Contribution of Tuna Oil in Vegetable Oil Pack

Most commercially packed tuna contains added vegetable oil, usually soybean, resulting in a quantity of vegetable oil many times greater than that of the natural tuna oil. The present study showed that under these conditions, an analysis of the drained or extracted oil from such a pack reflects almost entirely the fatty acid content of the vegetable oil and that the fatty acid characteristics of the fish oils are obscured. For that reason, the data on the analyses of the vegetable-oil pack tuna are not presented.

Conclusions

1.) Twenty fatty acids comprising more than 98% of those present in the oil of albacore, bluefin, yellowfin, and skipjack tuna were identified. The principal fatty acids were: 14:0; 15:0; 16:0; 16:1; 18:0; 18:1; 20:1; 20:4; 20:5; and 22:6; with the three fatty acids—16:0; 18:1; and 22:6—constituting over 60% of the oil and with three other fatty acids—16:1; 18:0; and 20:5—constituting about half the relative weight of the remaining fatty acids. Except for the three fatty acids—20:5; 22:1; and 22:6—the data for the light and dark meats of all four species were closely comparable.

It was observed that the oil content of the light and dark meat did not appear to differ significantly.

2.) There was no marked degradation of unsaturation nor was there differential extraction of fatty acids due to processing.

3.) Owing to the preponderantly greater amount of vegetable oil present, the relative amount of tuna oil, which is important from a dietary standpoint, in either (a) the drained oil or in (b) the rendered oil in a vegetable oil pack could not be determined by the GLC techniques used in these studies.

ACKNOWLEDGMENTS

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Bleaching Off-Colored Cottonseed Oils with Activated Alumina: A Preliminary Cost Study[1]

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Abstract

The majority of off-colored cottonseed oils can be bleached to a prime color with 4% by weight or less of activated alumina in a single operation. Increasing the amount of alumina beyond 4% makes it possible to bleach the most difficult-to-bleach off-colored cottonseed oils. Although additional research is required to establish the process and optimize conditions, results of a preliminary cost study indicate that this method should be competitive on a large scale with rerefining followed by conventional earth bleaching.

A flow sheet is given. Investment and operating costs are reported for bleaching for six months annually in plants having daily capacities of 100,000, 500,000, and 1,000,000 lb of cottonseed oil, prime and/or off-colored, in batches of 6,000, 30,000, and 60,000 lb, respectively.

It is estimated that alumina bleaching of off-colored oil, with solvent extraction of oil from spent alumina, would cost as little as 0.4¢/lb in the largest plant, 0.5¢/lb in the medium plant, and 1.2¢/lb in the small plant. These costs are calculated on the basis of the use of 4% alumina by weight of oil for off-colored oil during one-fourth of the season, in combination with 1%, 2%, or 4% of alumina for prime oil during three-fourths of the season.

Costs could be lowered by reducing oil losses and losses of alumina in regeneration, increasing filtration rates, and lowering alumina price as a result of additional research on its preparation. Lowered cost would make the method more attractive for *prime* oils as well.

Introduction

It is estimated that in recent years, off-colored, bleach-resistant oils might have constituted as much as 25% of cottonseed oil production in the U. S. This is equivalent to 450 million lb of the 1.8 billion lb of cottonseed oil produced annually. These oils are either rerefined, overrefined, or blended with lighter oils. Because of costs, the trend in the industry is to do as little rerefining as is necessary and to blend as much as possible. Since blending is dependent upon the availability of an adequate supply of sufficiently light oils, there is a real need to develop a process for bleaching the off-colored oils at lower cost. In early work by Swift et al. (4), activated alumina was used in combination with activated carbon, bleaching earth, and deodorization to reduce unsaponifiable matter, color, and tocopherol content of cottonseed oil. Later, Fisher and Bickford (1) reported that natural antioxidants and color bodies could be removed from vegetable oils by adsorption on activated alumina and carbon. Subsequently, Pons et al. (3), reported that activated alumina was found to be a superior adsorbent for removing red color bodies from cottonseed oil.

[1] Presented at the AOCS meeting in New Orleans, La., 1962.
[2] A laboratory of the So. Utiliz. Res. & Dev. Div., ARS, U.S.D.A.

The activated alumina bleaching process is being studied further as a replacement for rerefining or overrefining followed by conventional earth bleaching of cottonseed oil.

This paper presents a preliminary cost study based on available data obtained in developmental work on an alumina bleaching process now in progress. Investment and operating costs are reported for bleaching for six months annually in plants having daily capacities of 100,000, 500,000, and 1,000,000 lb of cottonseed oil, prime and/or off-colored, in batches of 6,000, 30,000, and 60,000 lb, respectively.

At these three capacities, costs are given for bleaching off-colored cottonseed oil with 4% of alumina by weight, with and without solvent extraction of the adsorbed oil from the spent alumina. Costs are also given for bleaching prime oil with 1%, 2%, and 4% of alumina by weight. It is assumed that off-colored oil is bleached one quarter of the time in each plant, and prime oil the remainder. Accordingly, the costs reported are based on use of 4% of alumina for off-colored oil during one-fourth of the season, in combination with 1%, 2%, or 4% of alumina for prime oil during three-fourths of the season.

These costs were calculated for all-new plants and for existing plants requiring the purchase of only that equipment which a processor bleaching with earth would need for conversion to alumina bleaching.

Procedures and Data

Process

The process, Figure 1, consists essentially of mixing cottonseed oil with 1–4% of its weight of alumina and 0.1% of its weight of activated carbon, in a mixing tank; deaerating the mixture using vacuum; heating it to 440F ± 10F at 1–5 mm Hg absolute pressure; cooling, by heat exchange with incoming oil, and removing the alumina by filtration. The filtered refined bleached oil is stored for further processing. The filter cake, which is alumina containing 38% by weight of adsorbed oil after blowing with nitrogen, is solvent extracted when economical to remove at least two-thirds of the adsorbed oil. The alumina is then regenerated for reuse in a furnace. The oil removed from the alumina by extraction is also refined bleached oil which is sent to storage.

Plant

Each of the three hypothetical plants is equipped with two outside storage tanks having capacities for one week's supply of refined oil and refined bleached oil, one mixing tank, two deaeration tanks, two bleaching tanks and one filter surge tank, all equipped with mixers for vigorous agitation; two pressure-leaf filters; six pumps for oil transfer and storage and for the filters; a heat-transfer-liquid boiler system; two heat exchangers; an alumina regeneration system including multiple-hearth furnace accessories, and an alumina storage bin with automatic scale. Process equipment and piping are generally of carbon steel, with 304 and 316 stainless steel in contact with the oil-alumina mixture at high temperatures. A multistory building houses process equipment, with the exception of alumina regeneration and solvent extraction equipment which is unhoused. The building is of structural steel construction with a covering of corrugated steel, and cost is estimated at $5/sq ft for the two smaller plants and $7/sq ft for the largest plant.

Equipment and Total Plant Costs

Refer to Tables I, II, and III for equipment and total plant costs. These costs include installed equipment, process piping, instrumentation, building, engineering and construction, and contingencies.

ALUMINA BLEACHING OF COTTONSEED OIL

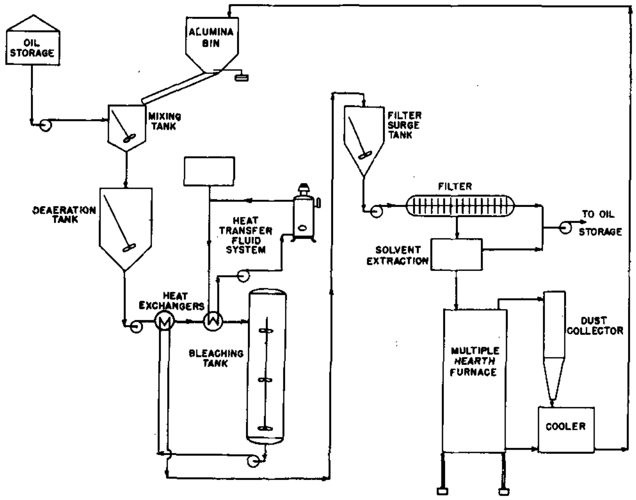

FIG. 1

Operating Costs

Operating costs for the plant having a capacity of 500,000 lb of oil per day, given in Tables IV and V, are for bleaching 16 hr per day, 5 days a week, for six months annually. They include direct, indirect and fixed costs, and general expenses.

Alumina Cost. On the basis of estimated potential markets for activated alumina in the particle size range of 10–60 μ needed for this process, it is estimated that alumina in this size range but having from 10% to 25% of "minus-10" micron particles would cost 10¢/lb. This price was used in this estimate. Reactivation is allowed in the estimate since experimental work indicated repeated regeneration can be achieved (2). Although it is possible that loss of alumina in regeneration might be less, a 5% loss is assumed on the advice of a majority of industry contacts.

Estimated regeneration cost, exclusive of alumina loss, varies significantly from less than 1/4¢/lb at an annual rate of 3,250,000 lb up to 3¢/lb at a rate of 130,000 lb. The low cost refers to the large plant using 4% of alumina for both prime and off-colored oils, and the high cost to the small plant if only off-colored oil would be alumina bleached, this at 4% alumina. Taking into consideration the cost of alumina lost in regeneration, which is 1/2¢/lb regenerated, cost of alumina consumed in the process varies from less than 3/4¢/lb at a regeneration rate of 3,250,000 lb up to 3.5¢/lb at a rate of 130,000 lb.

Other Raw Materials. Other raw materials include activated carbon at 11–1/4¢/lb and oil losses. In the pilot plant at the Southern Laboratory, the alumina filter cake contained 38% oil after blowing with nitrogen. Costs without solvent extraction were based on loss of this amount of oil, or 0.61 lb per pound of oil-free alumina. In the laboratory, solvent washing of the filter cake removed two-thirds of the oil, so it was conservatively estimated that at least this amount of recovery would occur with solvent extraction. Bleaching with 4% alumina and using a refined, bleached oil priced at 14¢/lb, oil losses amount to 0.11¢/lb of oil bleached with solvent extraction, and 0.34¢/lb without solvent extraction. An analysis of costs of solvent extraction reveals that solvent-extraction of oil-wet alumina would be economical for the large plant

TABLE I

Alumina Bleaching of Cottonseed Oil Equipment Costs[a]

Daily capactiy, lb oil / Batch size, lb oil	100,000 / 6,000			500,000 / 30,000			1,000,000 / 60,000		
		Purchased cost ($)	Installed cost ($)		Purchased cost ($)	Installed cost ($)		Purchased cost ($)	Installed cost ($)
Tanks									
Oil storage (2) mild steel, vertical w/breathers	84,000 gal	$17,000(2)	$20,400	420,000 gal	$36,000(2)	$43,200	840,000 gal	$55,000(2)	$66,000
Deaeration (2),[b] cs closed	1,000 gal	570(2)	685	5,000 gal	1,605(2)	1,925	10,000 gal	2,650(2)	3,180
Mixing, cs, open conical bottom	200 gal	145	175	750 gal	380	455	1,500 gal	535	640
Filter surge,[b] *ss clad, closed*	1,500 gal	3,295	3,625	7,500 gal	7,855	8,640	10,000 gal	9,685	10,655
Total			$24,885			$54,220			$80,475
Pumps									
Oil transfer No. 1 centrifugal 60′ TDH	27.4 gpm	860	950	130 gpm	1,155	1,270	260 gpm	1,460	1,610
Oil transfer No. 2 centrifugal 60′ TDH	27.4 gpm	910	1,000	130 gpm	1,140	1,250	260 gpm	1,515	1,665
Filter feed (2) centrifugal 100′ TDH	13 gpm	1,620(2)	1,780	65 gpm	2,000(2)	2,200	125 gpm	2,140(2)	2,350
Oil storage (2) rotary 200′ TDH	42 gpm	760(2)	835	195 gpm	1,350(2)	1,485	390 gpm	2,160(2)	2,375
Total			$ 4,565			$ 6,205			$ 8,000
Mixers									
Mixing tanks, ss	......	210	220	......	325	340	......	365	385
Bleaching tanks (2), ss[b]	......	2,220(2)	2,330	......	3,500(2)	3,760	......	4,720(2)	4,955
Deaeration tanks (2), ss[b]	......	1,200(2)	1,260	......	1,470(2)	1,545	......	1,640(2)	1,720
Filter-surge, ss[b]	......	600	630	......	735	770	......	820	860
Total			$ 4,400			$ 6,415			$ 7,920
Bleaching unit (2),[b] ss unjacketed	1,250 gal	10,800	$12,420	6,000 gal	26,000	$29,900	12,000 gal	42,000	$48,300
Filters, cs, with ss leaves	246.8 sq ft	14,000(2)	$17,500	1,072.8 sq ft	40,000(2)	$50,000	1,072.8 sq ft	80,000(4)	$100,000
Solvent extraction[b]	3.2 ton/day	......	$81,000	15 ton/day	......	$91,000	30 ton/day	......	$101,000
Regeneration[b]	4,000 # alumina	......	......	20,000 # alumina	......	......	40,000 # alumina	......	....
Furnace	6′-0″-6 hearth	12,000	15,000	8′-6″-8 hearth	25,000	31,250	13′-6″-6 hearth	36,000	45,000
Burners	......	2,000	2,500	......	3,000	3,750	......	3,000	3,750
Instruments	......	2,000	2,250	......	2,000	2,250	......	2,000	2,250
Platform	......	......	1,000	......	......	5,500	......	......	10,000
Dust collector system	......	......	6,100	......	......	6,875	......	......	7,905
Total			$26,940			$49,625			$ 68,905
Scale[b]	Up to 80 lb/min	......	3,700	Up to 80 lb/min	......	3,700	Up to 80 lb/min	......	3,700
Heat transfer fluid system[b]									
Boiler	0.75 mil BTU/hr	6,120	7,040	3 mil BTU/hr	10,985	12,635	6 mil BTU/hr	13,980	16,080
Pump	......	800	880	......	900	990	......	1,250	1,375
Receiver	......	600	720	......	600	720	......	800	960
Total			$ 8,640			$14,345			$ 18,415
Heat exchanger (2)[b]	100 sq ft	3,475(2)	3,820	450 sq ft	13,770(2)	15,150	900 sq ft	25,000(2)	27,500
Ejector system[b]	3.1 # dry air/15 min 5 mm Hg	5,460(2)	6,005	5.8 # dry air/15 min 5 mm Hg	7,600	8,360	10.2 # dry air/15 min 5 mm Hg	8,400	9,240
Total equipment cost[a]			$193,915			$328,920			$473,455
Equipment cost for conversion[b]	......	......	$151,055	......	......	$228,720	......	......	$298,420

[a] All equipment units listed are required for all-new plants.
[b] These units are required for conversion of existing facilities for earth bleaching to alumina bleaching.

TABLE II
Total Plant Costs—All New Plants

Processing rate, lb c/s oil/day	100,000		500,000		1,000,0000	
Hours/day operation	16	16	16	16	16	16
Days/year operation	130	130	130	130	130	130
	W SE [c]	W/O SE [d]	W SE	W/O SE	W SE	W/O SE
Investment cost						
a) Installed equipment cost	$193,915	$112,915	$328,920	$237,920	$473,455	$372,455
b) Process piping, 10% of selected units	7,785	7,785	17,820	17,820	29,195	29,195
c) Instrumentation, 3% of selected units	2,075	2,075	4,915	4,915	8,205	8,205
d) Outside lines, 5% of selected units	5,115	1,065	7,810	3,260	11,425	6,375
e) Auxiliary facilities [a]	......	......	......	......	......	......
f) Buildings	7,150	7,150	14,750	14,750	33,705	33,705
g) Total physical plant cost	216,040	130,990	374,215	278,665	555,985	449,935
h) Engineering & construction, 20% of g)	43,210	26,200	74,845	55,735	111,195	89,985
i) Contingencies, 10% of g)	21,605	13,100	37,420	27,865	55,600	44,995
j) Total plant cost	$280,855	$170,290	$486,480	$362,265	$722,780	$584,915
adj. j) Total plant cost [b]	$245,835	$135,270	$421.965	$297,755	$633,205	$495,340

[a] Heat transfer fluid system included in installed equipment cost.
[b] These costs are total plant costs excluding regeneration equipment. They are significant in calculation of operating costs exclusive of regeneration cost which is reported separately.
[c] W SE = with solvent extraction (all tables).
[d] W/O SE = without solvent extraction (all tables).

TABLE III
Conversion from Earth Bleaching to Alumina Bleaching—Total Plant Costs

Processing rate, lb c/s oil/day	100,000		500,000		1,000,000	
Hours/day operation	16		16		16	
Day/year operation	130		130		130	
	W SE	W/O SE	W SE	W/O SE	W SE	W/O SE
Investment cost						
a) Installed equipment cost	$175,055	$70,055	$252,720	$137,720	$298,430	$197,430
b) Process piping, 10% of selected units	3,520	3,520	7,830	7,830	11,730	11,730
c) Instrumentation, 3% of selected units	795	795	1,920	1,920	2,970	2,970
d) Outside lines, 5% of selected units	4,050	......	4,550	......	5,050	......
e) Auxiliary facilities [a]	......	......	......	......	......	......
f) Buildings	......	......	......	......	......	......
g) Total physical plant cost	159,420	74,370	243,020	147,470	318,180	212,130
h) Engineering and construction, 20% of g)	31,885	14,875	48,605	29,495	63,635	42,425
i) Contingencies, 10% of g)	15,940	7,435	24,300	14,745	31,820	21,215
j) Total plant cost	$207,245	$96,680	$315,925	$191,710	$413,635	$275,770
adj. j) Total plant cost [b]	$172,225	$61,660	$251,410	$127,195	$324,060	$186,195

[a] Heat transfer fluid system included in installed equipment cost.
[b] These costs are total plant costs excluding regeneration equipment. They are significant in calculation of operating costs exclusive of regeneration cost which is reported separately.

whether alumina bleaching all of the oil or only the off-colored oil. Similarly, savings accrue in the medium size plant in all cases except when bleaching prime oil with 1% alumina. In the small plant, with only two-thirds oil recovery, solvent extraction becomes uneconomical.

Other Operating Costs. Labor costs, without solvent extraction, were estimated on the basis of 2 operators at $2.50/hr base salary and 1 foreman, ¼ time, at $3.00/hr base salary. A night differential of 10% was allowed for one shift daily. One additional operator at $2.50/hr base salary was included for solvent extraction.

Utilities costs include those for steam, electricity, gas and cooling water. Rates used were 50¢/1000 lb of steam, industrial electric and gas rates prevalent in Louisiana and 3¢/1000 gal for recycled cooling water.

For all new plants fixed costs were estimated as percentages of total plant cost exclusive of regeneration equipment cost. Fixed costs for regeneration equipment were included in regeneration costs. Fixed costs for plants converting from earth bleaching to

TABLE IV
Operating Costs—All New Plants
Cents Per Pound
500,000 lb/day

	W SE		W/O SE		W SE		W/O SE		W SE	W/O SE
Oil Quality	Prime	Off-colored	Prime	Off-colored	Prime	Off-colored	Prime	Off-colored	Both	Both
Annual processing rate, mil lb	48.75	16.25	48.75	16.25	48.75	16.25	48.75	16.25	65	65
Percent alumina used	1%	4%	1%	4%	2%	4%	2%	4%	4%	4%
Operating cost										
k)1 Alumina	0.005	0.020	0.005	0.020	0.010	0.020	0.010	0.020	0.020	0.020
k)2 Other raw material (incl. oil loss)	0.040	0.126	0.097	0.354	0.068	0.126	0.183	0.354	0.126	0.354
k)3 Regeneration	0.007	0.030	0.007	0.030	0.010	0.021	0.010	0.021	0.014	0.014
l) Labor and supervision	0.028	0.028	0.019	0.019	0.028	0.028	0.019	0.019	0.028	0.019
m) Maintenance, 6.5% of adj. j) [a]	0.042	0.042	0.030	0.030	0.042	0.042	0.030	0.030	0.042	0.030
n) Plant supplies, 15% of m)	0.006	0.006	0.004	0.004	0.006	0.006	0.004	0.004	0.006	0.004
o) Utilities	0.009	0.009	0.008	0.008	0.009	0.009	0.008	0.008	0.009	0.008
p) Total direct	0.137	0.261	0.170	0.465	0.173	0.252	0.264	0.456	0.245	0.449
q) Payroll overhead, 15% of l)	0.004	0.004	0.003	0.003	0.004	0.004	0.003	0.003	0.004	0.003
r) Gen. plant overhead, 50% of l)	0.014	0.014	0.009	0.009	0.014	0.014	0.009	0.009	0.014	0.009
s) Control lab., 15% of l)	0.004	0.004	0.003	0.003	0.004	0.004	0.003	0.003	0.004	0.003
t) Total indirect	0.022	0.022	0.015	0.015	0.022	0.022	0.015	0.015	0.022	0.015
u) Insurance, 2% of adj. j)	0.013	0.013	0.009	0.009	0.013	0.013	0.009	0.009	0.013	0.009
v) Prop. taxes, 2% of adj. j)	0.013	0.013	0.009	0.009	0.013	0.013	0.009	0.009	0.013	0.009
w) Depreciation, 10% of adj. j)	0.065	0.065	0.046	0.046	0.065	0.065	0.046	0.046	0.065	0.046
x) Total fixed	0.091	0.091	0.064	0.064	0.091	0.091	0.064	0.064	0.091	0.064
y) Contingencies [5% of (p+t+x)]	0.013	0.019	0.013	0.027	0.014	0.018	0.017	0.027	0.018	0.026
z) Total operating costs	0.263	0.393	0.262	0.571	0.300	0.383	0.360	0.562	0.376	0.554
General expenses										
Gen. adm. & off. overhead, 3% of z)	0.008	0.012	0.008	0.017	0.009	0.012	0.011	0.017	0.011	0.017
Financing [b]	0.121	0.124	0.109	0.117	0.122	0.124	0.112	0.117	0.123	0.115
Total gen. expenses	0.129	0.136	0.117	0.134	0.131	0.136	0.123	0.134	0.134	0.132
Total cost	0.392	0.529	0.379	0.705	0.431	0.519	0.483	0.696	0.510	0.686

[a] For adj. j see Table II. [b] [(6% of j) + (3% of working capital)]. For j see Table II.

TABLE V
Operating Costs—Converted Plants
Cents Per Pound
500,000 lb/day

	W SE		W/O SE		W SE		W/O SE		W SE	W/O SE
Oil quality	Prime	Off-colored	Prime	Off-colored	Prime	Off-colored	Prime	Off-colored	Both	Both
Annual processing rate, mil lb.	48.75	16.25	48.75	16.25	48.75	16.25	48.75	16.25	65	65
Percent alumina used	1%	4%	1%	4%	2%	4%	2%	4%	4%	4%
Operating cost										
p) Total direct costs [a]	0.137	0.261	0.171	0.465	0.174	0.252	0.265	0.456	0.245	0.449
t) Total indirect costs [a]	0.022	0.022	0.015	0.015	0.022	0.022	0.015	0.015	0.022	0.015
u) Insurance [b]	0.010	0.010	0.007	0.007	0.010	0.010	0.007	0.007	0.010	0.007
v) Property taxes [b]	0.010	0.010	0.007	0.007	0.010	0.010	0.007	0.007	0.010	0.007
w) Depreciation, 10% of adj. j)	0.040	0.040	0.021	0.021	0.040	0.040	0.021	0.021	0.040	0.021
x) Total fixed	0.060	0.060	0.035	0.035	0.060	0.060	0.035	0.035	0.060	0.035
y) Contingencies [5% of (p+t+x)]	0.011	0.017	0.011	0.026	0.013	0.017	0.016	0.025	0.016	0.025
z) Total operating costs	0.230	0.360	0.232	0.541	0.269	0.351	0.331	0.531	0.343	0.524
General expenses										
Gen. adm. & off. overhead, 3% of z)	0.007	0.011	0.007	0.016	0.008	0.011	0.010	0.016	0.010	0.016
Financing [c]	0.106	0.108	0.093	0.101	0.106	0.108	0.096	0.101	0.107	0.099
Total gen. expenses	0.113	0.119	0.100	0.117	0.114	0.119	0.106	0.117	0.117	0.115
Total cost	0.343	0.479	0.332	0.658	0.383	0.470	0.437	0.648	0.460	0.639

[a] Same as for all new plants.
[b] (2% of adj. j) + (1% of cost of existing plant). For adj. j see Table III.
[c] (6% of j) + (3% of working capital). For j see Table III.

alumina bleaching include insurance and taxes for existing facilities. However, existing facilities were considered fully depreciated, requiring no further financing.

Operating Costs for All New Plants. Costs for bleaching prime oil with 1% alumina, with solvent extraction of the cake, range from 1.0¢/lb for the small plant to 0.31¢/lb for the large plant. Without solvent extraction, they range from 0.74¢/lb to 0.33¢/lb. For bleaching prime oil with 2% alumina with solvent extraction, costs range from 1.1¢/lb for the small plant to 0.35¢/lb for the large plant. Without solvent extraction they range from 0.86¢/lb to 0.44¢/lb. For bleaching prime or off-colored oils with 4% alumina with solvent extraction, costs range from 1.2¢/lb to 0.43¢/lb. Costs without solvent extraction range from 1.1¢/lb to 0.64¢/lb.

Operating Costs for Plants Converting from Earth Bleaching to Alumina Bleaching. Costs for bleaching prime oil with 1% alumina, with solvent extraction of the cake, range from 0.92¢/lb for the small plant to 0.27¢/lb for the large plant. Without solvent extraction, they range from 0.64¢/lb to 0.29¢/lb. Costs for bleaching prime oil with 2% alumina, with solvent extraction of the cake, range from 0.97¢/lb for the small plant to 0.31¢/lb for the large plant. Without solvent extraction they range from 0.75¢/lb to 0.39¢/lb. For bleaching prime or off-colored oils with 4% alumina with solvent extraction, costs range from 1.1¢/lb to 0.38¢/lb. Costs without solvent extraction range from 1.0¢/lb to 0.59¢/lb.

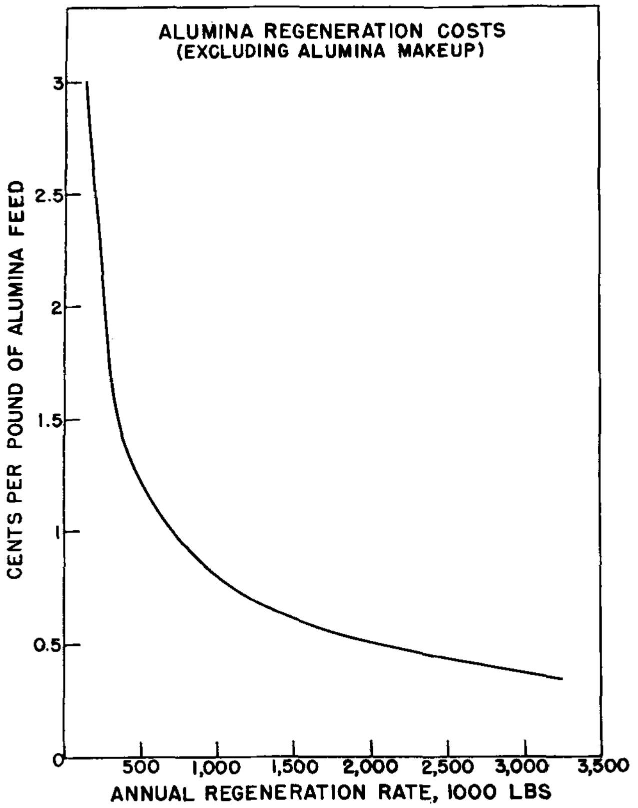

FIG. 2

Discussion

To generalize, with solvent extraction it would cost 0.4¢/lb to alumina bleach off-colored cottonseed oil in the large plant, 0.5¢/lb in the medium plant and 1.2¢/lb in the small plant. Without solvent extraction it would cost 0.6¢/lb in the large plant, 0.65¢/lb in the medium and 1.1¢/lb in the small. At a production between those of the medium and large plants, rerefining or overrefining followed by earth bleaching is estimated to cost 0.43¢/lb, or about the same as alumina bleaching. Additional research favors reduction of alumina bleaching costs by reducing oil losses, reducing alumina regeneration losses, increasing filtration rates, and in other ways optimizing processing conditions. If much of the oil remaining on the spent alumina could be recovered, this alone would reduce costs 0.1¢/lb. Further experimentation could show this to be easily attainable. If this would happen, value of products could be increased about $45,000 annually in the large plant.

Reduction of oil losses would at the same time make alumina bleaching of *prime* oils more attractive. Earth bleaching of prime oils costs as little as 0.18¢/lb. There is also the possibility that the price of alumina can be reduced as a result of additional research on its preparation.

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