time 5 minutes) fig. 6.4.1. From this figure it can be concluded that the treatment condition can not completely inactivate the active enzyme. When the treatment time is increased this behaviour dissapears.

6.4.1 Effect of treatment time

From fig. series 6.4 and table series 6.3, the hydrolysis constant(K) decreases when increasing the treatment time for various treatment temperature. This result is the same as that found in the case of cloth bag containers,but the hydrolysis reaction is stopped when treatment temperature is equal to 105°C and treatment time is equal or greater than 35 minutes, the same result is obtained when treatment temperature is equal or greater than 115°C although treatment time is equal to 5 minutes.

6.4.2 Effect of treatment temperature

Effect on treatment temperature at constant treatment time of 5 minutes is shown in fig.6.5, from this figure the hydrolysis constant clearly decreases with increasing treatment temperature, and the K value is zero when treatment temperature exceeds 105°C another treatment time the effect of treatment temperature show the same result.This also shows the different result from two system of using container cloth bag and polyethylene bag.

6.4.3 Effect of storage time

There are yet the deterioration of oil in treated rice bran at some treatment conditions, in other word, the FFA content is still increased with storage times for the treated rice bran treated at temperatures lower than 105°C this due to the same phenomena which are explained in section 6.3.1 .

Deterioration of the treated rice bran in cloth bag containers does not stop during storage. This may be explained by the moisture content of treated rice bran in cloth bag containers which is about 3 times(9% moisture content) of treated rice bran kept in polyethylene bags. At this moisture content pests and ants tended to multiply in cloth bag containers. This moisture content in treated rice bran can reactivate the enzyme activity during storage.

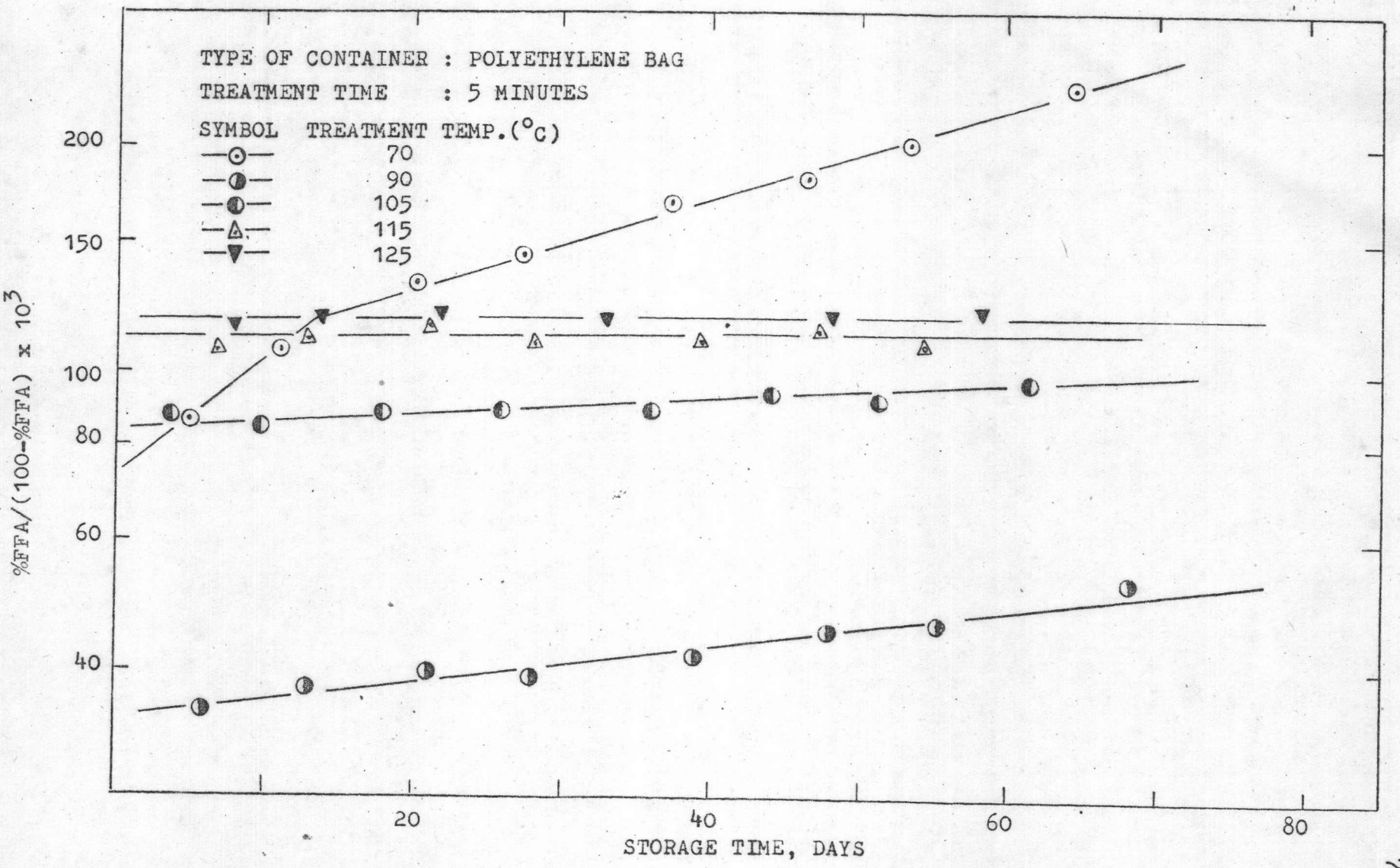

Fig. 6.5 The relation between storage time and a function of the percentage of free fatty acid formed in the oil of treated rice bran

6.4.4 Comparing the result of treated with untreated rice bran

From fig. series 6.4, the slope of the curves showing unt untreated rice bran are greater than that of treated rice bran at various conditions, this indicates that the treated rice bran can be stored for a longer period of time than untreated rice bran with no increase of FFA for at least three months(expermental time) for a given condition(temp.= 105°C, time 35 minutes or temp.= 115°C, time = 5 minutes).

6.4.5 The effect of treatment conditions on the quality and quantity of oil and rice bran

The quality of oil in rice bran in two different types of container is the same(the higher temperature the darker in color). The quantity of oil of treated rice bran(see %oil fraction) in polyethylene bag containers does not change(compared with the untreated rice bran), however for the treated rice bran at a treatment temperature of 125°C, the quantity of oil is less than the untreated rice bran. This may be due to the temperature causing vaporization of oil in rice bran and also burnt the rice bran.