NRRC: Heart of soybean research

Peoria, Illinois, has symbolically represented the United States' heartland in diverse subject areas, but it undeniably is the center of research for utilization of soybeans and soy oil.

Peoria is the home of the USDA's Northern Regional Research Center, one of the four original USDA utilization labs established just before World War II. Dr. William H. Tallent, an active AOCS member, is center director. Dr. Herbert Dutton, an NRRC staff member since 1945, notes that two-thirds of the Center's work deals with cereal crops and about one-third with oilseeds. The NRRC has about 380 employees, and another USDA agency, the Food Safety and Quality Service, has about 50 persons in the three-story E-shaped building on the northern edge of Bradley Park in Peoria.

Administratively, the NRRC is divided into six laboratories each with a specific subject area: Cereal Products Laboratory; Cereal Science and Foods Laboratory; Horticultural and Special Crops Laboratory; Engineering and Development Laboratory; Fermentation Laboratory; and Oilseed Crops Laboratory. Dr. H.J. Dutton, Chief, and Dr. E.H. Pryde, Research Coordinator, give direction to the last-mentioned Oilseed Crops Laboratory, where work on soybean oil and soybean meal is concentrated.

Dr. Dutton has recently initiated work on photosynthesis, a new research area at the NRRC. "It's tremendous to be back rattling test tubes; that's where the action is," Dr. Dutton said as he described his new mission.

Within the Oilseed Crops Laboratory, there are five research groups: Biochemical and Biophysical Properties Research, led by Dr. E.A. Emken, is undertaking research on the metabolic fate in humans of isomeric fats, using techniques and methodology unique to the NRRC. Edible Oil Products and Process Research, headed by T.L. Mounts, is working on how to get more benefit from each harvest by reducing postharvest losses and also through new processing techniques such as high pressure continuous hydrogenation and physical refining of soybean oil. The Exploratory Organic Reactions Research group, which is headed by Dr. E.N. Frankel, is seeking ways to hydrogenate soybean oil while retaining *cis* unsaturation and how to increase oxidative stability of soybean oil. Research on industrial uses, continuing in this unit at a much reduced rate after last year's budget cut, includes work on coatings, plasticizers, and sulfur-containing lubricants. The Meal Products Research group, headed by Dr. W.J. Wolf, is where work is done on soy protein for human consumption as well as for feed, with emphasis on problems of flavor, nutrition, and functionality. And finally there is the newly created Photosynthesis Research unit which is searching for ways to improve the photosynthetic efficiency and yield of soybean and other crops with Dr. Dutton as acting leader.

Other laboratories within the Center contribute to oilseed work. The Engineering Laboratory, under Dr. E.B. Bagley, provides technical help to all five other laboratories. Composite products – such as corn-soy-milk blends – require cooperative efforts, as may other projects. The Fermentation Laboratory, under Dr. C.W. Hesseltine, studies the production of oriental-type fermented foods from soybeans, on the one hand, and microbial resistance to spoilage of beans in storage, on the other.

The research center's historic mission has been to find new uses for farm crops. In recent years the emphasis has shifted to insuring the quality and safety of agricultural food products and increasing production, as well as finding new edible uses.

"Historically, we were created in an era of surpluses (of farm crops)," Dr. Dutton says. "We were told to make a silk purse out of a sow's ear." One of the major original "sow's ears" for the NRRC was soybean oil. It was NRRC's research work and industry's implementation that paved the way for soy oil's current status as the nation's most used edible oil.

It was also at the NRRC that wartime research efforts produced a method to mass produce penicillin, which had been discovered in England. The NRRC work meant the "wonder drug" was available for military use before the end of World War II.

What's new in oilseed research at the NRRC?

Construction of a new odor evaluation room has been completed. The NRRC's taste panel on edible oils is well known and has provided help to many oil flavor researchers. But a remaining hindrance to expanding European markets for soy oil has been that European housewives accustomed to peanut, safflower, and olive oils as a cooking oil object to the odor of soybean oil. An odor evaluation panel, similar to the taste evaluation panel, will be established to help researchers as they try to determine how specific soy oil constituents affect the odor.

Soybean seed analysis services previously provided by the U.S. Regional Soybean Laboratory in Urbana, Illinois, were shifted to NRRC this past October. The NRRC computer system will help store data on analysis of new and old soybean varieties. Data on oil, protein, carbohydrates, methionine, and linolenic content and on minor constituents may aid breeders trying to develop soybean for a particular end use.

The work on how the human body metabolizes fatty acid isomers is of major interest to edible oil food processors. The work began in 1970 when the NRRC started developing a method to feed mixtures of ^{14}C- and ^{3}H-labeled fatty acid isomers to chickens. This dual-labeled methodology is a highly accurate and sensitive technique for these metabolic studies. Later, researchers would analyze the lipids in the yolks of the hens' eggs to see if there had been any biological selectivity for utilization of the fatty acid isomers which were fed, Dr. Dutton explains.

Now the program has advanced to where human volunteers are fed mixtures containing two fatty acid isomers labeled with different numbers of nontoxic deuterium atoms. Recently these dual-labeled experiments have been expanded to allow triple-labeled experiments to be used. Development of the methodology for using deuterium-labeled isomers in human studies was complex. Dr. Dutton says simply that the work could not be done anywhere except at NRRC. Dr. Emken, who heads the research team, said it took about a year to work out suitable synthetic procedures for preparation of the initial deuterated samples, partially because one objective was to develop versatile synthetic methods that could be used to prepare both geometric and positional fatty acid isomers for later metabolic studies also.

Volunteer medical students at Georgetown University, Washington, DC, were the initial subjects in the feeding of deuterium-labeled elaidic and oleic acid isomers to humans, but personnel changes at that university and logistical problems have led NRRC to transfer that portion of the work to a local Peoria medical facility, St. Francis Hospital.

Once volunteers have ingested labeled isomers in a "deuterated milk shake," blood samples are taken at specific intervals during the next 3 days. The samples are fractionated and analyzed to see which isomer predominates in various lipid fractions from blood components, such as lipoproteins, plasma, red cell, and platelets.

Blood samples drawn at 0, 2, 4, 6, 8, 12, 16, 24 & 48 hrs

Results are too sparse as yet to permit conclusions. The initial reports will be eagerly awaited by many edible oil and health researchers.

"We've fed about three generations of homo sapiens on hydrogenated oils with no untoward effects," Dr. Dutton says. "This work is not pointed at atherosclerosis. It is a new way to study how the body handles fats."

As a portion of the work, the research team analyzed butter for isomeric fats and found just about all the forms that are found in margarine, although in smaller amounts. Dr. Dutton notes that a cow's rumen is an anerobic environment chamber doing about what a hydrogenation plant does.

An NRRC paper on "Zero *trans* Margarines" appeared in *JAOCS* 54:408 (1977) last October. Oil blends containing only *cis* fatty acids were produced by interesterification. Initial results from testing for flavor and oxidative stability were favorable, the paper reported. Thus, an alternative to partial hydrogenation is available for hardening oils.

One reason NRRC has been able to undertake the dual-labeled isomeric fats experiments is its computer center and mass spectrometric facilities. Electrical input stations and typewriter printers throughout NRRC are connected to the center which can acquire, process, and store data from all types of lab work. For example, a mass spectrum is displayed to a researcher as it is being done, and these data also are stored in the computer memory. Four months later, the researcher can get a printout of that same mass spectrum, or particular portions, for further study. Development of mass spectrometry techniques for analyzing blood lipid fractions was crucial to NRRC's human studies program. The mass spectrometry procedure, selective ion monitoring, was used to solve this analytical problem.

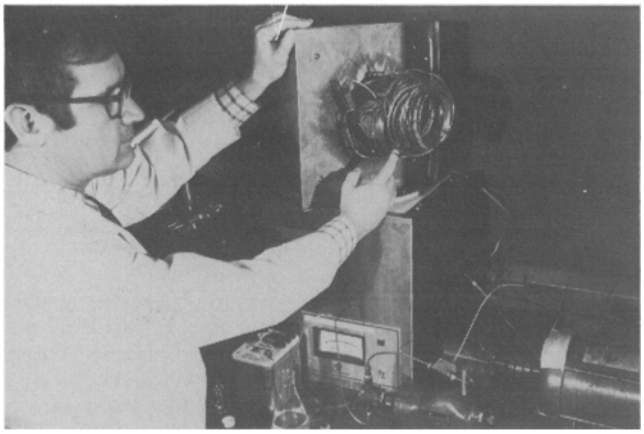
Literature also is being stored in the computer memory. Key word literature searches are completed in seconds, providing a researcher with a full list of pertinent articles on oilseeds published by NRRC since 1962.

Fermented food products from oilseeds are another subject for NRRC researchers. Long a staple in East Asian cultures, these products have become popular in the U.S., particularly on the West Coast, Dr. Dutton notes. Tempeh, miso, tofu, and others are researched as a means to expanding foreign markets for U.S. soybeans. Dr. H.L. Wang heads the fermented food research aimed at the foreign markets, but the results may lead to a larger domestic market for such foods.

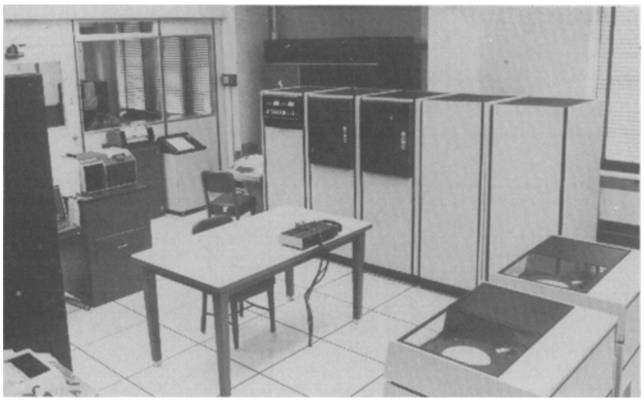
The NRRC effort to reduce quantitative and qualitative post-harvest losses in oilseeds is directed by T.L. Mounts, research leader for edible oil products and processes research.

The NRRC is cooperating with other federal agencies, for example, to determine what type of damage and how much damage occurs to soybeans in overseas transport. Specific samples are identified as early as possible in their trip to foreign ports and analyzed at each stop. Data obtained eventually may lead to revisions in the grading of soybeans for export or in development of new methods for processing damaged beans or for handling beans. Physical or steam refining as an alternative to caustic processing, for example, may permit more economical use of some beans with a high percentage of splits.

Mounts' group also is researching continuous hydrogenation using a copper chromite catalyst. A bench apparatus has been developed to help evaluate the process, which shows promise of a more efficient operation for lowering linolenic content, and is run at pressures up to 1,000 psi. A pilot-plant model may be under construction within a year.



T.L. Mounts with bench apparatus for continuous hydrogenation with copper catalyst.



NRRC computer center.

The group also is looking at ways to improve degumming of soybean oil, which Mounts describes as still being an art rather than a science. This ties to the group's work on transportation and storage damage to beans.

NRRC's work on soy protein is well known. Factors causing flatulence, growth inhibition by raw soybeans, and grassy/beany and bitter flavors have been investigated. Recent work showed that oxidized phosphatidyl choline, one of the residual lipids in defatted soybean flakes, is bitter; its contribution to bitterness of soybean proteins is being examined. Other work by the meal products group involves ultrasonic treatment to extract proteins from soybean flakes, irreversible insolubilization of protein during preparation of isolates, and quantitative analysis of carbohydrates in soybean protein products. Dr. Tallent, center director, is serving on the Steering Committee and as a session chairman for the 1978 World Conference on Vegetable Food Proteins.

Discontinued by virtue of budget cuts last year was research work on protective coatings from linseed oil. A linseed oil emulsion to protect concrete continues to attract attention from industry and state highway boards. What had been the Oil Coatings Research group is now merged with the Exploratory Organic Reactions Research group.

The newest major research effort at NRRC, however, is also one of Dr. Dutton's oldest research interests – photosynthesis. That was Dr. Dutton's research topic in graduate school at the University of Wisconsin. He was among the first researchers to show that photosynthesis could be carried out with plant pigments other than chlorophyll.

"Maybe soybeans ought to be brown or olive brown," Dr. Dutton says with a smile. This past summer, a small test plot of soybeans was grown at NRRC under ultraviolet lights to see if that would increase yields. Other variables – particularly weather – made it hard to evaluate the results.

Why study soybean photosynthesis?

Many plant breeders feel they have gone about as far as they can in improving yields with current knowledge, Dr. Dutton explains, and many believe photosynthetic limitations are responsible.

"Why can't we engineer the soybean plant, as we have the corn plant, to produce more," Dr. Dutton asks.

His proposed research will study how the soybean plant throughout the year distributes its sugars – some going to make roots to fix nitrogen, some to produce leaves, and some for reproductive purposes – to produce beans.

Dr. Dutton's group will try to find out how to produce plants that put more effort into producing beans on healthy, vigorous plants and fixing nitrogen with solar energy.

Various portions of the program already have begun. Laser beams are used to separate light to determine how different carotenoids respond to various wavelengths. All shades of green and yellow algae are being tested for reactions to controlled lighting. Chlorophyll cells are overloaded with brief, brilliant flashes of light to determine how they react. In cooperation with plant physiologists at the University of Illinois in Urbana, oxygen losses during the two-way photosynthesis process may be studied with oxygen isotopes. The entire program is just beginning. It is part of a larger photosynthesis research effort involving ARS scientists stationed at both the University of Illinois and NRRC.

The list of research projects is lengthy. The latest NRRC report covers 216 pages of research on new products and processes, ways to improve human health and safety, food and nutrition, production efficiency, conservation and environmental quality, and expansion of agricultural exports.

Work on nonedible uses, as previously mentioned, has been virtually halted. "A nucleus still exists of a former sizable effort to exploit soybean and other vegetable oils as petrochemical-sparing industrial raw materials," Dr. Tallent wrote in one report. "From this nucleus, the research could be expanded rapidly, should national priorities so mandate."

Back when the NRRC building was new, some Central Illinois farmers would go out of their way to drive past the structure, marveling that such a large facility was being built to study what to do with farm crops. The results justified their wonderment. But today's farmer, if not awed by the building, might marvel just as much at the array of scientific instrumentation and computer linkages visible only inside the building – working toward the same goal of maximum utilization of farm crops from America's heartland. ●

Soybean Oil – The Ugly Duckling of the Soybean Industry

In the early 1940s, soybean oil was considered neither a good industrial paint oil nor a good edible oil. Only under the exigencies of World War II was it added to margarines – and then with an absolute limit of 30%! The history of soybean oil is a story of progress from a minor edible oil in the 1940s to the major edible oil, labeled on premium products, of the 1970s. It is also a story of cooperation of government research and industrial implementations of research findings.

Trivial as it may seem now, the first significant milestone in research was the development of objective methods to assess flavor and odor. Numerical values from a taste panel in one plant could then be easily reproduced by a panel in another institution. Equally important perhaps, research finally had a way to reliably assess the benefit of a given processing treatment rather than relying on the judgment of a single expert.

With this new tool, trace metals were identified as having special significance in soybean oil compared to other edible fats and oils. Whereas cottonseed oil can tolerate copper and iron in the parts per million (ppm) range, soybean oil is ruined by as little as 0.3 ppm of iron and 0.01 ppm of copper. What followed this announcement about the deleterious effect of trace metals, especially in soybean oil, was removal of brass valves in refineries and conversion from cold rolled steel deodorizers to stainless steel and even to nickel.

Strange as it may seem in retrospect, government scientists had to establish that "soybean flavor reversion," as it was incorrectly called, was an oxidative process. When scientists sharpened their analytical tools, the relation of peroxidation to off-flavor became unmistakable. Industry's response was to blanket oils with inert gas at all critical high-temperature steps, including final packaging.

The next milestone has the aspects of a cloak-and-dagger story. At the close of World War II, Warren H. Goss, a chemical engineer at NRRC, was commissioned a major in the Army on special assignment to follow Patton's advancing tanks through Germany and to investigate the German oilseed industry. As the troops advanced, he kept hearing about a recipe to cure soybean reversion, but not until he reached Hamburg did he learn exact details. It was a strange formula involving many washings and such steps as contacting oil with water glass; but strange or not, when tested at NRRC it worked. It worked not because of the unusual washing treatments, but because citric acid was added to the deodorizer. Based upon this discovery came the surge of metal deactivators, i.e., sorbitol, phosphoric acid, lecithin, polycarboxy acids, and starch phosphates. The immediate response of industry was to adopt metal deactivation, and today there may not be a pound of soybean oil product not protected by citric acid or some other metal deactivator.

These palliative steps, important as they were, still begged the question as to what causes off-flavor to develop, i.e., what is the unstable precursor? Unsaponifiables, i.e., sterols, were suspect. Circumstantial evidence pointed to the 7% content of linolenic acid which draws its name from linseed oil where this trienoic fatty acid amounts to ca. 50%.

In what is now a classic experiment, 9% per linolenic acid was interesterified into the glyceride structure of a nonreverting nonlinolenic acid oil; namely, cottonseed oil. The taste panel identified cottonseed oil interesterified with linolenic acid as soybean oil!

Armed with this new information, what could be done? Three alternatives suggest themselves with regard to linolenic acid removal: (a) breed it out; (b) extract it out; or (c) react it out.

Of the three alternatives, reacting out linolenic acid was chosen as the most practical research approach – and thereupon began a long search for selective hydrogenation catalysts – those that would react with linolenic acid but not attack the desired, essential polyunsaturated fatty acid – linoleic.

Fortunately, at this time basic researches of catalyst selectivity bore fruit. NRRC's scientists found that among many metals copper behaved with almost enzymatic specificity, hydrogenating linolenic acid some 15 to 20 times more rapidly than linoleic acid. It meant not 3% linolenic salad oils but "zero" percent linolenic oils could be produced, with little attack on the essential linoleic acid and with concomitantly low winterization losses. Room odor studies, similar to the study done in Italy but conducted by our taste-odor panel, could scarcely detect the fishy odors characteristic of unhydrogenated soybean oil or of soybean oil partially hydrogenated by conventional nickel catalysts.

Now a new plant has been built in the United States and has come on stream using copper catalysts. A large producer in Holland has test marketed three brands of copper-hydrogenated soybean oil in France, and a major French oil processor has a plant operating with copper catalysts.

The special interest in copper-hydrogenated soybean oil in France stems in part from the quadrupling in price of peanut oil. A French law permits soybean oil with less than 2% linolenic acid to be sold as a salad cooking oil. The copper-hydrogenation soybean oil should rank as one of the important developments in edible oil production in recent years.

With three decades of research and development by government and industry soybean oil the "ugly duckling" of the soybean processors has become the favorite source of edible oil products for the nation; moreover it promises increasing outlets for the American soybean farmer in foreign markets for the future.

H.J. Dutton

Major fund cuts proposed for NRRC, ERRC

For the second time in three years, major agricultural research fund cutbacks are proposed for USDA Regional Research Centers.

The first cuts, two years ago, bit deeply into the Eastern Regional Research Center's program on industrial uses for animal fats. A proposed $887,000 cut in the ERRC's Animal Fat Laboratory budget for Fiscal Year 1979 (beginning Oct. 1, 1978) would essentially wipe out that lab, says Dr. Gerhard Maerker, laboratory chief. Only two projects dealing with edible fats would be retained: one project on fractionation of beef tallow and a second project on minor constituents of lipids. The lab would lose 22 of 28 staff members under the proposed cuts.

For the ERRC as a whole, the fund cuts total $2.16 million with the other $1.2 million cuts being made in honey research, hides and leather, and the dairy research laboratories. Altogether, the ERRC staff in suburban Philadelphia would be reduced by 50 to 60 persons.

At the Northern Research Center in Peoria, the proposed cuts total $2.4 million, in effect wiping out the Cereal Products Laboratory. The $2.4 million represents about 20% of the center's budget, according to NRRC Director Dr. William H. Tallent, and would mean the loss of 32 scientists and 37 support employees. Seventeen of the 37 support employees would be from the Cereal Products Lab, the other 20 from other units within the center.

While the NRRC cuts do not directly affect the fats and oils programs, Dr. Tallent noted that any loss would reduce the opportunity for spin-off work from one lab to another and a reduction in support personnel would reduce services available to all NRRC labs.

The Agricultural Subcommittee of the Senate Appropriation Committee was expected to hold its initial hearing on the research budget on March 1 or 2, with its counterpart panel in the House scheduled to meet March 13. Government officials and budget planners testify at the initial hearings. Hearing dates for other interested persons were not available at press time, but were expected to be set for late March or early April.

Around Peoria, there has been a flurry of activity since the cuts were made public on Jan. 23. Many community and industrial leaders have been writing to government officials to protest the cuts. Many industrial firms also are expected to oppose the proposed reductions in Philadelphia.

Proposed cuts totaling $1 million at the Southern Regional Research Center in New Orleans affect primarily programs dealing with cotton utilization. In Albany, CA, the Western Regional Research Center faces cuts totaling $900,000 for fiber technology programs. There is a $64,000 cut of a safflower breeding research project in Tucson, AZ. Another program on oilseed production at Davis, CA, is scheduled to be ended with an estimated savings of $155,000.

Federal budget writers apparently looked askance at programs involving industrial use of agricultural commodities. Explanatory comments accompanying the budget said, "Research similar to many of these programs is currently performed by industrial installations."

Dr. Tallent agrees, but says "similar to" is not "same as." One major difference is that regional center research may stretch a decade or more before it reaches a point that private industry can develop a commercial application. Private industry's research, on the other hand, frequently looks for a research project to produce dividends within three to five years.

"We try to terminate a project before it reaches commercial stages, so that the industrial firms that see commercial applications can carry out final development in accordance with their proprietary interests and marketing strengths," Dr. Tallent said.

Private firms' research funds are increasingly used to meet regulatory demands by federal agencies such as OSHA, EPA, NIOSH and others, leaving less money for applied research.

The USDA funds being saved by reducing industrial research apparently are being channeled into nutritional research and a new federal grant program with work to be done largely by scientists outside the federal government.

While the budget for former ARS units (now part of the Science and Education Administration) appeared to show a $20 million increase for FY 79, this is somewhat misleading since that total includes $13 million for pay increases, which doesn't provide any additional manhours, and $10 million for the new grant program, which was not included in the ARS budget for the previous budget year. The net result is a $3 million decrease in funding from FY 78 program levels.

Some of the work to be cut has been aimed at finding ways to use renewable resources instead of petroleum in various products. Dr. Warner Linfield's continuing research on soap-based detergents and lime soap dispersing agents, for example, would be ended under the proposed cuts. The process has been commercialized in Japan.

In Peoria, the Cereal Products Laboratory is the lab that developed xanthan gum and "super slurper," a highly absorbent material finding many industrial uses. Another project that would be ended involves developing biodegradable plastic film from natural sources. One firm has developed biodegradable hospital laundry bags. Dirty linen and other possibly germ-laden items are discarded into the bag, it is sealed and tossed unopened into a washing machine, thus avoiding possible contamination in hand transfer from laundry bag to washing machine. ●

DECEMBER 1977

Tall Oil Fatty Acids & Statistics

IN THOUSAND POUNDS	2% & OVER ROSIN CONTENT		LESS THAN 2% ROSIN CONTENT	
	DECEMBER	Percent change from NOVEMBER	DECEMBER	Percent change from NOVEMBER
Stock on Hand DECEMBER 1, 1977	9,038	- 34.2	7,147	- 3.1
Production	13,241	+ 12.9	13,123	- 13.7
Purchases & Receipts	0		0	
Disposition Domestic	7,763	- 34.0	10,571	- 21.7
Export	5,082	+ 9.0	1,419	- 26.4
Total Disposition	12,845	- 21.8	11,990	- 22.3
Net Disposition*	12,845	- 21.8	11,990	- 22.3
Total Stock DECEMBER 31, 1977	9,434	+ 4.4	8,280	+ 15.9

*Net — Less purchases & receipts.
Definition: Fatty acids fractionated from crude tall oil having a minimum of 90% fatty acids, not including rosin acids. Primary fractions containing less than 90% fatty acids are classified as distilled tall oils.

Production of animal, vegetable, and marine fatty acids totaled 72.7 million pounds in December 1977, an increase of 900,000 pounds from November. Inclusion of tall oil types raises the overall December production level to 99.1 million pounds, compared with 98.7 million pounds for November, according to figures from the Fatty Acid Producers Council.

Acids in thousand pounds

Month December 1977
Issued Jan. 31, 1978
NUMBER OF MANUFACTURERS REPORTING 16

Saturated

SP – Single Pressed; DP – Double Pressed; TP – Triple Pressed

		FINISHED GOODS INVENTORIES (F) ON 11/30	PRODUCTION (A)	RECEIPTS (B)	DISPOSITION: Captive Consumption (C)	Domestic Shipments (D)	Shipment for Export (E)	TOTAL DISPOSITION	FINISHED GOODS INVENTORIES (F) ON 12/31
	STEARIC ACID (40-50% Stearic Content) (1)	8,696	8,799	1,181	2,897	SP 270 DP 2,289 TP 3,642	123	9,221	9,455
HYDROGENATED ANIMAL & VEGETABLE ACIDS	60 C maximum titer & minimum I.V. 5 (2a)	6,333	7,630	14	47	7,268	40	7,355	6,622
	57 C minimum titer & maximum I.V. under 5 (2b)	5,756	12,097	1,461	5,494	8,822	---	14,316	4,998
	Minimum Stearic Content of 70% (2c)	2,687	3,679	279	1,378	2,338	2	3,718	2,927
	HIGH PALMITIC (Over 60% palmitic I.V. maximum 12) (3)	1,009	1,242	---	511	255	2	768	1,483
	HYDROGENATED FISH & MARINE MAMMAL fatty acids (4)	1,091	650	---	45	715	---	760	981
	LAURIC-TYPE ACIDS (I.V. minimum 5-Sapon val. minimum 245—including coconut, palm kernel, babassu) (5)	4,971	5,368	225	2,033	3,264	20	5,317	5,247
FRACTIONATED FATTY ACIDS	C_{10} or lower, including capric (6a)	736	817	(2)	121	897	83	1,101	450
	Lauric and/or myristic content of 55% or more (6b)	2,659	904	95	509	582	30	1,121	2,537
	TOTAL—SATURATED FATTY ACIDS	33,938	41,186	3,253	13,035	30,342	300	43,677	34,700

Unsaturated

ND – Not distilled; SD – Single distilled; MD – Multiple distilled

	FINISHED GOODS INVENTORIES (F) ON 11/30	PRODUCTION (A)	RECEIPTS (B)	Captive Consumption (C)	Domestic Shipments (D)	Shipment for Export (E)	TOTAL DISPOSITION	FINISHED GOODS INVENTORIES (F) ON 12/31
OLEIC ACID (red oil) (7)	10,499	12,403	186	5,720	ND 36 SD 2,998 MD 2,251	569	12,221	10,867
ANIMAL FATTY ACIDS other than oleic (I.V. 36 to 80) (8)	5,897	12,334	1,077	3,640	8,623	1,795	14,058	5,250
VEGETABLE OR MARINE FATTY ACIDS (I.V. maximum 115) (9)	426	11	---	155	7	---	162	275
UNSATURATED FATTY ACIDS (I.V. 116 to 130) (10)	3,006	4,576	263	1,009	2,569	1,231	4,809	3,036
UNSATURATED FATTY ACIDS (I.V. over 130) (11)	2,337	2,165	290	73	2,098	18	2,189	2,603
TOTAL UNSATURATED FATTY ACIDS	22,165	31,489	1,816	10,597	19,229	3,613	33,439	22,031
TOTAL ALL FATTY ACIDS SATURATED & UNSATURATED	56,103	72,675	5,069	23,632	49,571	3,913	77,116	56,731