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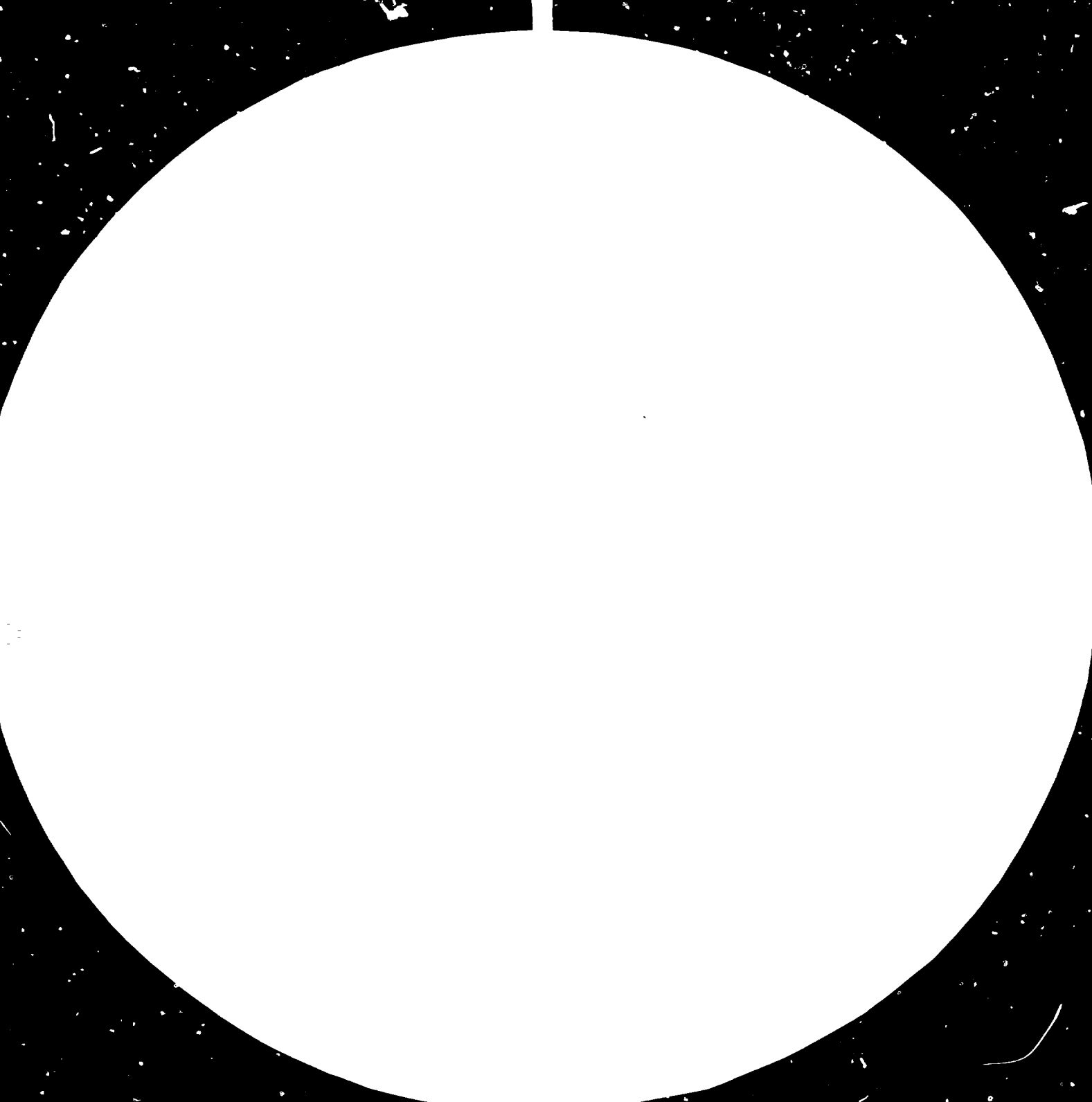

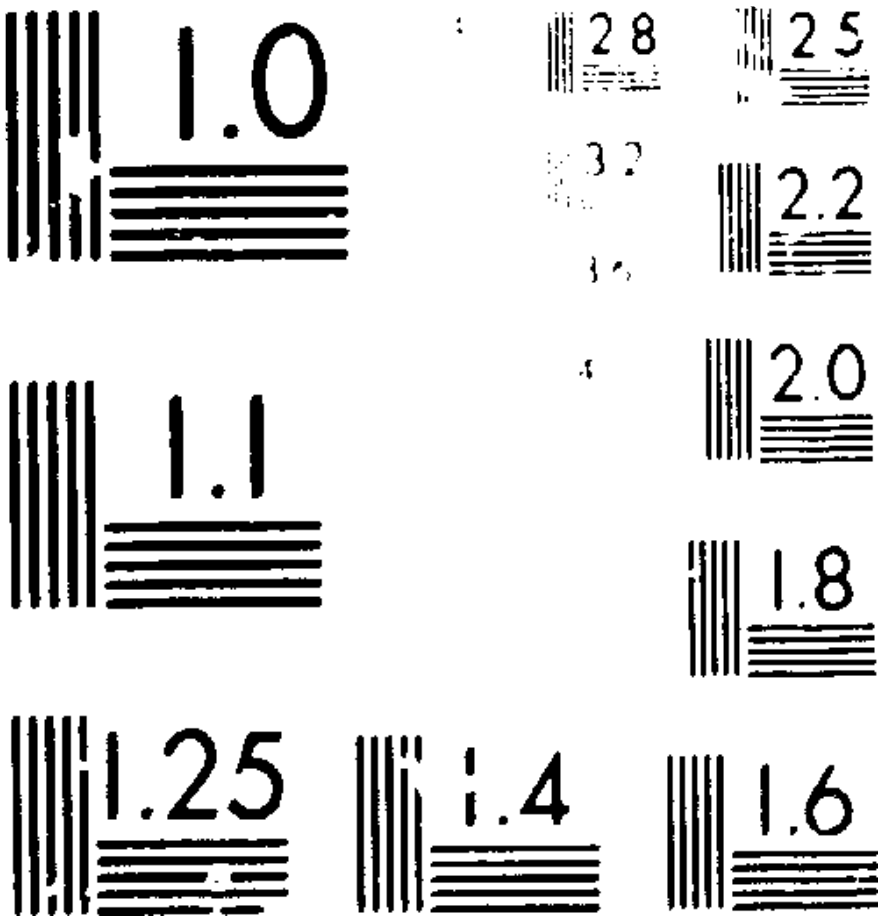
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Distr.
LIMITED

UNIDO/IO.482
14 January 1982

ENGLISH

UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

J O J O B A
AND INDUSTRIAL DEVELOPMENT *

by

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* This paper was prepared for presentation at the UNDP Regional Seminar on the Introduction of Jojoba in the Arab States held in Khartoum, Sudan from 21 to 28 February 1982.

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V.82-20435

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Reference

Reference is made to the UNIDO publication UNIDO/IO.425 entitled:

The Jojoba Potential.

1. Introduction

It has already became part of our life, the jojoba oil. Slowly and hardly noticed by the consumers it has started its way in the hard currency market of developed countries where a variety of Jojoba oil based products have recently been introduced. When attentively watching the advertising media, the name jojoba can be heard and read particularly in connexion with the cosmetics industry offering new expensive products and praising jojoba oil as the basis for new and more effective products.

The use of jojoba oil in the cosmetics industry is not just a coincidence but a very logic development. The relatively small amounts of jojoba oil presently available call for high prices and the cosmetics industry is the one industry that can afford hign price structures for its products if - and this is important - high prices go along with improved quality.

It is very likely that the cosmetics industry will always be a potential user of jojoba oil. Hair shampoos for example are one of the jojoba based products and certain creams and lotions. Three pre-conditions must be fulfilled for a cosmetic product, namely it must be eye-catching, it must appeal to the human senses and it must be safe for use on the human body. Jojoba oil meets all these conditions.

Jojoba oil indeed, is a very unique product which will without any doubts very soon play a very important role as an industrial raw material for the production of a great variety of products in many different fields of applications. The jojoba success story has already started and the time will soon come when jojoba oil has established itself in the world market and certain industrial productions will be unthinkable without it.

2. Jojoba oil - properties and utilization

Jojoba oil is one product - the main product - of jojoba seed processing operations, the other is jojoba cake/meal, the importance of which for many developing countries is still being neglected.

Jojoba oil is not a very exact name as it is not an oil but a liquid wax. It is composed of long chain acid alcohol esters predominantly consisting of C_{20-22} fatty acids and alcohols. Each characterized by one double bond which makes the oil liquid and are the key for its flexibility and very wide end-use opportunities because they permit chemical reactions. Jojoba oil does not contain glycerol esters which makes it distinctly different from vegetable oils and fats.

I would not consider it the purpose of this paper to enter into the details of the physical and chemical jojoba oil properties but should like to make a reference to the UNIDO publication IO.425 dated 4 May 1981, entitled "The Jojoba Potential". A summary of the jojoba properties may be seen from table 1 attached to this paper.

The oil obtained from jojoba seed processing is a light golden liquid that requires no or very little refining. The jojoba oil normally is of very low acidity and remains essentially unchanged even after repeated heating up to 350°C.

The special jojoba properties permit the production of a variety of derivatives by chemical and physical reactions. These derivatives again have different properties than the original jojoba oil and, therefore, allow very wide fields of applications.

Jojoba oil can be isomerized - which means the conversion into a solid product - in the presence of nitrogen oxydes, selenium, sulfur oxyde and others and the product obtained is a creamy texture which is of particular interest for the cosmetics and pharmaceutical industry.

Jojoba oil can also be hydrogenized. Complete hydrogenation results in a hard cristalline jojoba wax while partial hydrogenation turns the oil into a creamy, semi-solid paste.

Jojoba oil can further be sulfurized by using agents such as sulfur and chlorine. Sulfurization results in a wide range of products with different chemical and physical properties. When the sulphur content is low, the product will be liquid and will generally be suitable as lubrication additive. Increasing the sulphur content will increase the viscosity until a rubber-like mass is obtained. It is particularly the sulfonation process that makes jojoba oil of great interest as a sperm oil replacer. It may be recalled in this context that due to safeguarding the world's whale population, less and less sperm oil is being produced and steadily increasing market demands exist.

Other processes are sulfur-bromination of jojoba oil, its reduction to alcohols and last but not least also epoxidation. Sulfur-brominates have very excellent superior properties as a lubrication additive that can resist extreme pressures and temperatures. Such products may easily become of strategic importance. Sodium reduction of jojoba oil leads to a mixture of unsaturated long chain alcohols, the application of which in industry again is very wide and probably not yet fully explored. This is also the case with epoxidized jojoba oil which is equal if not superior to epoxidized soya bean oil.

3. Industrial uses of jojoba oil

When discussing industrial uses of jojoba oil, it should be clearly mentioned that it is not suitable as a food and the food industry, therefore, is not a user of jojoba oil. However, jojoba oil is suitable as a carrier for pharmaceutical preparations which have to pass the intestines before assimilation. The pharmaceutical industry, therefore, already is and will definitely become more and more a user of jojoba oil not only as a carrier but also as an antifoam agent for example in the production of penicillin.

A very important branch of industries expected to use jojoba oil is the metal working and engineering industry which is always in need of lubrication oils and naturally the lubrication oil and lubrication additive industry itself. This particular sector of industries, indeed, might soon show special interest in jojoba oil products. Lubrication oils may be classified according to their uses in engine lubricants, lubricants for gears and drives as well as those for turbines, compressors and useful rolling operations and cutting oils and machine tool lubricants. Very special properties are required for each special use. Lubrication oil additives are substances which add new desirable properties to the lubricant particularly those of high pressure and high temperature resistancy to avoid friction of metal on metal surfaces. Naturally, the lubrication additive sector will become a very important field of application to jojoba oil products as sperm oil product replacers.

A further field of application for jojoba oil is the leather industry. Leather basically is a highly interwoven three dimensional fibrous net work which becomes a hard and unflexibale material after tanning and drying unless it is softened by special oil emulsification treatment. Jojoba oil is a very excellent leather softener and superior to the traditional products like animal fats, vegetable oils, fish oil and petroleum based mineral oils.

As already mentioned earlier, another potential jojoba oil user already is and will continue to be the cosmetics industry. There are, however, a number of other industries that may become additional potential jojoba oil users. There is for example the wax industry which might use Jojoba oil as a carnauba wax replacer for the production of polish wax, carbon paper, special quality candles, etc. Considerable applied research work continues in many parts of the world in the jojoba utilization sector particularly in the pharmaceutical industry and in the anti-foam agent production sector for various applications. Many new fields of application for jojoba oil may soon become evident as jojoba research continues, and the market for jojoba oil and its products will certainly become wider and wider.

4. Practical development considerations

As it can be seen from the above review, jojoba oil will start a series of new products and processes that will soon be taken up by the relevant industries. Jojoba oil, therefore, will certainly bring about further broad industrial development effecting various different branches of industries. In addition to the cultivation of the jojoba plant and the production of jojoba oil, the developing countries will also have the opportunity to enter into secondary jojoba processing operations with and without the co-operation of the established industries in the industrialized world.

However, no matter how interesting and even fascinating the jojoba development perspectives may be, the jojoba industry has just started and still is in its early stages with tremendous work to be done. It is, therefore, important to return to the present stage of jojoba development and look at it from a practical view point. Any industry can only grow effectively if steps be taken at the appropriate time in the appropriate order of priority to establish its viability.

No doubts exist about the urgent need for further agricultural development and the improvement of the overall jojoba cultivation harvesting and post-harvesting methods. It is, however, not the purpose of this paper to discuss and analyse the details of the agricultural production sector but what should be discussed and reviewed in this context are the very important jojoba fruit processing operations for the production of jojoba oil and cake or meal for use as a protein animal feed.

5. The jojoba processing industry

Very valuable work has been done with appreciable results in the jojoba cultivation sector, however, hardly any thoughtful considerations have been given to efficient jojoba processing operations. The otherwise very thorough international jojoba research activities have so far been satisfied with the statement that "traditional oil seed processing equipment" can be used for the production of jojoba oil from jojoba fruits. Let us discuss this statement and let us see how valid it really is.

The quantity of jojoba nuts available to date is comparatively small. It is, therefore, understandable that low capacity equipment will have to be used for processing and somewhat naturally the mechanical pressing operations as traditionally applied in oilseed processing operations offer themselves for this purpose. In fact all - to our knowledge - jojoba processors up to now operate that way with the result that the jojoba press cakes normally have residual oil contents of 20 per cent and more. Because of the special jojoba oil properties only insufficient pressure can develop in the cages of the traditional mechanical presses which make efficient de-oiling operations impossible. More than 20 per cent residual oil in the press cakes mean unproportionally high jojoba oil production losses which matter very much particularly in view of the limited amount of jojoba nuts available today.

The high production losses certainly very unfavourably effect the jojoba oil production economy which will only become of real concern to jojoba processors after the present experimental plantations and processing operations will reach the full commercial scale.

The very high residual oil content in the press cakes in addition to the high production loss factor causes another equally important problem, namely the unsuitability of the jojoba cake as an animal feed and its, therefore, very low value as an only waste product. It may be recalled in this context that jojoba oil as a liquid wax is not edible which refers to human beings as well as to animals.

In order to use the jojoba cake as a protein animal feed component to the benefit of the jojoba processor and to a country's animal production sector, it has to be free of residual oil to the optimum possible extent.

Appropriate reasoning based on the above mentioned facts would lead to the conclusion that efficient jojoba processing operations for the production of jojoba oil and cake/meal will have to be characterized by the following basic criteria:

1. Small or medium capacity;
2. Optimum oil extraction rates;
3. No residual oil content (less than 1 per cent) in the cake.

These criteria can only be met by solvent extraction operations. The well known vegetable oil solvent extraction technology, however, is characterized by the economy of scale and capacities of 50 tons per day are about the smallest available. Further considering the fact that a modern continuous solvent extraction plant has to operate round the clock and 300 days a year in order to be economic, the minimum quantities of approximately 15.000 tons of jojoba seed would have to be made available. Such quantities to be obtained from one location are out of reach in the near future.

A specific jojoba processing technology will, therefore, have to be developed as a very urgent and important task. The jojoba processing development work has to go parallel with further agricultural development work in order to achieve the desired results and bring the overall jojoba industries up to the high technical and economic level it certainly deserves. To obtain the required funds for the development of an efficient jojoba processing technology that can be made available to jojoba producing developing countries for operation is UNIDO's concern at present.

6. The jojoba meal

Comparisons between oilseeds and jojoba seed are generally hardly permissible but industrial processing operations have an aspect in common and this is the economic need for the production of two products of value, namely the oil and the meal. Negligance of the jojoba meal will result in various economic disadvantages.

Realizing this fact UNIDO has paid special attention to the utilization of jojoba meal within the framework of its world-wide jojoba evaluation study. Reference is again made to the UNIDO publication IO.425 of 4 May 1981 entitled, "The Jojoba Potential".

As a matter of fact the relative profitability in the production and processing of jojoba seed depends to a large extent on the utilization of jojoba meal as an animal feed component. Jojoba seeds contain on the average fifty per cent crude oil (within the range of 45 to 60 per cent). The amount of meal that can be produced by solvent extraction is, therefore, approximately fifty per cent of the seed weight. The protein content of the meal represents the most important nutrient with regard to its utilization as animal feed. Since the crude protein content in jojoba seeds is between fourteen and fifteen per cent, the protein content in the meal will be between twenty-eight and thirty per cent after the extraction of the oil. The protein content is rather low compared with soyabean meal (40 per cent to 50 per cent) but still high enough for animal feeding purposes. The amino acid profile shows a shortage in methionine which may be compensated by a relatively high level of cytine which both are sulfur containing essential amino acids. Still in order to have a balanced amino acid composition, the addition of synthetic methionine may be required or the shortage is to be compensated by relevant formulations of mixed compounded animal feed. The table 2 shows the composition of jojoba materials and the table 3 outlining the amino acid composition of jojoba meal.

Although the nutritional composition of the jojoba meal had reasonably been balanced, feeding trials were disappointing with regard to the pallatability and nutritional utilization of jojoba meal when incorporated in mixed feed products. This fact leads to the conclusion that some toxin and/or other anti-metabolites are present which need to be destroyed by appropriate treatment prior to animal feeding.

Relevant detoxification methods have been developed which are still being studied in their effective details. Such methods for example can be water extraction, alcohol extraction, germination, ammonia treatment and others. This is the appropriate place to point out that the most appropriate jojoba processing technology to be developed (see para. 5 above) will have to combine the most effective oil extraction method with a suitable meal detoxification method in one unit operations if possible.

Extensive development work and feeding tests combined with computer evaluations have indicated that the utilization of jojoba meal as an animal feed component is not only possible but also economically advantageous. The best way of incorporating jojoba meal into mixed compounded animal feed may have to be defined on a case by case basis as it depends on the special situation of the producing country. The development work in this direction continues.

7. Conclusion

The influence jojoba products will have on industrial development is tremendous. Many new products will be created based on jojoba oil and its derivatives for which there is a wide open market. In this context economic considerations will play a vital role and should, therefore, always be kept in mind in the forthcoming jojoba development work. While we do not under-estimate the need for further product and process development work based on jojoba oil and the urgent need for further agricultural production improvement, we would attach priority to the development and definition of the most suitable jojoba processing technology for the production of jojoba oil and quality animal feed meal.

Table No. 1

Properties of Jojoba Oil

Property		Property	
Freezing point [a] (°C)	10.6-7.0	Smoke point (AOCS Cc 9a-48)[b] (°C)	195
Melting points (°C)	6.8-7.0	Flash point (AOCS Cc 9a-48)[b] (°C)	295
Boiling point at 757 mm under N_2 (°C)	393	Fire point (COC) (°C)	338
Heat of fusion by differential		Iodine value	82
Scanning calorimetry	21 cal/g	Saponification value	92
Refractive index at 25°C	1.4650	Acid value	2
Dielectric constant at 27°C	2.680	Acetyl value	2
Specific conductivity at 27°C	$8.86 \cdot 10^{-13}$ mho/cm	Unsaponifiable matter (%)	51
Specific gravity at 25°C	0.863	Total acids (%)	52
Viscosity		Iodine value of alcohols	77
Rotovisco at 25°C		Iodine value of acids	76
MV-1 rotor in MV cup	35 cp	Average molecular weight	
Plate and cone with Pk-1	33 cp	of wax esters	606
Brookfield, spindle # 1, at 25°C	37 cp		
Cannon-Fenske at 25°C	50 cp		
Cannon-Fenske at 100°C	27 centistokes		
Saybolt at 100°C	127 SUS[c]		
Saybolt at 210°C	48 SUS[c]		

a - Oil from expeller-pressed jojoba seeds starts to freeze at 10.6°C. It solidifies into a thick paste at 7°C.

b - Smoke and flash points determined according to the official method, Cc 9a-48, of the American Oil Chemists' Society.

c - Saybolt Universal Seconds.

Table No. 2

Composition of Jojoba Materials

(in %)

Composition	Type of Jojoba Material						
	Whole Seed		Dehulled Whole Seed	Hulls	Dehulled Meal	Partially Dehulled Meal (10% hulls)	Undehulled Meal (17% hulls)
Moisture	0.8	4.4	4.3	10.7	8.9	5.8	5.7
Crude protein (N x 6.25)	15.1	13.7	14.9	7.0	29.1	24.1	20.1
Crude oil (Ether Extract)	50.2	49.9	53.8	0.7	3.0	1.6	0.9
Crude fiber	4.2	-	3.5	15.6	8.1	11.0	14.3
Ash	1.6	1.4	1.4	4.4	3.1	4.9	3.6
N.F.E.	28.1	-	22.1	61.6	47.8	52.6	55.4
Total sugars	29.3	16.6	3.7	3.3	8.7	-	-
Polysaccarides	20.3	-	17.4	-	-	-	-
References	137	145	137	137	138	138	38

Table No. 3

Amino Acid Composition of Jojoba Meal Protein

Types of Amino acid	Total amino acids in jojoba meal of 24.5% protein (in % **)	Amino acids expressed as percent of amino acids recovered	Total amino acid in a meal with 30% protein (in % **)
Lysine*	1.4	5.7	1.71
Histidine	0.6	2.5	0.75
Arginine	1.9	7.8	2.34
Aspartic acid	2.6	10.6	3.18
Threonine*	1.3	5.3	1.59
Serine	1.3	5.3	1.59
Glulamic acid	3.2	13.1	3.93
Proline	1.5	6.1	1.83
Glycine	2.4	9.8	2.94
Alanine	1.1	4.5	1.35
Valine*	1.5	6.1	1.83
Methionine*	0.1	0.4	0.12
Cystine (half)	0.6	2.4	0.72
Isoleucine*	0.9	3.7	1.11
Leucine*	1.8	7.3	2.19
Tryosine	1.1	4.5	1.35
Phenylalanine*	1.2	4.9	1.47
Total	24.5	100.0	30.00
Total Sulfur Amino Acids	0.7	2.8	0.84

* Essential amino acid.

** Grams of amino acids per 100 grams of meal.