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THE UTILIZATION OF WASTE TOMATO SEEDS AND SKINS.

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CONTENTS.

INTRODUCTION.

The manufacture of tomato products in the United States constitutes an industry of large and growing proportions and importance. Tomatoes serve as the basis for two general classes of products, in one of which the fresh whole tomatoes are used and in the other the pulp alone, as in the manufacture of catsups and soups. For this latter class large quantities of tomatoes are required, from which the seeds and skins at present are discarded as useless.

The increased interest in the production of foodstuffs throughout the country will doubtless result in an extension of all canning and packing operations, including tomato products. In the following pages attention is directed to the possible utilization of the waste tomato material, not only from the standpoint of food conservation, but as a profitable adjunct to the tomato-canning industry.

COMMERCIAL PRODUCTS FROM TOMATO REFUSE.

By proper treatment, tomato refuse may be made to produce two important products, namely, fixed oil and meal, both of which

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possess considerable value. The seeds of the tomato contain a fatty oil of excellent quality, and the seed cake is valuable as a stock food.

Considerable work has already been done in foreign countries, especially in Italy, on the utilization of tomato waste. Battaglia (4)[1] in 1901 investigated tomato-seed oil and reported on its properties. Later, Kochs (9), in an investigation of certain residues, mentioned tomato-seed oil and discussed its properties, stating that 17.3 per cent of oil having an agreeable taste and smell could be obtained from the seeds.

In the manufacture of tomato products, Italy perhaps leads all countries. The industry there has assumed such proportions that the problem of the proper disposal of the residues has become an important consideration. Perciabosco and Semeraro (12) in 1910 investigated tomato residues with a view to extracting the fatty oil, determining also the industrial value of the oil and the fertilizer and feeding values of the residues after extraction. The oil extracted by carbon bisulphid was found to have properties similar to those of the oil previously reported by Battaglia. The fat-free residues were found to be useful for fertilizing purposes.

Harcourt (6) in 1907 called attention to the tomato refuse accumulating in increasing quantities at the canning factories in Canada. It was reported that a large portion of the refuse was flushed into near-by rivers, but in some cases it was allowed to accumulate near the factories, thus becoming a nuisance. Some of the refuse was spread over the land as a fertilizer. The manurial value was tested and found to compare favorably with barnyard manure in the three important elements, potash, phosphoric acid, and nitrogen.

Accomazzo (1) in 1910 stated that in the province of Parma, Italy, 850,000 quintals (83,660 tons) of tomatoes were used annually. This quantity would yield from 11,000 to 12,000 tons of skins and seeds, containing about 80 per cent moisture. After removing the greater portion of the moisture the residue would amount to about 3,000 to 4,000 tons, of which about two-thirds are seeds. It is stated that these seeds when extracted by pressure yield 18 per cent of oil and by solvents 20 per cent. It would therefore be possible to recover from 500 to 600 tons of oil from the waste seeds. Tomato-seed oil is stated to have a heat value about equal to that of olive oil. When treated with driers it acquires good drying properties and is also useful in soap making. The press cake is said to have excellent nutritive value.

Fachini (5) also recommends the extraction of oil from the seeds, but instead of drying the residue, as proposed by Accomazzo, he

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[1] The serial numbers in parentheses refer to "Literature cited," pp. 14–15.

suggests a method of separating the seeds from the skins by agitating the material with water and allowing it to settle, whereupon the seeds fall to the bottom. The greater part of the water can then be removed from the wet seeds by centrifugal machines, after which the seeds are dried easily and the oil can be removed by extraction or pressure.

According to Consul Keena (8), Florence, Italy, the utilization of tomato waste and the extraction of the oil from the seeds was first attempted by a firm in Parma in 1910. The success of the undertaking led to the establishment of two other factories the following year. About 5,000 metric tons (1 metric ton=2,204 pounds) of wet tomato waste, corresponding to 1,500 metric tons of dry waste, were worked out for the extraction of the oil and manufacture of the meal. These operations yielded 150 tons of oil, 800 tons of oil cake, and 500 tons of tomato skins.

Tomato-seed oil has been utilized in the manufacture of soap, and the conversion of the crude oil into an edible oil is also receiving attention. The press cake is used in the manufacture of stock feed, while the skins are suggested as a fertilizer.

The seeds are sold at Parma for 14 cents per 100 pounds, while at Naples the wet residue is sold at 4 to 8 cents per 100 pounds. This residue, which ferments readily, must be collected and dried daily. When dry it sells at $1.75 to $2.20 per 100 pounds.

More recently attention has been called by Shriver (14) to the vast quantities of tomato seeds and skins accumulating as waste products from the rapidly growing canned-tomato industry in Italy. The problem of the proper disposition of this waste has been receiving attention since 1908, at which time a manufacturing plant was established in Milan, with branch drying plants at Parma, Ceriale, Cervia, Piacenza, and Pilastro.

The oil is sold in the crude state for $7 per 100 pounds, and the refined oil for $8.75 per 100 pounds. The press cake is mixed with the skins and other ingredients and sold as stock feed.

The yield of oil from the seeds is stated by Shriver to be about 20 per cent by pressure and 22 per cent by solvents. In 1913, from 100 to 150 metric tons of oil and 1,000 metric tons of stock feed were manufactured in Milan from the press cake and skins.

Bailey and Burnett (3), working with American tomato seeds, extracted the oil by pressure and found that it could be refined and bleached easily and was apparently a satisfactory food oil.

ACCUMULATION AND DISPOSAL OF TOMATO WASTE.

PERCENTAGES OF SEEDS AND SKINS.

For the preparation of tomato pulp, the fresh tomatoes, after being carefully sorted to remove the culls, are thoroughly washed by a stream of water under pressure, then passed into receptacles where they are cooked with steam, and afterward are transferred to a cyclone machine, which removes the pulp. The seeds and skins pass out and are discarded. By the cold process the washed tomatoes pass directly to the cyclone machine.

The total quantity of tomato waste which accumulates annually in the United States depends not only upon the pack of any particular season but also upon the percentage of seeds contained in the fresh tomatoes. The seed content varies with the variety of tomato. Estimated from the figures given by Accomazzo (1), Italian-grown tomatoes contain 14.7 per cent of wet waste, of which about 80 per cent is water. After removing the greater portion of the water, the waste amounts to 4.8 per cent. Of this waste, which probably still contains some moisture, 73 per cent is seeds. The dry waste as it occurs in Italy is stated to contain about 66 per cent by weight of seeds (15). These percentages are considerably higher than the results obtained from American-grown tomatoes.

Two experiments in different localities were made with American-grown tomatoes which had been used for pulping purposes, to determine the percentage of seeds and skins. The quantity of fresh tomatoes used in the two experiments was 2,320 pounds and 5,344 pounds, respectively. The results were as follows: Wet waste, 5.43 and 5.44 per cent; dry waste, 1.11 and 0.95 per cent. The dry waste in these experiments contained 46.3 and 42.8 per cent seeds and 53.7 and 57.2 per cent skins, respectively.

According to Street (16, p. 128–129), fresh tomatoes contain 1.35 per cent dry waste, consisting of 49.3 per cent seeds and 50.7 per cent skins. Using these figures as a basis for calculation, American-grown tomatoes contain on the average about 1.13 per cent dry waste, of which 46.1 per cent is seeds and 53.9 per cent skins. Fresh tomatoes therefore contain the equivalent of 0.52 per cent dry seeds and 0.61 per cent dry skins.

In order to learn the approximate annual output of tomato refuse in the United States, the writer personally visited 21 of the largest tomato-pulping firms. These manufacturing concerns operate largely in Indiana, Iowa, Michigan, and Ohio in the Middle West, and New Jersey, Pennsylvania, New York, Delaware, and Maryland in the East. Detailed figures regarding the output of refuse were not available in each State. The extent of the industry, however, may be realized when it is learned that in Indiana alone 120,000 tons of tomatoes are pulped annually. Applying the percentages previously mentioned, the amount of dry waste in this one State would be about 1,356 tons, or 624 tons of seeds and 732 tons of skins.

Not all the firms engaged in pulping tomatoes could be reached; therefore accurate information in regard to the total quantity used annually could not be obtained. But from the figures given by the firms visited, supplemented by correspondence with other firms, it is estimated that 275,000 tons are pulped annually. Adding to this the tonnage of culls, from which also the seeds and skins could be separated, a conservative estimate would be about 300,000 tons.

This tonnage, of course, would vary from year to year. However, owing to the increasing demand for tomato products, the tonnage will tend to increase each year.

The quantity of wet waste resulting annually would be about 16,000 tons, which would yield approximately 3,000 tons of dry waste. This dry waste would yield about 1,500 tons of dry seeds and 1,800 tons of dry skins.

DRYING THE WASTE MATERIAL AND SEPARATING THE SEEDS.

An important problem in connection with the utilization of tomato waste is the drying of the mass and separating the seeds from the skins. According to Shriver (14, p. 21–22), this problem is handled in Italy in the following manner:

> The wet seeds and skins are passed through a press to remove as much of the moisture as possible. They are then passed through a desiccator, or drier, in which the material is kept in constant motion by means of horizontal conveyers, finally emerging from the machine in a dry condition. Heat is applied to the drier by means of steam pipes or by forced air.

It is stated that about 10 tons of residue can be dried in 24 hours. The final operation consists in passing the dried material through a machine supplied with a series of sieves and fans, which results in the complete separation of the seeds from the skins.

A number of types of desiccators, or driers, are manufactured in the United States which would be admirably suited for drying the wet waste. It has been suggested that a sugar-beet drier would handle the material efficiently. No great difficulty should be experienced in constructing a separator consisting of sieves and fans for the separation of the seeds from the skins.

EXTRACTION OF TOMATO-SEED OIL.

Two methods of extraction are applicable for obtaining fatty oil from seeds. The pressure method is perhaps the simplest and most expeditious, being well adapted to seeds containing a fairly high percentage of oil. The most careful manipulation of this process, however, leaves a residual portion of the oil in the press cake. The expeller type of press is perhaps the best adapted for seeds having a comparatively low percentage of oil. Even with this type of machine a small percentage of oil remains in the press cake. This, however, is not a total loss, since the value of the cake is enhanced by the presence of some fat. A distinct advantage of the pressure method is in the better quality of the product obtained. Pressed oils usually contain less impurities and consequently are more readily and effectively refined.

When the maximum percentage of oil is desired from certain materials the volatile-solvent method of extraction serves best. The principal solvents which may be employed are benzine, petroleum ether, gasoline, and carbon tetrachlorid. A disadvantage of this method is in the inflammability of many of the solvents, necessitating careful handling and operation. This trouble is largely overcome by the use of carbon tetrachlorid, which is noninflammable and possesses a higher boiling point than any of the other solvents and hence is capable of effecting more complete recovery. Oils obtained by the solvent extraction method are usually less pure than expressed oils, containing much coloring matter and other impurities extracted by the particular solvent employed. No great difficulty is experienced, however, in refining the oils thus obtained. Pressed oils also require refining.

Apparatus of the continuous-extraction type is usually employed. This kind of apparatus minimizes the quantity of solvent used and prevents loss of the solvent during the operation. Practically all the solvent may be recovered from the oil and residue and thus be available for further use. A practical example of the use of a volatile solvent for the extraction of fatty oil is the use of benzine in the extraction of soy-bean oil (11). The disadvantages of the solvent method as compared with the advantages of the pressure method are largely offset by the lower cost of the apparatus, the smaller expense of operation, and the higher yield of oil obtainable.

Continuous extractors and hydraulic presses are obtainable from American manufacturers of chemical and pharmaceutical machinery.

Either of the two methods mentioned may be used effectively in the extraction of oil from tomato seeds. The solvent extraction method was used for obtaining the samples in the experiments described in this bulletin. The apparatus employed was the continuous-extraction type, the solvents used being ether and carbon tetrachlorid. The yield of oil from the ground seeds with either solvent was practically the same, averaging 22 per cent. The crude oil was pale greenish yellow in color with a fatty, slightly rancid odor and fatty, slightly bitter taste.

In refining the crude oil the objectionable odor was removed by passing steam through the oil until little or no odor was perceptible. The deodorized oil was then heated on a steam bath for about one hour with fuller's earth (kaolin) and finally filtered while hot through filter paper. This procedure effected decolorization of the oil to a marked degree. The refined oil possessed a very pale yellowish color with bland fatty and agreeable nutlike taste and smell.

PHYSICAL AND CHEMICAL PROPERTIES OF THE CRUDE AND THE REFINED OILS.

Some of the more common physical and chemical constants of the crude and the refined oils were determined, as shown in Table I. For purposes of comparison the properties of some of the tomato-seed oils of foreign origin are also included in the table.

TABLE I.—*Physical and chemical constants* [a] *of tomato-seed oil from domestic and foreign tomatoes.*

Physical and chemical constants.	Domestic oil.		Foreign investigators.			
	Crude.	Refined.	Accomazzo (1).	Battaglia (4).	Kochs (9).	Perciabosco and Semeraro (12).
Color	Pale greenish yellow.	Very pale yellow			Brownish red.	
Odor	Fatty, nutlike, slightly rancid.	Fatty, bland, nutlike.			Agreeable, tomatolike.	
Taste	Fatty, slightly bitter.	Fatty, bland, nutlike; no bitter aftertaste.			do	
Specific gravity	0.9216 [b]	0.9184 [b]	0.920 [c]	0.922 [c]	0.920 [c]	0.9244. [c]
Index of refraction.	1.4694 [d]	1.4715 [d]		1.4730		
Congealing point	Turbid at 0° C.; yellow gelatinous mass at −7° C.	Turbid at 2° C.; solid, very pale yellow mass at −10° C.			Thick liquid at −9° C.	
Acid value	8.8	2.5		26.3	9	1.823.
Saponification value.	190.4	188.6	183.6	190.4	183.6	189.4.
Iodin value	108	114.2	117	106.9	117.8	87.7.

[a] Determined according to standard methods (17). [b] At 24° C. [c] At 15° C. [d] At 25° C.

From Table I may be noted the general effect of the refining process upon the physical and chemical properties of the oil. The color, odor, and taste of the refined oil show much improvement over the same properties of the crude oil. The specific gravity and index of refraction show changes due to the removal of impurities by the refining process. The congealing point of the refined oil has likewise changed. The acid value is materially lower than that of the crude oil, owing to the removal of the free fatty acids. The saponification and iodin values show similar differences due to the removal of impurities.

Among the oils of foreign origin the properties reported by Battaglia correspond more nearly to those of the crude oil of domestic origin, while the remainder compare favorably in most cases with the refined domestic oil.

CHEMICAL EXAMINATION OF THE OIL.

In addition to the chemical constants a further examination of the refined oil was made to determine its approximate composition. The determinations were made according to standard methods (17, p. 138–139). No soluble acids were found, but 96.2 per cent of insoluble acids were present. These insoluble acids were separated into the solid and liquid acids by means of the lead-ether method (17, p. 45). The mixed acids were found to consist of solid acids 17.54 per cent and liquid acids 75.84 per cent.

The physical and chemical properties of the insoluble acids and the solid and liquid acids, were determined with the results shown in Table II.

TABLE II.—*Physical and chemical properties of insoluble, solid, and liquid acids of tomato-seed oil.*

Physical and chemical properties.	Insoluble acids.	Solid acids.	Liquid acids.
Color	Pale golden yellow; partly solid.	Snowy white, flaky	Pale golden yellow.
Odor	Fatty, nutlike	Fatty	Pleasant, nutlike.
Taste	Sweetish, fatty	Fatty, tallowlike	Sweetish, nutlike, becoming slightly bitter.
Specific gravity at 25° C.	0.9100		0.9013.
Index of refraction at 25° C.	1.4655		1.4654.
Congealing point	+21.5° C. to +20.5° C.	Melting point, 53.5° C.	
Neutralization value	180	204	192.3
Iodin value	104.3		130.

The solid acids, comprising 17.54 per cent of the oil, probably consist largely of palmitic and stearic acids with neutralization values of 219.1 and 197.5, respectively. The neutralization value 204 would indicate a mixture of these two acids. Although the melting point of crude solid acids is considerably lower than either palmitic or stearic acids, which melt when pure at 62° C. and 69° C., respectively, it is very probable that this is due to the presence of impurities.

Calculating from the neutralization value 204, the mean molecular weight of the solid acids was found to be 275. This indicates the presence of palmitic and stearic acids, since the molecular weight of these acids are 256 and 284, respectively.

In order to ascertain the approximate proportions of these two acids in the mixed solid acids, a calculation was made according to the method suggested by Lewkowitsch (10, v. 1, p. 515), using as a basis 275, the mean molecular weight of these solid acids. By this method, the percentage of palmitic acid was found to be 67.8 and of stearic acid 32.2.

Since 17.54 per cent of the original oil consists of solid acids, the oil therefore contains palmitic acid 11.88 per cent and stearic acid 5.64 per cent. Because the palmitic and stearic acids exist in the oil as palmitin and stearin, it is necessary to reduce the above figures to terms of these glycerids. The glycerid palmitin contains 95.29 per cent of palmitic acid, and the glycerid stearin contains 95.73 per cent of stearic acid. By calculation, therefore, it is found that tomato-seed oil contains 12.47 per cent of palmitin and 5.89 per cent of stearin.

The liquid acids, constituting 75.84 per cent of the oil, possess properties which indicate the presence of oleic acid and possibly some linoleic acid.

The specific gravity of the liquid acids, 0.9013 at 25° C., would indicate a mixture of oleic and linoleic acids, since the specific gravity of pure oleic acid is 0.893 at 25° C. and linoleic acid 0.9206 at 14° C. The index of refraction corresponds closely with oleic acid, which possesses an index of refraction of 1.4603 at 25° C.

The neutralization value of 192.3 is somewhat lower than that of pure oleic acid, 198.9, and pure linoleic acid, 200.4. The iodin value, 130, possibly also indicates a mixture of oleic and linoleic acids with a preponderance of oleic acid. Some commercial oleic acids have idoin values as high as 100 to 110, while pure linoleic acid possesses an iodin value of 181.42.

Using the method of Lewkowitsch (10, v. 1, p. 457), for calculating the approximate proportions of oleic and linoleic acids present from the iodin value as a basis, it was found that the liquid acids consist of 56.8 per cent of oleic acid and 43.2 per cent of linoleic acid. Reducing these percentages of oleic and linoleic acids to terms of the original oil, which consists of 75.84 per cent of liquid acids, it is found that the oil contains approximately 43.07 per cent of oleic acid and 32.76 per cent of linoleic acid. These acids are contained in the oil in the form of the glycerids olein and linolein, which contain 95.7 and 95.67 per cent, respectively, of oleic and linoleic acids. By calculation it is found, therefore, that the oil consists approximately of 45 per cent of olein and 34.2 per cent of linolein.

A summary of the results of the chemical examination of tomato-seed oil indicates the following approximate composition: Olein, 45 per cent; linolein, 34.2 per cent; palmitin, 12.47 per cent; stearin, 5.89 per cent—the remaining portion consisting of free acids and unsaponifiable matter.

AVAILABLE QUANTITY OF THE OIL.

Estimating the annual output of dry tomato waste from the various pulping plants in the United States at 3,390 tons, there would result from this waste 1,560 tons of dry seeds. The quantity of oil capable of being extracted from these seeds is readily ascertained. Since by extracting with volatile solvents 22 per cent of the oil can be obtained, the total available quantity would be about 343 tons annually. This quantity would, however, increase each year with the increased output of tomato products.

USES AND VALUE OF THE OIL.

Classifying fatty oils as drying, semidrying, and nondrying, tomato-seed oil possibly falls into the semidrying class, bordering, however, very nearly on the nondrying class. In order that the nature of tomato-seed oil may be better understood, a comparison is given in Table III of some of the more important properties of a number of oils of commerce belonging in the same class with tomato-seed oil (10, v. 2).

TABLE III.—*Physical and chemical properties of tomato-seed oil and several important oils of commerce.*

Oils.	Specific gravity at 15° C.	Congealing point (° C).	Saponification value.	Iodin value.	Index of refraction at 20° C.
Tomato seed	0.9184 [a]	Turbid at −2; pale yellow solid mass at −10.	188.6	114.2	[b] 1.4715
Cotton seed, Lewkowitsch (10, p. 149–150).	0.922 to 0.930	3 to 4	191 to 196.5	100.9 to 116.9	1.4722
Soy bean, Lewkowitsch (10, p. 123).	0.924 to 0.927	+15 to + 8	190.6 to 192.9	121 to 124	
Sesame, Lewkowitsch (10, p. 173).	0.9203 to 0.9260	− 4 to − 6	187.6 to 194.6	103 to 115	1.4728
Corn, Lewkowitsch (10, p. 131–132).	0.9213	−10 to −20	188 to 193.4	112 to 130.8	[c] 1.4768

[a] At 24° C. [b] At 25° C. [c] At 15.5 °C.

The similarity of tomato-seed oil to the commercial oils given in Table III indicates the classification of this oil. The oils mentioned in connection with tomato-seed oil are applied commercially in a number of ways. As edible oils they are highly prized. On account of their drying properties some are employed extensively in the manufacture of paints and varnishes, while others find important application as soap stock.

Tomato-seed oil, with properties similar to cottonseed, soy-bean, sesame, and corn oils, should be equally useful and applicable to the same purposes as these oils of commerce.

Experiments conducted with tomato-seed oil by Dr. A. D. Holmes, of the Office of Home Economics, U. S. Department of Agriculture, to determine its digestibility, showed that the oil possesses a coefficient of digestibility of 97, comparing favorably with olive, almond, cottonseed, peanut, coconut, sesame, walnut, and brazil-nut oils. Well-refined tomato-seed oil is therefore to be recommended for culinary purposes. As a salad oil it should prove very satisfactory. The edible quality of the oil suggests also its possible hydrogenation and application as a margarine oil.

An experiment to determine its saponifying properties was conducted in order to obtain information regarding its possible use as soap stock. By cold saponification with caustic soda and subsequent salting and pressing, a soap of good texture with excellent lathering qualities was produced. If combined with oils rich in palmitin or stearin, satisfactory toilet soap doubtless could be prepared. Owing to the present threatened shortage of oils for the manufacture of soaps and glycerine the utilization of tomato-seed oil as a soap stock asserts itself.

Experiments to determine the drying properties of the oil showed that 16 days were required to form a soft, sticky film. The nature of the film as well as the time of drying could in all probability be improved and hastened by the addition of siccatives or driers to the oil. It appears, therefore, that the oil possesses a certain value as a paint or varnish oil.

The value of the oil in commerce would necessarily depend upon the particular use to which it could be applied and to the demand in general for fatty oils. From the results of the investigation, it appears that it should prove a valuable addition to the edible or condimental oils now in use. Likewise it should find an important place among the much-needed soap oils of commerce.

TOMATO-SEED MEAL.

UTILIZATION FOR STOCK FEEDING.

The residue remaining after extracting the oil from the seeds constitutes the meal. The utilization of this meal as stock feed is suggested. In order to ascertain the approximate composition of the meal, a careful analysis was made. The results are shown in Table IV, together with analyses of some commercial stock feeds as given by Henry and Morrison (7, p. 634–636).

TABLE IV.—*Composition of tomato-seed meal as compared with various commercial stock feeds.*

Feeding stuff.	Constituents (per cent).					
	Moisture.	Ash.	Protein.	Nitrogen-free extract.	Fiber.	Ether extract.
Tomato-seed meal	7.15	4.64	37.0	29.10	22.11	....
Cottonseed meal	7.8	6.6	39.8	27.4	10.1	8.3
Sunflower seed (prime)	10.0	4.2	34.8	21.8	10.9	18.3
Sesame-oil cake	9.8	10.7	37.5	21.7	6.3	14.0
Palm-nut cake	10.4	4.3	16.8	35.0	24.0	9.5
Rape seedcake	10.0	7.9	31.2	30.0	11.3	9.6
Linseed meal (new process)	9.6	5.6	36.9	36.3	8.7	2.9

In moisture and ash content, the tomato-seed meal compares favorably with the other feed stuffs. In protein content, it ranks with sunflower seedcake, cottonseed meal, sesame-oil cake, rape seedcake, and linseed meal, being considerably higher than palm-nut cake and somewhat lower than cottonseed meal. Since the tomato-seed meal which was subjected to analysis was from ether-extracted seeds, the ether extract does not enter into consideration. The meal from seed expressed by hydraulic pressure would contain from 5 to 7 per cent ether extract, which represents the residual fat left in the cake. The crude-fiber content is relatively high as compared with the other feeds, being lower, however, than that of palm-nut cake. The content of nitrogen-free extract, consisting largely of carbohydrates, is higher than in such meals as cottonseed, sunflower, and sesame, and lower than in palm-nut, rape-seed, and linseed cake.

From the results of the analysis and the comparison with standard stock feeds it would appear that tomato-seed meal possesses properties of considerable value for stock feeding. In this connection it may be stated that in Italy, where the utilization of tomato residues is in practical operation, experiments with the meal or cake have demonstrated its value as a feed for stock. Aguet (2) has reported a factory in operation at San Giovanni a Teduccio, near Naples, for the industrial manufacture of tomato seedcake. Feeding trials conducted at the Royal Higher School of Agriculture at Portici with milch cows showed tomato seedcake to be equal in food value to linseed cake. Later, Scarpitti (13) conducted extensive investigations with the seedcake as a feed for milch cows, stating that it is richer than flaxseed cake in protein and fat and is superior to it in its influence upon the weight and lacteal secretion of the cows.

Shriver (14, p. 21–23) describes the manufacture of stock feed from the dried tomato waste after the extraction of the oil. A number of grades of stock feed under the name "Nutritivo" are manufactured by a firm at Milan, Italy, from the dried skins mixed with molasses and the meal from the extracted seeds. This feed for cattle is sold at prices ranging, according to quality, from $1.32 to $1.49 per 100 pounds. The seedcake after the oil is expressed is sold at $1.32 per 100 pounds.

AVAILABLE QUANTITY OF THE MEAL.

After extracting the oil from the estimated quantity of tomato seeds which accumulate annually, there would remain as a by-product about 1,200 tons of the meal. In addition to this large quantity of meal there would also be available about 1,800 tons of tomato skins. In view of the use to which the dried skins are applied in Italy by incorporating them with the meal, this would increase the total available quantity to about 3,000 tons.

SUMMARY.

The foregoing investigation shows that the vast quantities of tomato refuse accumulating each year at tomato-pulping factories can be reduced to two products, namely, fixed oil and meal, each of which may be made commercially useful.

The oil from the seeds should find ready disposal as an edible oil or as a soap oil, as shown by the experiments made to determine its applicability to these purposes. By proper treatment it can be made useful as a drying oil for paint and varnish purposes.

The meal has been shown by analysis and comparison with other meals to possess valuable qualities as stock feed, and the utility of the meal for this purpose should therefore be assured.

The accumulation of tomato residues occurs principally in two sections of the United States, namely, the North-Central States lying east of the Mississippi and north of the Ohio Rivers and the North Atlantic States. The reduction of this waste material to oil and meal could be handled most logically by establishing reducing plants at some central point in each of these sections, where the crude material could be collected with the least expense for transportation and handling. A cooperative plan of manufacture would perhaps be the most feasible and effective method for establishing the industry upon a practical basis.

In view therefore of the threatened shortage of fatty oils and in the interest of food conservation, tomato refuse may be considered as an available source for the manufacture of oil and oil cake. As the demand for tomato products increases, the quantity of this waste material will also increase, and it is suggested as an economic measure of both agricultural and industrial importance that the utilization of this material be considered.

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