WEST AFRICA.

COMMITTEE ON EDIBLE AND OIL-PRODUCING NUTS AND SEEDS.

REPORT;

WITH A

DESPATCH FROM THE SECRETARY OF STATE FOR THE COLONIES.

(*Minutes of Evidence are printed separately as* [*Cd.* 8248].)

Presented to both Houses of Parliament by Command of His Majesty.
June 1916.

LONDON:
PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S STATIONERY OFFICE
BY EYRE AND SPOTTISWOODE, LIMITED, EAST HARDING STREET, E.C.,
PRINTERS TO THE KING'S MOST EXCELLENT MAJESTY.

To be purchased, either directly or through any Bookseller, from
WYMAN AND SONS, LIMITED, 29, BREAMS BUILDINGS, FETTER LANE, E.C., and
28, ABINGDON STREET, S.W., and 54, ST. MARY STREET, CARDIFF; or
H.M. STATIONERY OFFICE (SCOTTISH BRANCH), 23, FORTH STREET, EDINBURGH; or
E. PONSONBY, LIMITED, 116, GRAFTON STREET, DUBLIN;
or from the Agencies in the British Colonies and Dependencies,
the United States of America and other Foreign Countries of
T. FISHER UNWIN, LIMITED, LONDON, W.C.

1916.

[Cd. 8247.] *Price* 5*d.*

TABLE OF CONTENTS.

PAGE

I.—SCOPE OF THE INQUIRY - - - - - - - - - 4

II.—MAGNITUDE OF THE TRADE - - - - - - - - - 5

III.—NATURE OF THE TRADE AND COGNATE INDUSTRIES - - - 6

1. Different Branches of the Trade - - - - - - - - 6
2. Two-fold Nature of the Product - - - - - - - - 6
3. "Crushing" *versus* "Extraction." - - - - - - - - 6
4. Refining - - - - - - - - - - - - 8
5. The General Nature of Palm-kernel Cake and Meal - - - - - - 8
6. Use of Palm-kernel Oil for Soap and Margarine - - - - - - 11
7. Possible Competitors with Palm-kernel Oil - - - - - - - 11

IV.—POSITION OF THE TRADE AT THE OUTBREAK OF WAR - - - 12

1. Import Statistics - - - - - - - - - - 12
2. Shipping - - - - - - - - - - - 12
3. Hamburg as a Market - - - - - - - - - - 13
4. Milling before the War - - - - - - - - - - 13
5. Margarine - - - - - - - - - - - 13
6. Reasons for the condition of the Trade in 1914:— - - - - - - 13
   (*a*) Origin.
   (*b*) Secret Freight Rebates and other facilities.
   (*c*) The question of Outports.
   (*d*) Port Charges and Delivery Costs.
   (*e*) The Value of a constant Market.
   (*f*) Inland Carriage.
   (*g*) Cost of Milling and Refining.
   (*h*) Carriage from the Mill to the Margarine Factory.
   (*j*) Duties.
   (*k*) General considerations affecting the Continental Trade - - - - - 16
7. Outlook for British Trade before the Outbreak of War.

V.—WEST AFRICA - - - - - - - - - - - - - 17

1. Points of interest excluded from this Report - - - - - - - 17
2. Nature of the Oil Palm - - - - - - - - - - 18
3. Proportion of the Crop at present gathered - - - - - - - 19
4. Milling in West Africa: Advantages and Drawbacks - - - - - - 19
5. The Local Manufacture of Palm Oil - - - - - - - - 19

VI.—THE TRADE DURING THE WAR - - - - - - - - 20

VII.—CONCLUSIONS AND RECOMMENDATIONS - - - - - - - 21

1. Report by the Committee - - - - - - - - - 21
2. Report by Mr. T. Wiles, M.P. - - - - - - - - - 25

APPENDICES.

PAGE

APPENDIX A.

Tables illustrating the Nature and Growth of the Export Trade from West Africa - - 27

APPENDIX B.

Memorandum by Professor Crowther on the results of Feeding Experiments with Palm-kernel Cake, Coconut Cake, and Ground-nut (Earth-nut) Cake, with Notes on values as determined by Analyses - - - - - - - - - - - - - 28

APPENDIX C.

Duties in Force on Vegetable Oils and Margarine in some of the principal European Countries - 43

APPENDIX D.

Memorandum by Mr. G. A. Moore - - - - - - - - - 45

Despatch from the Secretary of State to the Governors of West African Colonies - - - 46

COMMITTEE ON EDIBLE AND OIL-PRODUCING NUTS AND SEEDS.

To the Rt. Hon. A. BONAR LAW, M.P., &c., &c., His Majesty's Secretary of State for the Colonies.

SIR,

IN June last you approved the appointment of a Committee to consider and report upon the present condition and the prospects of the West African trade in palm kernels and other edible and oil-producing nuts and seeds, and to make recommendations for the promotion in the United Kingdom of the industries dependent thereon.

The members of the Committee were as follows:—

Mr. A. D. STEEL MAITLAND, M.P., Parliamentary Under Secretary of State (*Chairman*).

Sir G. V. FIDDES, K.C.M.G., Assistant Under Secretary of State (*Vice-Chairman*).

Sir HUGH CLIFFORD, K.C.M.G., Governor of the Gold Coast.

Mr. L. COUPER.

Professor WYNDHAM R. DUNSTAN, C.M.G., F.R.S., Director of the Imperial Institute.

Mr. C. C. KNOWLES.

Sir FREDERICK LUGARD, G.C.M.G., C.B., D.S.O., Governor-General of Nigeria.

Mr. T. H. MIDDLETON, C.B., Board of Agriculture and Fisheries.

Mr. G. A. MOORE.

Sir OWEN PHILIPPS, K.C.M.G., M.P.

Mr. T. WALKDEN.

Sir W. G. WATSON, Bart.

Mr. T. WILES, M.P.

Mr. T. WORTHINGTON, Director of the Commercial Intelligence Branch, Board of Trade.

Of these members Sir Owen Philipps, Mr. Moore, and Mr. Walkden were appointed on the recommendation of the London, Liverpool, and Manchester Chambers of Commerce respectively.

The Committee much regret that the return to West Africa of Sir Frederick Lugard and Sir Hugh Clifford prevented them from being present at the later sittings of the Committee.

The first meeting of the Committee was held on the 18th of August 1915, and twenty-one meetings have been held. Oral evidence has been received from twenty-six witnesses, representing as far as possible all the interests concerned in the West African trade, and including various members of the Committee.

The Committee now have the honour to present the following report.

O (6)31313 5000 6/16 E & S A 2

REPORT.

I.—Scope of the Inquiry.

The subject of the Committee's inquiry is one which perhaps it may be difficult to make generally interesting, but at any rate it is possible to make intelligible. Outside the circle of those immediately interested, the West African trade in palm kernels is not so well known or appreciated as ought to be the case, and therefore the magnitude of the interests involved is first stated. In the next section a brief description is given of the trade and the industries related to it, together with their inter-connection. This description is very simple as contrasted with that of some industries, but, at the same time, such an account seems desirable for the purpose of conveying a comprehensive view of the subject matter with its different parts seen in their proper perspective. The state of the industry at the outbreak of war is next outlined; its international distribution, and the causes which have occasioned such a distribution. It would then seem natural to deal with direct issues as between Germany and this country, examining the advantages possessed by Germany in the past, and the extent to which they can be counterbalanced. The question, however, is complicated in two ways by considerations affecting West Africa, viz.:—(1) Is it likely that the demand for the West African produce will continue as great as, or greater than, it is at present? (2) If so, how far in competition with the United Kingdom is West Africa itself suitable or likely to be a legatee of the German industry? The sixth section describes the course of the trade since the outbreak of war, and the seventh and last portion of the report gives the conclusions and recommendations of the Committee.

It will be noted that while, by the terms of reference, the attention of the Committee was principally directed to the question of palm kernels, yet palm oil, ground nuts (*Arachis hypogaea*), shea nuts (*Butyrospermum Parkii*), benniseed (*Sesamum Indicum*), and other oil-producing nuts and seeds were also within the scope of their inquiry. The Committee have examined witnesses with reference to shea nuts and benniseed, but the condition of the trade does not appear to be such as to warrant prolonged treatment in this report. At the same time it is possible that the trade in shea nuts may become important if the difficulties can be surmounted which hitherto have stood in the way of successfully refining the fat. But in any event, no case has been made out for exceptional measures in this connection. The trade in ground-nuts is different. It is a large and important trade, of which the principal centre is in France, though considerable quantities are imported into other European countries. Its value to West Africa is about one-seventh of that of palm oil and palm kernels. It forms the mainstay of the Gambia (Q. 1518, 5365), both industrially and financially, and there is every sign of a considerable development of the production and export of ground nuts from Northern Nigeria. At the same time, it would appear that very large shipments have been made to the United Kingdom within the last year. There is every opening for a development, if crushers in this country will embrace their opportunity, and the Committee therefore do not wish to recommend that further measures should be taken. As regards palm kernels, the circumstances are entirely different. It is an immense trade, and demands exceptional interest by reason of its size. Not only so, but nearly the whole of the industry of crushing kernels was in German hands. The inquiries of the Committee, reported in the following pages, have therefore been predominantly directed to the problem of establishing in this country the trade in palm kernels and the industries which crush them, or which refine or manufacture the oil thus obtained.

II.—Magnitude of the Trade.

The magnitude of the export trade from West Africa of vegetable oils and oil-producing substances is proved by the fact that in 1913 its value amounted to nearly ten millions sterling. Of that trade palm oil and palm kernels accounted for over eight millions. Analysed according to the country of origin, the exports from British Possessions amounted to 7,519,000*l.*; from French Possessions (in 1912) to 2,782,000*l.*, and from the former German Possessions (in 1912) to 535,000*l.* Nor is this all. Rapid expansion is proceeding. Exports from British Possessions in West Africa have trebled in value in the last decade, and, unless unfavourable conditions, arise this expansion may continue.

Certain of the tables which illustrate the facts are so instructive that they are given here. But it is well worth noting other features which are shown by the three additional tables given in Appendix A. One main and cardinal fact, however, cannot be brought out too clearly. The trade in palm kernels amounted in 1913 to over 5,000,000*l.* sterling, or one half of the total exports from West Africa. Of this great total, over 4,250,000*l.*, or four-fifths of the whole, came from British Possessions. Yet three-quarters of it went to Germany to be milled.

Table I.

Exports in 1913 *of the principal vegetable oils and oil-nuts from British West Africa* to various markets (in thousand £).*

—	To United Kingdom.		To Germany.		To France.		To Holland.		To South Africa.		To all Countries.	
	Tons.	£1,000	Tons.	£1,000	Tons.	£1,000	Tons.	£1,000	Tons.	£1,000	Tons.	£1,000
Palm kernels	35,175	681	181,305	3,314	1,938	28	5,984	80	5,305	97	234,208	4,199
Palm oil	74,237	1,644	10,426	242	3,203	63	—	—	981	23	88,997	1,977
Ground nuts	10,323	80	26,559	256	42,942	389	4,440	40	—	—	86,693	797
Shea nuts	4,781	36	2,988	24	—	—	1,637	10	14	—	9,420	70
Palm-kernel oil	3,795	129	62	—	—	—	—	—	—	—	3,857	129
Palm-kernel cake	—	—	5,412	31	—	—	—	—	—	—	5,412	31
†Copra	12	—	93	2	620	14	—	—	—	—	726	16
Benniseed	1,039	8	86	—	113	1	—	—	—	—	1,250	9
Total of above products	129362	2,578	226,930	3,869	48,816	495	12061	130	6,300	120	430,563	7,228

* Gambia, Sierra Leone, Gold Coast, and Nigeria.

† It will be noted that the total imports of copra are given here, though West Africa is a very minor source of supply of copra. But the figures are worth consideration, not only because the cultivation of copra in West Africa is increasing, but because coconut oil and palm-kernel oil are very similar in character, and, indeed, for most purposes are interchangeable.

Table II.

French West Africa.

From "Statistiques du Commerce des Colonies Françaises pour l'année 1912."

Exports (partly estimated) in 1912 *of palm kernels, palm oil, and ground-nuts from French West Africa‡ to various markets.*

—	To United Kingdom.		To Germany.		To France.		To Holland.		To Belgium.		To Portugal.		To all Countries.	
	Tons.	£1,000	Tons.	£1,00	Tons.	£1,000	Tons.	£1,000	Tons.	£1,000	Tons.	£1,000	Tons.	£1,000
Palm kernels	3,459	47	43,089	586	3,604	43	—	—	—	—	—	—	50,174	676
Palm oil	4,561	101	589	13	13,227	289	—	—	151	3	—	—	18,533	407
Ground nuts	103	1	18,954	169	136,357	1,226	25,238	225	3,297	29	3,201	29	189,570	1,699

‡ Senegal, French Guinea, Upper Senegal and Niger, Ivory Coast, and Dahomey.

TABLE III.

GERMAN WEST AFRICA.

From the "Deutscher Kolonialatlas," 1914.

Production for Export in Cameroons and Togoland of Palm Kernels and Palm Oil, and Copra in Togoland.

	Palm Kernels and Palm Oil.				Copra, Togoland.	
	Cameroons.		Togoland.			
	Tons.	£1,000	Tons.	£1,000	Tons.	£1,000
1906 - - -	*	145	*	42	*	*
1907 - - -	16,479	206	5,259	68	28	0·6
1908 - - -	*	157	*	73	*	0·9
1909 - - -	*	182	*	125	*	1·7
1910 - - -	16,560	237	11,131	161	133	2·0
1911 - - -	18,261	275	17,021	259	186	3·1
1912 - - -	19,279	296	14,736	236	160	3·0

* Figures not available.

III.—DESCRIPTION OF THE TRADE AND COGNATE INDUSTRIES.

1. *The different branches of the Trade.*

It is requisite to distinguish the different phases in the commercial history of the palm kernel, as an alteration in any one of them may definitely affect the whole question. On the African coast the cones containing the fruit of the palm are gathered; the fleshy exterior or pericarp of the fruit treated for palm oil; the nuts cracked and the kernels collected and sold to the European trader. Second comes the shipment to Europe. Third, the market. Fourth, when the kernel has been sold and brought to the mill, the palm-kernel oil is obtained by crushing or extraction. Next, the crude oil is refined. This process is, of course, distinct from crushing, but for obvious reasons both are usually conducted side by side under the same management. At this point, two products, oil and feeding-cake (or meal) emerge and go through the last two stages of manufacture and distribution to the consumer. On the one hand, the oil may be made, according to circumstances, either into soap, vegetable lard, or margarine, and the feeding cake or meal is either sold in its existing form as palm-kernel cake or meal, or used as a component of one of the compound cakes now on the market.

The distinction between palm oil obtained from the pericarp and palm-kernel oil subsequently obtained from the kernel is well known to all acquainted with the subject. The former is produced exclusively in West Africa and is dealt with at a later stage. It is with palm kernels and palm-kernel oil that the following paragraphs are concerned.

2. *Two-fold nature of the Product.*

It is important to note that the product of the palm kernel is not single but two-fold, *i.e.*, oil and feeding stuff. The oil is, of course, much the more important of the two, being worth about five times as much as the cake. But even so, where the margin of profit is cut fine as regards the principal product, the value of the secondary product may be decisive. In any case, it is not the price of one article, but the scale of prices obtained for both, that must be considered.

3. "*Crushing*" *and* "*Extraction.*"

Crushing and extraction are alternative processes for obtaining the oil from the kernel when it has been ground. It is necessary to understand the difference between the two, even if only in the barest essentials, as it is possible that this difference may affect the establishment of the industry in the United Kingdom.

When crushed, the kernel, ground small, is heated, placed in a special press, and subjected to a very high pressure, which makes the oil flow out. It is important to note that the hardness of the kernel necessitates special machinery. Thus a mill that will crush kernels can also (with a slight alteration of the rollers) crush linseed or cotton seed, &c., economically, but not necessarily *vice versâ*. The resultant cake is a feeding stuff, and, as the pressure applied is very great, the cake is proportionately hard.

When the process of extraction is used, the kernel after grinding is placed in a special cylinder and mixed with a solvent, generally benzine or trichlorethylene. The solvent passes through to another receptacle, carrying the oil with it. The solvent is then recovered by distillation and the oil remains. The resultant feeding stuff is a light and fluffy meal (Q. 207, 2527, 3892-94, 5153), unsuitable for use in the open, but capable of being used for making compound cakes, or for indoor feeding in the form of meal for pigs or other animals (Q. 3982-3).

The comparative advantages of the two processes are still somewhat in doubt. The actual cost of dealing with a ton of kernels will differ in either case according to the perfection of machinery and method. But if equal care be used, the cost of handling a ton of kernels by extraction is variously estimated at from 5*s*. to 10*s*. a ton more than crushing. Next, it must be remembered that the proportion of oil obtained will differ considerably. If the oil is extracted, the proportion left in the meal may be as low as 1 per cent. In crushing, under the best results at present obtained by the latest machinery, the average percentage of oil left in the cake is seldom less than 6 per cent. (Q. 2376, 3505, 3694) and, with any but the best methods, may easily reach 10 per cent. If the extra cost of handling, therefore, is not excessive, it would thus look as if the advantage would be on the side of extraction, since a higher proportion of the more valuable product is extracted. The value of the feeding stuff is somewhat reduced, but not in a degree corresponding to the advantage in the increased volume of oil obtained. But, on the other hand, the substance of the meal obtained by extraction* presents difficulties from which cake is free, and its usefulness depends on its suitability either for use in compound cakes or the existence of sufficient objects for which it is naturally adapted, *e.g.*, the indoor feeding of pigs and other live stock. Equally or more important, however, is the character of the oil produced. Even in crushing, the heat employed may have an effect on the nature of the oil (Q. 5268, 2425), but otherwise the separation is mechanical. Extraction, however, involves the use of a solvent which may affect the oil (Q. 4140, 5189-91) in some degree, rendering it liable to retain a trace of the taste of the solvent. Any such trace may be removed by the subsequent refining, but the price of the crude oil in any case may be somewhat affected and thus offset the advantage of the larger volume produced.

Keeping in mind, however, the object before the Committee, namely, the establishment in this country of the industry previously conducted in Germany, the material points that arise are two :—

(*a*) Will it be more difficult to establish a market in this country for meal obtained by extraction, than for cake, and, if so, is the difference in the price obtainable likely to be serious ?

(*b*) German mills are already established and are mainly, though by no means exclusively, devoted to crushing. Is the advantage, if any, possessed by the extraction process so clear and so material that by its adoption British mills now being set up, or to be set up, can get a decided advantage ?

To the latter question the answer in the present state of knowledge is "No." To the former, the reply is not so simple. Apart from mechanical difficulties due to its fluffiness, there is no hindrance to the use of meal in compound cake, but this fluffiness prevents any such cake containing more than about 10 per cent. of meal and in this way its use, even for that purpose, is limited. Palm-kernel cake, at a little added cost, can be ground and similarly used. For direct use palm-kernel cake has to fight its way to an established use, just like palm-kernel meal, but the difficulties are greater with the meal than with the cake.

* In this report the term "meal" is used to indicate the meal obtained by the extraction process but it is important to remember that the cake produced by crushing is sometimes ground up and sold in the form of a meal.

4. *Refining.*

When an oil is to be used for edible purposes, it requires to be refined. The problems in refining are mainly chemical, and chemistry in connection with the present question is concerned alike with the preparation of oils by refining, and with the selection and use of the proper oils for manufacture into the product desired, such as margarine, or soap. As regards refining, the removal of any taint or taste and the production of a neutral and tasteless oil are of the first importance. Similarly, in manufacture, it must be remembered that, just as the composition of oils differs both generically and specifically, so does their behaviour at different temperatures or in different combinations. In each class of product certain qualities must be constantly kept in view, as, for example, saponification in soap, and taste, melting point, keeping quality, and texture in margarine. In the former case, the recovery of by-products must be remembered, a matter of no small importance when glycerine is so valuable as at present. Lastly, while all oils differ, some are much more closely allied than others (palm-kernel oil and coconut oil forming a striking instance of close similarity (Q. 5013)), and among such nearly related oils there may, within limitations, be a free choice determined by price. It is thus clear that the chemical process is of an importance equal to machinery, though with a practical difference. It is not an easy thing to keep the nature of machinery secret. But it is possible to keep a chemical process from being divulged. To judge from the information that has reached the Committee, the necessity for first-class chemical assistance is as fully realised by the leading firms in this country as in Germany (Q. 2402, 2942–44, 5009). More important still is the necessity that the whole direction of the industry should be influenced by the conclusions reached on the chemical side. In this respect it is inevitable that some works should be ahead of others, but we have no reason to think that the most advanced British firms are behind the Germans in this respect.

5. *The General Nature of Palm-kernel Cake and Meal.*

Several witnesses have given evidence before the Committee on this aspect of the subject. A number of feeding experiments have already been conducted both with palm-kernel cake and meal. Others have been suggested by the Committee and are being instituted. The main considerations in this branch of the subject will be readily appreciated. Granted that the composition of a feeding stuff is such as to bring it within the range of choice, it will, of course, be seen that quality and price are inter-dependent. The witnesses whom the Committee have had the privilege of examining gave much valuable information, but the opinions given showed considerable variation, and this variation is reflected in the reports which have reached the Committee of the experiments mentioned above.

An account of recent experiments in feeding palm-kernel cake will be found in the memorandum by Dr. Crowther printed as Appendix B. Special attention may be directed to the conclusions drawn from the experiments made on fattening cattle and on dairy cows in this country (pp. 33 and 37); also to the results of an extensive experiment on dairy cows which was conducted by a German agricultural society in 1910 (p. 37). The German experiment emphasises one most important property of palm-kernel cake, viz., its effect on the composition of milk.

Other investigations which had previously been made as to the influence of the diet of the animal on the composition of milk pointed to the conclusion that, given an adequate ration, it is not possible to influence the percentage of butter fat in milk by alterations in feeding (Q. 400–404, 5317). Slight changes in the composition of the milk may follow a change in feeding, but the percentage of fat soon returns to the normal for the particular animal. This extensive German experiment (Q. 173), however, goes to show that palm-kernel cake forms an exception among feeding stuffs, and that it definitely increases the amount of milk fat. If further experiments uphold this conclusion, palm-kernel cake will form a most important addition to the feeding stuffs now at the disposal of the dairy farmer. The increase in milk fat in the German experiment varied with different animals from 0·16 per cent. to 0·34 per cent. The significance of this result will be apparent when it is pointed out that the second figure is equal to about one-tenth of the total quantity of fat present in ordinary milk, and that under certain conditions dairy farmers may have difficulty in

securing even as much as 3·0 per cent. of fat in the mixed milk of a herd of cows. Milk which contains less than 3·0 per cent. of fat is presumed to be adulterated, and there would be a keen demand on the part of dairy farmers for any feeding stuff which was known to improve milk of poor quality; even if the increase amounted to not more than 0·1 per cent. To the maker of butter, the increase in the percentage of fat is also of special importance, for, assuming no change in the yield of milk, an increase of 0·34 per cent. of fat would mean that nine cows would produce as much butter as ten did before. Palm-kernel cake has a further special value to the dairy farmer in its effect on the texture of butter. It produces a firm butter and is thus well adapted for feeding to cows in summer.

There is less evidence as to the value of palm-kernel cake for use in fattening cattle and sheep, since the experiments hitherto made have been of a preliminary character; but enough information has been collected to prove that it is a wholesome food, quite suitable for blending with farm fodders, and it is now being extensively used by cattle feeders, especially in Scotland.

The Committee have received evidence showing that palm-kernel residue, either as cake or meal, is a very suitable food for pigs. This has an important bearing on its future as a feeding stuff in this country, since cotton cake, its chief competitor among the cheaper oil cakes, is unsuitable for pig-feeding.

The Committee have had much evidence to the effect that before the war palm-kernel cake was not appreciated by British farmers and that the small quantity manufactured in this country found its chief market in Germany. The reasons alleged were that British farmers were prejudiced, that the cake was not readily eaten by stock, and that it did not keep well. While all three allegations have some foundation, the Committee are of opinion that none of them would seriously affect the future use of the cake if the crushing trade is established in this country. The conservatism of the farmer has not hindered the development of a great trade in other oil cakes, some of which, *e.g.*, Bombay cotton cake, were regarded with disfavour when first introduced; it was only to be expected that with large supplies of cotton seed, linseed, and other cakes at his disposal, the insignificant amount of palm-kernel cake offered to him by British crushers should have attracted no attention in the past, and with well-tested feeding stuffs at his disposal he was not likely to experiment with a new food offering no advantage in price over those he already knew. Evidence has been laid before the Committee that at the outset live stock show some reluctance to take the cake. But it seems equally clear that before long they eat it readily (Q. 51). If therefore it will produce better milk or cheaper bacon than competing foods, this objection is not likely to prevent it from coming into general use. As regards keeping qualities, there has been evidence that palm-kernel cake keeps quite satisfactorily and at least as well as undecorticated cotton cake (Q. 152). Indeed, a progressive improvement as regards palm-kernel cake is already noticeable. When war was declared very few English crushers had machinery at their disposal which was well adapted for crushing palm kernels. But this was merely a temporary difficulty. Mills with suitable machinery have been and are being erected, so that a cake of satisfactory keeping quality may be anticipated. The Committee have not met with any evidence that its keeping qualities have given trouble to German farmers, with whom it is a very popular feeding stuff.

Professor Wood, of the Cambridge School of Agriculture, has submitted to the Committee the results of an investigation into the causes of rancidity in palm-kernel cake. According to these results, the tendency of palm-kernel cake to become rancid is due to the presence of a fat-splitting ferment, which under suitable conditions (warmth and moisture) is able to decompose the fat left in the cake, liberating fatty acids, which have a rancid odour.

The results show, further, that if the cake is kept cool and dry this rancidity does not occur, and also that the fat-splitting ferment becomes inactive when the cake is heated to 70° Centigrade. Apparently, therefore, all that is necessary to insure that palm-kernel cake shall not develop rancidity on keeping is to see that the heating by steam of the ground kernels (Q. 2536, 4018), which is an essential preliminary in the manufacture of cake, is efficiently carried out, as this will render the ferment inactive and so prevent any development of rancidity from this cause, even if the cake is not very carefully stored.

Two forms of palm-kernel residue are on the market, (i) cake from mills in which the oil is removed by pressure, and (ii) extracted meal from mills where solvents are

used for removing the oil from the kernel. The usual variations in the percentages of the chief constituents are :—

	Palm-kernel Cake.	Palm-kernel (extracted) Meal.
Oil	5·5 to 7·5 %	1·75 to 2·25 %
Albuminoids	17·0 to 19·0 %	19·0 to 20·0 %
Carbohydrates	42·0 to 48·0 %	49·0 to 52·0 %

Typical analyses of palm-kernel residues are given in the table below,* in which the average composition of certain other feeding stuffs is given for comparison.

The commercial value of palm-kernel cake and meal depends partly on the purposes for which they are required and partly on their composition, and there is no reason to suppose that the constituents of palm-kernel cake are intrinsically of any less value than the same constituents in other cakes. Adopting this view, Dr. Crowther in his evidence placed the relative values of one ton of average samples of linseed cake, palm-kernel cake, and Egyptian cotton seed cake at 11*l.*, 7*l.* 13*s.*, and 6*l.* 12*s.*, respectively (see Dr. Crowther's précis of evidence and Q. 268). In his memorandum appended to this Report (see Appendix B.) he has further compared the values of palm-kernel cake with other oil cakes. The values have been arrived at by different methods, which are applicable to the different circumstances in which a purchaser might wish to use the feeding stuffs. Judged by these standards, it would appear that, in proportion to its value as a foodstuff, palm-kernel cake has been selling at a lower price during the past year than the more popular and well-known oil cakes.

The Committee are of opinion that agricultural colleges should be encouraged to make further experiments with both palm-kernel cake and meal. It is particularly important that the specific effect of these feeding stuffs on milk fat should be investigated, with the object of ascertaining the extent to which the composition of milk may be influenced. The effects of palm-kernel cake on fattening cattle also call for closer investigation. Two experimenters have remarked on the "bloom" of the coats of animals fed on palm-kernel cake, and the suggestion that this oil cake may have a favourable influence on the appearance of cattle comparable, for example, with the effects produced by linseed cake should be followed up. Methods of using the meal in pig-feeding, and also the best means of blending it with other foods for cattle, should be studied. Finally, the Committee think that continued attention should be given by crushers to the subject of rancidity in cake. It is clearly desirable that a feeding stuff should stand prolonged storage under the ordinary conditions met with in farm buildings; and the failure of an occasional consignment to keep fresh would much detract from the popularity of a new oil cake. They suggest that if experiments could be arranged by the Cambridge School of Agriculture in co-operation with seed-crushers, very useful information might be forthcoming.

* *Average Composition of Palm-kernel Cake and other Feeding Stuffs.*

Feeding Stuff.	Moisture.	Albuminoids.	Oil.	Carbo-hydrates.	Fibre.	Ash.
	%	%	%	%	%	%
Palm-kernel cake	12	17	6·5	46	14	4
Palm-kernel meal, E.	12	19	2·0	50	11	5
Ground-nut cake, D.	9	47	8·0	25	6	6
Ground-nut cake, U.	10	30	8·5	23	23	6
Ground-nut meal, E., D.	11	49	1·5	24	8	4
Ground-nut meal, E., U.	11	35	1·5	26	23	5
Coconut cake	10	21	9·5	41	12	5
Linseed cake	11	33	8·5	32	9	6
Cottonseed cake, D.	9	41	9·0	26	8	6
Cottonseed cake, U.	12	20	6·0	33	22	6
Bran (medium)	14	15	4·5	53	10	4
Dried distillery grains	8	24	10·5	42	14	2
Maize, River Plate	14	10	5·0	69	1	1

E. = Extracted. D. = Decorticated. U. = Undecorticated.

6. *Use of Palm-kernel Oil for Soap and Margarine.*

At first, palm-kernel oil was used exclusively for non-edible purposes, of which the principal was soap-making. For such objects it is admirably suited by its high saponification value and other qualities. After 1900 came the extension of the margarine trade. Suitability for edible purposes admits of a higher price being paid than for ordinary non-edible objects, and therefore, at the present time, palm-kernel oil is not so much used as formerly in the manufacture of soaps, though it is still of value because of its lathering qualities.

The future of the kernel trade in this country is intimately connected with the security of the position occupied by the oil. For this reason it is necessary to deal, in general terms, with the composition of margarine.

Although the idea of using animal and vegetable fats on a large scale as substitutes for butter is said to have originated in France early in the nineteenth century, the industry was actually started in Holland about forty years ago, and the use of the name "margarine" was legalised in this country by Act of Parliament, in 1887.

Many improvements in the manufacture have been introduced, especially in the substitution of vegetable for animal fats (Q. 4920–23) and in the addition of certain ferments to the milk which cause the resulting product to approximate more closely in flavour to butter.

At present, palm-kernel oil and coconut oil are largely employed in the manufacture of margarine, and other substances commonly used are "Premier Jus" and oleo (bullocks' fat) and lard (pigs' fat). To these may be added a certain admixture of oils fluid at ordinary temperatures, such as cotton-seed oil and ground-nut oil, according as chemical opinion advised their addition for attaining certain ends. These ends may be briefly summarised as (*a*) taste, (*b*) proper melting point, (*c*) keeping quality, (*d*) texture.

7. *Possible Competitors with Palm-kernel Oil.*

(*a*) So far as present conditions indicate, there is not much likelihood of the supply of animal fats from either cattle, sheep, or pigs becoming sufficiently abundant for the price to fall seriously and affect that of palm-kernel oil. Indeed, so far as such fats are concerned, the indications are all the other way. The consumption of fats is steadily and largely increasing, while the world supplies of live stock are likely to fall below, rather than to exceed, the demand.

(*b*) As regards coconut oil and palm-kernel oil the position is different. Both these oils are similar in composition and properties, and for practical purposes are interchangeable.

Effective competition by one oil of a suitable quality with another does not, of course, necessarily mean that the other will not continue to be used *at a price*, and it is only if the price fell below that of profitable production that the oil would go out of use altogether. As regards coconut oil and palm-kernel oil, the ruling price is affected by both, but predominantly by coconut oil in so far as the present world's supply of the former is double that of the latter. The production of both is increasing, and it would be rash to say which has the greater possibilities. But only if the cost of one or the other is suddenly reduced to a quite different level is it likely to affect the general position, and the Committee do not anticipate that this will take place on a sufficient scale to change the whole nature of the situation within the next decade.

(*c*) Competition from palm oil produced by improved methods is another possibility, and one of which there is distinct likelihood. The question is dealt with in detail in a later section. So far, however, as the importation of kernels is concerned, an extended use of palm oil obviously implies a supply of kernels. The present difference in price between the two may be altered, but obviously the amount of kernels available is not likely to be diminished as it might be by other competition.

(*d*) A more detrimental competition is likely to be furnished by some of the oils naturally liquid at ordinary temperatures (Q. 2481–83, 4801–6). The treatment of oils with hydrogen has been introduced with the effect of converting into solid fats those oils which are now liquid at ordinary temperatures, and of raising the

melting point of solid fats. Thus "hardened" cotton-seed oil is already largely used for making "compound lard"—which indeed in some cases contains no lard, properly so-called, at all. In so far, therefore, as any distinctive taste can be removed by refining, or other difficulties overcome, cotton-seed oil, linseed oil, soya bean oil, and even whale oil, may soon become largely used in the manufacture of margarine. Indeed, it is probably the case that whale oil has already been so used on the continent of Europe. It should also be remembered that the immense quantities of linseed and cotton-seed available make such competition formidable, despite their comparatively low percentage of oil.

(*c*) Lastly, it is possible that new varieties of nuts from other parts of the world may be placed on the market. In Central and South America, the cohune and babassu nuts have lately been engaging attention (Q. 1337–39, 2469–71), and the Committee have been informed that other varieties of oil-producing nuts may become available. At present, owing to the shortage of labour in the countries of its origin, there are difficulties in collecting an adequate supply of the cohune nut, and in the case of both nuts the thick shell requires special machinery for cracking.

Taking the question as a whole, the data do not exist for forming any estimate on which a confident prediction can be based. An increasing use of hydrogenated oils, however, seems certain, and is, indeed, already beginning. Palm oil so improved in quality as to be edible is a distinct possibility, but is not likely to be available in large quantities for some years. The cheaper production of copra is also a possibility. On the other hand, the world's consumption of edible fats is rapidly increasing and is far from satisfied. Moreover, even if oils at present absorbed in non-edible products are made available for edible uses, the demand for the non-edible products is also very great. Hence, in the absence of some new source of supply hitherto entirely unknown or at least untapped, the result may well be that the prices of edible and non-edible products will approximate. But the approximation may take effect partly through a rise in the price of the latter and not wholly through a fall in the price of the former.

The general conclusion of the Committee, therefore, is, that the future for palm-kernel oil appears sufficiently secure to warrant any reasonable efforts to establish the trade in palm kernels in this country.

III.—Position of the Trade at the Outbreak of War.

1. *Import Statistics.*

A glance at the figures given on pages 5 and 6 will reveal the principal features of the situation. The total European import of palm kernels was about 300,000 tons, of palm oil some 200,000 tons, and of ground nuts 670,000 tons. Of palm kernels, three-quarters were crushed in Germany and only a small proportion in the United Kingdom. Of palm oil, the United Kingdom took three-quarters, and the remainder was divided between France and Germany in almost equal proportions. Of ground nuts, France took three-quarters and Germany and the Netherlands nearly all the remainder, Germany taking nearly 100,000 tons and the Netherlands two-thirds of that amount. The European imports of copra amounted to rather under 600,000 tons, and were more evenly distributed, Germany coming first with a third of the whole, and France next with one-fifth.

Of the existing supply of both palm kernels and palm oil, five-sixths come from British Possessions in West Africa, and predominantly from Southern Nigeria.

2. *Shipping.*

Before the war practically the whole of the shipments from British and German possessions in West Africa were carried by two groups of steamship companies, one British and one German (see précis prefixed to Sir O. Philipps's evidence and Q. 6068–73). The British group was under the management of Elder Dempster and Company, Limited, and included the African Steamship Company, the British and African Steam Navigation Company, Limited, and the Elder Line, Limited. The German group consisted of the Woermann Line, the Hamburg-America Line,

and the Hamburg–Bremen–Africa Line. Other lines had occasionally intervened in the trade, but not to any great or lasting extent. Between the two groups mentioned an arrangement had been made by which equal rates were charged and equal rebates given, and this arrangement was still in existence at the outbreak of war. Goods were shipped by the steamers of both groups to Hamburg, Rotterdam, and Continental ports generally, but the United Kingdom was served by the British lines exclusively.

3. *Hamburg as a Market.*

Hamburg was the only great centre for kernels before the war (Q. 2091, 2557, 3593). As contrasted with Liverpool, a buyer for Hamburg could be sure in the season of going into the market and obtaining a price. For Liverpool delivery he could not, and the influence of such a situation on trade is obvious. As part cause and part effect of the foregoing, Hamburg was also the great distributing centre, the vast bulk of the season's produce of kernels being consigned to Hamburg, whether by British, French, or German merchants. There they might be forwarded on transit options to Bremen, Flensburg, or other out-ports (Q. 3780). Or they might be put on lighter or barge, or possibly rail, for conveyance to the mills.

4. *Milling before the War.*

Just as Hamburg was the general centre for distribution, so Germany was the principal milling country, and while some nuts and seeds were forwarded to the interior of Germany or to Austria, the great centres of the milling industry are at places such as Harburg, not far from Hamburg, and Emmerich, near the Dutch frontier, which possessed facilities for water-carriage to and from the mill.

5. *Margarine.*

In contrast to the milling trade, the greatest trade in margarine is probably centred in Holland. As has been already stated, the margarine industry was first started in Holland about the year 1870. The tariff imposed on margarine imported into Germany has caused the erection of works in that country to supply the home market, and the same course has been followed by most other Continental nations. But the industry in Holland is on an immense scale and supplies the greater part of the export trade as well as the home market. The United Kingdom is the greatest purchaser. In 1913, the importations of margarine amounted to 1,518,297 cwts., of a value of 3,917,701*l.*, and of these totals 1,483,417 cwts., worth 3,810,409*l.*, came from the Netherlands.

6. *Reasons for the Condition of the Trade in* 1914.

(*a*) *Origin.*—Seeing that the great bulk of the produce comes from British possessions, it may seem very remarkable that, from the outset, the trade should have been with the Continent, notwithstanding that the general milling industry in the United Kingdom was as highly developed as in any country. One factor in producing this result has probably been the influence of the German firm of Messrs. Gaiser & Company (Q. 1677, 1693, 1741). This company was one of the oldest of those engaged in the West African trade. Its principal branch in West Africa was at Lagos, a great centre for kernels, and at one time the company not only acted as importer but also conducted a crushing business in Germany. It has also been the fact that, while the value of oil-cakes for feeding purposes was recognised both in Germany and the United Kingdom, that of palm-kernel cake has been particularly appreciated in Germany.

Even when an industry has taken root in a particular place, it may be transferred to another seat from one of the two following causes. As the trade develops it may become more widely distributed owing to influences natural or artificial, such as cost of carriage, or a tariff. Again, the natural advantages of another centre may be recognised as so distinctly superior as to cause a transference. But, in the absence of such influences, it frequently happens that the growth and development of a

trade tend to gather round the original centre even though it may not have possessed any overwhelming advantages in comparison with similar places. As with the jute trade of Dundee, or the toy trade of Nuremberg, so with the palm-kernel industry in the neighbourhood of Hamburg. Once thus established, the *vis inertiæ*, or, more strictly, the *vis momenti*, of such a trade is difficult to overcome, especially when, as in the present instance, it possesses, not a single, but a two-fold product, each part of which has cut its own trade channels and established its own market.

(*b*) *Secret Freight-Rebates and other Facilities.*—It has already been stated that the British and German shipping companies charged similar freights and gave similar rebates. Suggestions have been made to the Committee that, in addition to the published rebates, the Woermann line secretly gave extra facilities to merchants shipping to Germany by their steamers (Q. 1408, 1829-31, 2195, 2774-77, 2842, 3543). Though, however, the statement has often been made as a matter of belief, no proof has in fact been forthcoming (Q. 3544, 5899), but, even if secret facilities have not been directly given, this does not negative the possibility of a stimulus to importations to Germany being indirectly applied. In fact, the habitual practice of some of the great German banks, possibly not unconnected with the German Government, both in financing traders and in influencing the course of trade, makes such a supposition quite possible and, indeed, probable.

In another respect, however, the existence of a large trade in Hamburg gives that port a considerable advantage, owing to the greater proportion of kernels that can be shipped there in bulk. A number of witnesses gave evidence on this point, and the advantage of shipping in bulk, including the saving in bags, is estimated at from 3*s*. to 5*s*. per ton.

(*c*) *The Question of Outports.*—Transhipment or transit to an outport may in a question like the present be a matter of considerable importance. Thus, in the United Kingdom, although the primary centre of the West African trade is at Liverpool, it may be that other ports present special advantages. Liverpool is a dear port for this purpose. Again, inland carriage by rail is expensive for an article like cake, the value of which is low in proportion to its weight, and this fact, *cæteris paribus*, makes proximity to an agricultural hinterland an advantage. Not only so, but the local influence of mills and milling companies in a matter like this is very considerable. Therefore, in contemplating the establishment of the industry in the United Kingdom, Liverpool must not only or preponderantly be considered, but such important centres of crushing as Hull, or such ports as London, Bristol, or Leith (Q. 2570, 2707, 3775). The opinion was not infrequently expressed by witnesses that the system of transit options was much more favourable to the miller in the German than in the British outport (Q. 3777), and it is true that, on shipments to Hamburg, options to Bremen or Rotterdam were granted free, but, apart from these two cases (which in the circumstances are quite natural), the Committee do not find that there was any difference in the charges made. It is not, however, the rate of charge that is alone of importance. There is also the feasibility of utilising the option as a matter of regular business, and it is probably in this difference between British and German outports that a real advantage lay with the German miller.

(*d*) *Port Charges and Delivery Costs.*—Evidence has also been submitted on the question of port charges. The comparative cheapness of Hamburg as contrasted with Liverpool has, in our opinion, been clearly established by the figures furnished to us. According to the calculations of one witness, the difference between Hamburg and Liverpool, exclusive of delivery costs, amounted to 2*s*. 7*d*. per ton in favour of Hamburg, and we think this figure approximately represents the facts as they existed at the outbreak of war. It must be remembered, however, that the figure above-named applies to kernels landed on the quay in Liverpool as compared with the general practice of discharge into lighters in Hamburg.

It is important in this connection to consider what are the charges made at other British ports where the crushing of palm kernels has been, or might be, carried on. As a result of inquiries made on this subject, we have compiled the following tables showing the approximate pre-war charges and costs of delivery at certain British ports (A) for mills alongside water, and (B) for mills not alongside water. As Liverpool was the only port where palm kernels were handled prior to the war, the charges quoted for the other ports are those applicable to oil seeds

in general, but they may be taken as approximately correct for palm kernels in original bags :—

(A) *Comparison of Approximate Port Charges and Costs of Delivery to Mills alongside Water. (On pre-War basis.)*

	Port Dues on Palm Kernels.	Overside Charges to Craft.	Lighterage to Mills.	Total.
	s. d.	*s. d.*	*s. d.*	*s. d.*
London	0 4	1 4	1 9	3 5
Liverpool	No mills alongside water at Liverpool.			
Manchester	3 3	0 9	0 6	4 6
Hull	Nil	0 11	1 1	2 0
Sharpness	1 0	0 9	1 4	3 1
Bristol	0 8	1 3	Nil	1 11
Leith	No mills alongside water at Leith.			
Glasgow	1 3½	1 2	2 6	4 11½
Ipswich	0 3	0 9	1 3	2 3

(B) *Comparison of Approximate Port Charges and Costs of Delivery to Mills not alongside Water. (On pre-War basis.)*

	Port Dues on Palm Kernels.	Landing Charges to Quay.	Haulage to Mills.	Total.
	s. d.	*s. d.*	*s. d.*	*s. d.*
London	All mills alongside water in London.			
Liverpool	1 1½	2 9	1 8	5 6½
Manchester	3 3	1 0	0 6	4 9
Hull	Nil	2 6	2 0	4 6
Sharpness	All mills alongside water at Sharpness.			
Bristol	0 8	1 6	0 6	2 8
Leith	0 6	1 4	0 3*	2 1
Glasgow	1 3½	1 10½	1 9	4 11
Ipswich	0 7½	0 7½	1 6	2 9

* Rate for existing mills—rail rate for new mills would depend on site.

It may be true that this table does not tell the whole of the story. Part of the greater cost in some ports may be due to heavier working costs or greater expense in the equipment of the port, but in part, no doubt, expenses that are met in one port from charges on merchandise may in another be defrayed out of general revenues. Such revenues have to be raised somehow, and they are, therefore, a burden on industry indirectly, if not directly borne. The Committee did not feel justified in the time at their disposal in inquiring further into this point, and in general they do not think that the extra cheapness of some ports, as compared with others, can be seriously denied.

(*e*) *The Value of a constant Market.*—The advantage of having a continuous free market will be readily apparent and has been already mentioned. Merchants hitherto have been unwilling to consign palm kernels to Liverpool unless the goods are sold to arrive (Q. 2357-65). It is not easy to put a money value on the drawback which the absence of a constant market represents, but it is none the less real.

(*f*) *Inland Carriage.*—Inland waterways confer a great advantage on the continental industry, as the lighter into which the kernels are discharged can proceed straight to Harburg or Emmerich and there deliver direct into the mill. The whole charge in the case of Harburg did not amount to more than one mark per ton. There is, however, no reason why this fact should continue to constitute an advantage in favour of Germany, as conveyance by lighter in the United Kingdom is not more costly than in Germany under similar conditions, and the establishment of river-side or dock-side mills in the principal British ports is perfectly practicable.

(*g*) *Cost of Milling and Refining.*—The Committee have examined the principal points involved in connection with milling and oil-refining. Special machinery plays an important part in this connection, and at the outbreak of war it is probable that the amount of milling machinery in this country which was as efficient for dealing with kernels as that of the best German mills was small (Q. 1296, 2721, 3502–6, 3694). In oil-refining there was little difference between the most modern mills in the two countries. In respect of working costs there does not appear to be much difference. In the opinion of those who have reliable sources of information, the labour cost in Germany was as great as here. The burden of taxation differs, of course, in different localities, but a statement furnished to the Committee with reference to a typical factory indicates that it is at least as heavy in Germany as in Great Britain.

(*h*) *Carriage from the Mill to the Margarine Factory.*—Hitherto the British market for margarine has been supplied partly by home production, but predominantly from Holland. As regards the question of the comparative cost of transport, the Committee have been informed that the freight on oil from the Continent to works in this country was approximately 30*s.* per ton (Q. 1494, 4816), including expenses in re-coopering when casks are used, or, in the case of drums, the cost of return carriage. On the Continent, on the other hand, the oil is taken by water in a tank barge direct from the refinery to the margarine factory, and the cost would not, at most, exceed 5*s.* per ton. The extra cost of the subsequent carriage of margarine from Holland to this country over that of the distribution here of British-made margarine must be remembered, but it does not fully offset the previously mentioned disadvantage.

(*j*) *Duties.*—An important element in the location of the trade has been the question of duties, which has already been briefly mentioned. A table of the principal duties in force in different European countries on oils and margarine is given in Appendix C.

(*k*) *General Considerations affecting the Continental Trade.*—A general idea will have been gathered from the foregoing of the trade in Germany and Holland so far as it affects this country; but no idea can be adequate without some appreciation of the general control of the industry. The bulk of it is in the hands of two large companies first established in Holland, but in which, in one case at least, important British shareholding interests are concerned (Q. 4800). When import duties were imposed in Germany on edible oils and on margarine, the two companies in question erected factories in Germany, and are believed to control about 70–75 per cent. of the internal margarine trade in that country as well as to possess large interests in some of the principal milling companies. It should be added that the same companies have powerful interests in some of the largest retail organisations in the United Kingdom (Q. 4821), and the importance of these facts, in relation to the problem before the Committee, cannot be ignored.

(*l*) *Feeding Stuffs.*—The trade in palm-kernel cake and meal had been thoroughly established in Germany for some years before the outbreak of the war. While its value for general purposes is high, its adaptation for special uses, *e.g.*, feeding of milch cattle, made it particularly favoured in Germany. In other words, it commanded an "affektionspreis" (Q. 250) and would sell for slightly more than is warranted by an estimate of its value based on its composition, just as may be the case with linseed cake in this country. The same was true of meal, and, despite its poorness in oil, it has gradually approximated in Germany to cake in price (Q. 91), and, indeed, has been known to surpass it.

7. *Outlook for British Trade before the Outbreak of War.*

The foregoing paragraphs show how considerable were the difficulties that militated against any attempt to utilise palm kernels extensively in this country up to the summer of 1914. They were the more serious since the average margin of profit, whether to the importer or the crusher, in the trade was not large (Q. 1305–6, 2681–2, 3734). The clearest view, however, would be obtained if the inquirer were to endeavour to place himself in the position of the chairman of a British milling company, and consider whether he would have been justified in risking the shareholders' money in a venture into the palm-kernel trade. He would have to face the possibility that, with the mill in existence and standing charges running, he might find himself unable to obtain kernels on the best competitive terms at a given moment, while no such

apprehension need be entertained by his German competitor. But, given that kernels were obtainable, it is as likely as not that they would come to Liverpool in bags, and an additional cost be thereby entailed, while to this must be added the extra sum payable in port dues and charges in Liverpool as compared with Hamburg. Suppose, however, that the British mill was in some outport. In that case, though transit options to given ports might indeed be identical *viâ* Hamburg or *viâ* Liverpool, yet this fact would be cold comfort, as the British miller might very probably wish to crush in Hull, to which the transit option was 6*s.* 3*d.*, whereas his German competitor would either be in Bremen, for which no further charge would be made, or in Harburg, in which case the carriage would cost only a mark or a little more. Such would be the difficulties in the way of getting raw material. They would be no less in disposing of the products. For the oil the British miller might, indeed, till quite recent times look for a sale to one or two large British companies, but, apart from small consumers, he would find that his market lay with quite a few firms which possessed alternative sources of supply. In the matter of cake, his difficulty would be different though as considerable. A fair chance might exist that the manufacturer of compound cakes would buy it as an ingredient, at a price. There would be little hope of a direct sale to farmers, who were not familiar with it, and were not prepared to pay a price which would compete with that which it fetched in Germany.

The difficulties enumerated in the foregoing paragraph are formidable and yet, on examination, it will be seen that none of them is due to any natural disability in the British position. They are simply the result of an industry having developed along certain lines and in certain places. Trade channels once dug tend to deepen, unless some special circumstances arise, whether of design or not, to arrest the flow in the old direction or to give a special impetus along a new course. Once a market is created in the United Kingdom, the security of supplies should be as great as in Germany. If kernels were carried there in bulk, they can be carried here in bulk. Port and other dues may be high in Liverpool, but they may be decreased through handling by elevators and by lighterage, or the cargoes can come to other British ports where the charges before they reach the mill should be no higher than they were in Germany. What is true of the raw material is also true of the products. Palm-kernel cake has been unfamiliar to our farmers, and the farmer is said to be a conservative person. But there are indications that if he has good reason to believe that there is value in a new article he will give it a trial, and what has happened with Bombay cotton cake and soya bean cake may quite well happen too with palm-kernel cake or meal. If the difficulty of the cake is surmounted, the crux of the situation seems to be in the market for the oil. It is too valuable to be largely used for other than edible purposes, and in 1914 the margarine industry in this country was not great enough to absorb a large supply, while an export to Holland was unlikely in competition with protected oil carried by canal from Germany. Such was the state of affairs when the war supervened. There was a bar to this industry in the United Kingdom, which was due, not to natural disadvantages, but to a *vis inertiæ* which was a result of circumstance, and which a special stimulus could overcome.

V.—West Africa.

1. *Points of interest excluded from this Report.*

The Committee have heard a number of witnesses who have had long experience, official or commercial, of West African conditions, and much interesting information was placed before the Committee. The following were among the subjects discussed:—

(*a*) Methods of trading, both as regards collection and exchange.
(*b*) Produce inspection.
(*c*) The desirability of a system of grading kernels.
(*d*) The practicability of elevators at the ports, and the conditions under which they could successfully be erected and worked.

Consideration was given to these and kindred questions, since it was felt that such enquiry might reveal facts affecting the judgment of the Committee on the subject of their investigation. In so far, however, as the enquiries made did not reveal any data having direct bearing on that subject, they are not further discussed in this

report. The Committee feel, at the same time, that even in such cases their investigation into these points has not been wasted, since the questions, even if not material to the present issue, are still of great importance to West Africa and to West African trade generally.

The Committee are of the same opinion with regard to the questions which naturally interest merchants in connection with shipping. As with other points of importance affecting the trade, some latitude was allowed to enquiries connected with freights. It became apparent, however, that the conditions investigated applied equally to imports to Germany as to the United Kingdom. Bearing in mind, therefore, that their enquiry is directed to the establishment in the United Kingdom of industries dependent on palm kernels and other oil seeds, the Committee do not consider that it is their duty to deal with questions of rebates, or of the advantages or disadvantages of a liner service, as contrasted with the use of tramp steamers.

2. *Nature of the Oil Palm.*

The nature of the oil palm and its oil-producing properties has a very direct bearing on the enquiry. Two very important questions depend upon it—the possible increase in the supply alike of palm oil as of palm kernels, and the production of palm oil of better quality for export in quantity.

It is not necessary to give here an elaborate description of the oil palm. It is sufficient to say that the fruits are attached to the core of a conical-shaped cluster or fruithead about the size of a football, from which they are easily detached when fully ripe or verging on over-ripe. Some witnesses expressed the view that the oil-palm itself should not really be treated as a wild tree (Smart, Trevor) but rather as one suitable for cultivation in an orchard or plantation, and stated that the yield of fruit per acre will vary from half a ton to three or even four tons (Q. 3026), according to the state of cultivation. Except, however, in one or two special localities, it cannot be said that the palm receives proper cultivation at present. But if the yield per acre of fruit varies largely, so does the yield of oil from given fruits. In some of the varieties the shell of the nut is thin, and the yield of kernels small, but the amount of palm oil in the pericarp is unusually high. The facts are recorded in the following table, which is taken from the report of the Imperial Institute ("Bulletin of the Imperial Institute," 1909, pp. 357-394).

Nigerian Palm Fruits.

Variety.	Palm Oil in Fruits as received at the Imperial Institute.	Kernels in Fruits as received at the Imperial Institute.	Approximate Thickness of Nut Shells.
	Per Cent.	Per Cent.	Inches.
Ope-pankoro Western Province	19	19	0·10
Udin Central Province	16	13	0·20
Ak-por-ro-jub or Ok-po-ruk-pu Eastern Province	26	Moist, 11·0 Dry, 10·5	0·15
Ivioronmila Central Province	17	15	Nuts from small fruit, 0·05; large fruit, 0·20.
A-sog-e-jub or Au-su-ku Eastern Province	48	Moist, 9·0 Dry, 7·0	0·06
Ogiedi Central Province	35	8	0·07* 0·15†
Af-fin-ko-jub or O-ju-ku Eastern Province	38	Moist, 11·5 Dry, 7·8	0·08

* Small sample of broken shells received from S. Nigeria. † Shells of nuts extracted from fruits received from S. Nigeria.

The percentage of palm oil in the fruits is seen to vary from 16 to 48, and of kernels in the fruits from 7 to 19. The percentage of oil in the kernels (dried at 100° C.) is fairly constant, ranging between 51 and 57, and the yield of kernel oil will therefore depend on the percentage of kernels in the fruit, which is shown to be subject to great variation. The differences exhibited in the table are immense, and their importance can hardly be over-estimated. They affect the entire question of the future production of palm oil and palm kernels in West Africa. An improvement,

therefore, at once in the yield and quality of fruit, may reduce the area necessary to a fraction of what might otherwise be required. But a reduction in area may lead also to a reduction in the distance over which fruit must be transported to the mill, and, as will be seen from a later section, such a reduction may perhaps determine the practicability of local manufacture of palm oil by better methods than at present.

In these circumstances, it is important to know whether the trees yielding the better class of fruit are distinct and stable varieties that will breed true. On this point Mr. Farquhar* refers to results obtained in planting the seeds of the Lissombe variety in the Cameroons, in which about fifty per cent. came true to type, and expresses the opinion that by careful cultivation and selection the useful characteristics of this variety could be made more permanent. But the evidence on the point is not conclusive. The question is so important that the Committee are of opinion that the investigations previously conducted in West Africa with the co-operation of the Imperial Institute should be systematically continued and extended, and that the experimental plantations established by the Government should be further developed with this end in view.

3. *Proportion of the Crop at present gathered.*

The increase of future supplies is also directly affected by the proportion of the crop which is at present left ungathered, but which could be utilised. What this proportion is has only been vaguely estimated. On the evidence obtainable, therefore, the Committee do not feel justified in adopting any precise figure, though in any case it is considerable.

4. *Milling in West Africa: Advantages and Drawbacks.*

Evidence (Knowles, Smart, Trevor) has been placed before the Committee as to the advantage or otherwise of establishing mills in West Africa. It is said that the rate of wages paid for unskilled labour would be lower than in Europe, while the fruit would be near at hand, and the opinion was expressed by one witness that it would be possible to treat the pericarp as well as the kernels in the same mill. Further consideration, however, makes the difficulties appear more formidable, and this is in accordance with the actual experience of those who have attempted to work mills on the Coast. In the first place, although the charge for labour *per capita* may be low, yet there is a difficulty in getting and retaining a native staff for continuous work, and the cost of supervision by white foremen is high. Fuel, again, is said to present difficulties, although the development of the coal deposits in Southern Nigeria may remove these. Nor does carriage show a saving, but rather the reverse. In the absence of a local market for cake, the whole product must be carried to Europe, and it would be cheaper to carry the kernels in their original form than to convey the oil and the cake separately. Not only so, but for economical working a minimum quantity of kernels is required, and if there is local competition by merchants buying for the Home market, it may be difficult to secure this.

5. *The Local Manufacture of Palm Oil.*

The drawbacks just mentioned apply to the manipulation of palm kernels. But, in any final judgment, the question of palm oil is at least equally important. If palm oil of high quality could be produced, its texture and other qualities will probably make it at least as valuable for margarine as coconut or palm-kernel oil.

Through defects in the native methods of production, the amount of free fatty acids in palm oil has been as high as eighty per cent. and has seldom fallen below fifteen per cent., though for their own edible purposes a better quality is produced by the natives. If palm oil could be produced containing not more than six per cent. of free fatty acids, it would be available for edible purposes and might prove a serious competitor with palm-kernel oil. It has now been shown that it is possible to produce palm oil containing as little as six per cent. of free fatty acids (Q. 5428), though it has not hitherto been done on a large scale. But to attain this object it is essential to treat the fruit when absolutely fresh, before rancidity develops. The commercial success of the preparation of edible palm oil, therefore, depends on getting a

* The Oil Palm (1913), pp. 8–10.

continuous supply for treatment in a fresh condition. If for this purpose the fruit has to be brought to a central factory, facilities of carriage both as regards speed and cost are all-important. Clearly then, the less the area over which collection has to be made, the more economical is the working. In reducing the size of the area needed, also, the quality and the quantity of fruit, the nature of the collecting rights, and control of the labour supply, are all factors of importance. Similar considerations would make plantations of some shapes better than others, so as to economise head-carriage and yet not have a greater length of tramway than is necessary. Moreover, discussion of acreage, control of labour and the rest, pre-supposes ownership of the land discussed. It will be remembered, however, that in British Colonies and Protectorates in West Africa there is no such thing as vacant land (Q. 5553) which is in the bestowal of the Crown. The whole question of the tenure of land in British West Africa is under the consideration of another Committee. While, therefore, the Committee considered it within the scope of their inquiry to ascertain, as far as present information goes, the conditions under which local manufacture would succeed, they did not feel at liberty to inquire into questions of tenure of land, concession laws, and the like, which are the direct subject of investigation by another Committee, and only incidental to the present inquiry. A new factor in the situation will arise if any of the smaller machines now in the experimental stage prove commercially practicable by which it is hoped that natives will be able to make palm oil of good quality.

In the present state of knowledge, any forecast that can be formed must necessarily be tentative in character. It seems probable that good edible palm oil will be manufactured in West Africa in increasing quantities. On the other hand, it is not likely that palm kernels will be crushed in West Africa on a scale sufficiently large to affect European milling seriously, at any rate within the next few years.

VI.—The Trade during the War.

In the foregoing sections the Committee have dealt with the historical and descriptive parts of their subject, and have endeavoured to give at least an outline of the position of the trade in palm kernels from West Africa up to the time of the outbreak of war in the autumn of 1914. Before passing to their conclusions and recommendations as to what must, in their opinion, be done in the future in order to ensure the permanent retention of this industry in Great Britain, it is necessary to state briefly what practical measures have already been taken, and what has actually been accomplished during the war, in the direction of establishing the industry in this country.

The initiation of this movement was undertaken, in the first place, by the West African Sections of the Chambers of Commerce of London, Liverpool, and Manchester, whose members naturally realised at once the serious results to be apprehended from the closing of the principal market for the produce of the West African Colonies. The problem before them was to find a fresh outlet for the crops of palm kernels and other nuts and seeds already awaiting shipment, and a new market for the produce which would be coming forward during the war period. Efforts were directed to create widespread interest in the whole subject throughout the country, and, in particular, representations were made to the millers and crushers, the margarine manufacturers, and agriculturists.

As a result, several of the largest crushing concerns—more especially those in the neighbourhood of Hull—took the matter up from a practical standpoint, and commenced to import palm kernels and to crush them for the first time in their mills, adapting their existing machinery for the purpose. This adaptation did not give the best results in practice, and new plant has been ordered to deal with palm kernels by the most up-to-date methods. Very considerable quantities, however, have been, and are still being, dealt with by the existing machinery.

To meet the new demand for the delivery of palm kernels to Hull, the shipping interests concerned arranged to deliver kernels at Hull at the same ocean rate of freight as to Liverpool (Sir O. Philipps' précis, § 6 (*b*)), by themselves defraying the cost of on-carriage from Liverpool to Hull, so as to encourage the commencement of the new industry. Since the beginning of 1915 they afforded direct facilities from West Africa to Hull. During the year 15 steamers arrived at Hull direct from the West African coast, and these vessels discharged at that port 42,549 tons of palm

kernels, valued at 681,408*l*. In addition, three steamers brought kernels to London in 1915, the quantity discharged being 8,729 tons, valued at 146,245*l*.

These figures indicate the extent to which palm kernels are now being handled in Hull and the surrounding district, although prior to the war no palm kernels were delivered to this port and none had been crushed in that neighbourhood.

As regards Liverpool, 178,060 tons were discharged in 1915, compared with 73,187 tons in 1914, and 36,012 tons in 1913. The figures for the total imports of palm kernels into the United Kingdom were:—

1913 - - - - - - -	36,012 tons.
1914 - - - - - - -	74,797 ,,
1915 - - - - - - -	233,249 ,,

At the same time, satisfactory as these figures are in themselves as indicative of the progress which is being made in taking up the industry in this country, allowance must be made for the fact, brought to the notice of the Committee in the course of their inquiry, that considerable quantities of kernels delivered at British ports during the war have either been stored on account of companies operating in neutral countries or have been re-shipped to neutral ports.

With regard to the disposal of the oil and cake resulting from the increase in the quantity of palm kernels imported and crushed in this country, very satisfactory progress has also been made. The palm-kernel oil, instead of going to the soap-makers, as the British-crushed product formerly did, has been in keen demand by the margarine manufacturers, to replace the oil they formerly imported from the Continent. Moreover, owing to the high price of butter, and perhaps also to its improved quality and more attractive character, the popularity of margarine is rapidly increasing, and the public demand is growing. This is a fortunate circumstance in connection with the crushing of palm kernels in this country, and in itself is encouraging the erection of new factories, which will absorb an increasing quantity of edible oil.

As regards the disposal of the cake, it was anticipated that this would present the greatest difficulty in connection with the establishment of the industry in the United Kingdom. In the autumn o 1914 the interest and support of the agricultural authorities throughout the country were enlisted, and experimental tests were carried out at 14 or 15 different centres. The result of these tests was more satisfactory than could have been anticipated. By this means, and by the assistance of the press, the Board of Agriculture, and the Imperial Institute, the attention of farmers was drawn to what was to them a new feeding material. In this respect also the industry has been singularly assisted by the fact that there has been a great increase in the cost of the other foodstuffs commonly used by farmers, and thus a specially favourable opportunity was given to palm-kernel cake and meal. As a result, there has been no difficulty in disposing of all the cake and meal produced, and this feeding material has thus been widely introduced to farmers.

By the spring of 1915 a stage had been reached at which those concerned considered that individual effort had done all that was possible in the circumstances, and it was felt that the movement would be greatly reinforced and strengthened if the Government were to take it up. As a result of resolutions of the Chambers of Commerce of London, Liverpool, and Manchester, the Secretary of State for the Colonies appointed this Committee to inquire into the whole subject and to report as to the measures necessary for the permanent establishment of the industry in Great Britain. Since the appointment of the Committee steady progress has been and is being made, and the evidence which they have received has shown that large quantities of kernels are being crushed here and the products satisfactorily disposed of to British manufacturers and farmers.

VII.—Conclusions and Recommendations.

For reasons already explained, the Committee have concentrated their chief attention upon the trade in palm kernels. Two points were known to them from the beginning: firstly, the magnitude and value of the trade; and secondly, the fact that, with the exception of the small fraction which came to the United Kingdom, all exported kernels during the last thirty years went to Germany. In other words, the question at issue is between Germany and the United Kingdom.

As a result of their investigations, the Committee have satisfied themselves on some further points. Ample capacity can be provided in the United Kingdom for crushing the whole of the kernel crop. Mills with the most modern machinery and equal to any in Germany have been erected and are in process of erection. As with machinery, so in the matter of chemical methods, the most modern British mills are not behind their German competitors. As regards the product, all the oil produced should soon find a ready sale, and, even if this country could not absorb it all, there would be a good export market. As with the oil, so with the cake. Once established, there is no reason to doubt that it would keep a permanent place in the list of British feeding stuffs.

But while this is so, the Committee are still convinced, from the evidence before them, that the bulk of the trade will revert to Germany in the absence of specific measures to the contrary. On this point the Committee are quite clear. The trade will not have become sufficiently rooted in this country by the end of the war to overcome successfully the competition which it will then have to meet. The question before the Committee, therefore, is to decide what specific measure or measures can be suggested to establish and retain the industries in this country, having due regard to the interests alike of the native in West Africa and the consumer in the United Kingdom.

The need for such measures is reinforced by more general considerations, and it is well to mention these explicitly. The question is one between this country and Germany. For many years before the war, German traders in British Colonies in West Africa, as throughout the rest of the world, have enjoyed—and abused—British hospitality. Just as German trade has been fostered by the German Government, so German traders have in their turn been the political instruments of that Government. When the war is over, they may be expected to return and carry on trade, as before, if they are allowed to do so. Already discussion is taking place in Germany as to the reorganisation, when peace returns, of her commerce and industry "in anticipation of a fresh war."* Unless and until, therefore, there is a decisive change in the national policy of Germany it is to be hoped that never again will the opportunity for such commercial preparation be given to that country, so far as the Dominions and Colonies under the British Crown are concerned. Australia has already broken the hold of the German over the base metal industry. It can, and should, be broken also in West Africa in the case of the trade which has been the subject of investigation by the Committee.

Three methods of attaining this object have been suggested. The first is by a Government grant to the industries concerned in the United Kingdom. This expedient they consider to be out of the question under present conditions.

The Committee next considered the imposition of an import duty on margarine and edible oils. On this point they do not make any recommendations. At the conclusion of hostilities the whole question of the trade relations of the United Kingdom may need consideration in the light of the new condition of affairs created by the war. They are of opinion, therefore, that the consideration of import duties in this connection can be left until the whole question can be treated in its entirety.

The case is different as regards an export duty on palm kernels on leaving the country of origin, and the Committee recommend the imposition at an early date in the several West African Colonies of an export duty of not less than 2*l.* per ton on all palm kernels exported from British West Africa, the duty to continue during the war and for five years afterwards, and to be remitted on all kernels shipped to and crushed in any part of the British Empire. If a duty of 2*l.* per ton be found insufficient to divert the trade to this country, the amount should be raised until the duty is adequate to effect its purpose, and this determination should be made clear from the outset.

The foregoing proposal involves, let it be noted, no new departure in general principle. A similar differential charge has been imposed for some years in the Federated Malay States on exported tin ore, and it is understood that the same step as regards tin ore is contemplated in Nigeria.

In the case of palm kernels the Committee are alive to the objections that may be raised. The natural tendency of any restriction of the market for a commodity is to depress the price of that commodity, and it has been suggested that the imposition of an export duty, with the consequent loss of the German market, may

* "Cologne Gazette," November 1915.

thus depress the price paid for kernels to the native or prevent the increase that might otherwise occur. As against the loss of the German market, however, must be set the great expansion of the British home market which is taking place as well as the increasing demand for edible oils throughout the world, factors which *per se* operate against any tendency to lower prices for palm kernels resulting from the limitation of the market. In any event the Committee are of opinion that whatever risk there is in this matter is worth taking for the proposed term of years in view of the objects to be attained. Sir Frederick Lugard has expressed the same opinion to the Committee, and sees no objection to the duty proposed. If, as the Committee believe, the effective demand for palm-kernels in the United Kingdom will be equal to the supply, competition among importers, in the absence of a ring or trust, will keep up prices, and the native will suffer no hardship.

It has been represented, however, that the existence of an export duty may create a tendency to combinations among merchants or among crushers in this country. If such a ring among crushers should be formed, the obvious answer would be to repeal the duty, but it may at least be said with confidence that no such combination has hitherto existed (Q. 1334). An agreement between merchants in the West African trade presents a different problem. But is a durable combination at all a likely contingency? The trade is such that if profits are excessive outsiders will come in and buy (Q. 4061). Past experience points to the same conclusion. Pools have been known before the war (Q. 811, 1285, 1670), but they have never lasted long, and complaint has more generally been made of the "insanity" of the competition (Q. 876, 1467). The Committee agree with Sir Frederick Lugard in believing that, while the risk may exist, it is not very serious. Subject, therefore, to the right of the Colonial Governments concerned to reduce the duty or abolish it altogether, if advantage is being taken of it to depress the prices paid to the native producer, the risk is worth taking in view of the object to be attained and of the advantages enjoyed by the native under British administration.

The Committee do not apprehend that there would be any serious difficulty in carrying out their recommendation. Action by the Revenue Departments in this country would not be necessary. As regards the West African Colonies, the number of ports is large, but the Governments possess competent Customs Departments, and the present staff ought to be able to cope with the extra work involved, without any new machinery being necessary. It should also be possible, in the case of kernels crushed in the United Kingdom, to obviate the inconvenience to traders which would occur if the duty is first paid and then refunded. This could be effected by the merchant, on exportation, giving a bond to the satisfaction of the Colonial Government, for the payment of the export duty. The bond would then be cancelled on the production, within a fixed period, of a certificate from a seed crusher to the effect that the kernels had been delivered to him for crushing in the United Kingdom.

In estimating the amount of the duty proposed, the Committee have had regard to the products of the kernel and the prices which they commanded in Germany prior to the war. One ton of kernels will produce approximately half a ton of oil and half a ton of cake. For a considerable period before the war the half-ton of oil would have fetched at least 10*s.* more (Q. 2198, 2205, 2325, 2413) in the German home market than in this country, and the half-ton of cake 10*s.* to 15*s.* more (Q. 250, 3833) than here. A ton of kernels, therefore, is convertible into products which, taken together, were worth at least 1*l.* to 1*l.* 5*s.* more in Germany than in the United Kingdom. The conclusions thus reached agree with the opinions submitted to the Committee in evidence, and for these reasons they suggest that an export duty of 2*l.* per ton be placed on kernels in the first instance. It must be remembered that there is an appreciable danger of State aid on a lavish scale being used in Germany to retain such an industry as palm kernel crushing, and the British Colonies concerned must be prepared to adopt a resolute policy if they are to avert the danger of the trade returning to its pre-war channel. The Committee, therefore, have suggested a tax of 2*l.* per ton as a tentative measure. If it proves inadequate it should be raised.

The object to be kept in view, however, is not merely to bring the trade to the United Kingdom. It must be retained in British hands. Accordingly, although the imposition of an export duty for a year or two would give a temporary advantage to the British seed-crusher, yet it would not afford a reasonably secure prospect which would justify the installation of powerful modern plant specially adapted to deal with kernels. The Committee consider, therefore, that the suggested export

duty, once imposed, should remain in force for the period of the war and for five years after. At the end of this period the position could be again reviewed and a decision reached as to the advisability of continuing the export duty.

It will have been realised that the Committee attach great importance to the provision of a market for palm-kernel cake in this country. They recognise the difficulty of establishing a new food-stuff, but they think it probable that, if judiciously brought to the notice of agriculturists, the cake will before long acquire a place for itself among the feeding stuffs in general use. Much excellent work has already been done in this direction both by the Board of Agriculture and by Agricultural Colleges throughout the country, and the Committee recommend that the efforts to extend the knowledge and use of palm-kernel cake amongst farmers should be continued.

The Committee have already expressed their belief in the capacity of the market for oil in the United Kingdom. This capacity, however, will chiefly depend on the expansion of the British manufacture of margarine. Palm-kernel oil will always be used to a limited extent in the manufacture of certain soaps, but its principal use will without question be for edible purposes and predominantly for making margarine. The consumption of margarine in this country is rapidly increasing, and the Committee believe that British industry will be benefited if it be made legal to add the words " British made " to the word " margarine " on the statutory wrapper. For this purpose a slight amendment will be required in the Food and Drugs Act, and the Committee recommend that the Act should be amended accordingly.

There is one more recommendation which the Committee wish to propose. Looking to the future, they desire to place on record the fact that they are impressed with the desirability of extending not only the British demand for, but also the production of, palm kernels. Evidence has been adduced to show that there are several varieties of the oil palm, which differ considerably in the amount of palm oil which they contain, in the proportion of the kernel to the whole fruit, and in the thickness of the shell. They consider it advisable that the Agricultural and Forestry Departments of the West African Colonies should take measures for the careful investigation of the properties of the several varieties of oil palm in each Colony, and of the best methods of cultivation of the species which are considered most suitable for economic purposes, *i.e.*, for the production of palm oil and of palm kernels. These measures should be taken in co-operation, on the scientific and technical side, with the Imperial Institute, by which admirable work has been done in the past in connection with the oil palm, and to which much of the existing knowledge of the palm and its economic products is due (see précis of Dr. Henry's evidence).

One of the members of the Committee, while concurring in this Report, desires to put forward a further suggestion which, in his opinion, would help to divert the trade in palm kernels from Germany to the United Kingdom. Mr. Moore's views, which must not be taken as representing those of the Committee, are stated in his memorandum printed as an Appendix.

In conclusion, the Committee wish to express their sincere appreciation of the services rendered to them by Mr. J. E. W. Flood as Secretary.

A. STEEL-MAITLAND,
G. V. FIDDES,
LESLIE COUPER,
WYNDHAM R. DUNSTAN,
C. C. KNOWLES,
T. H. MIDDLETON,
G. A. MOORE,
OWEN PHILIPPS,
T. WALKDEN,
W. G. WATSON,
T. WORTHINGTON.

J. E. W. FLOOD,
Secretary.
5th May 1916.

REPORT BY MR. T. WILES, M.P.

It is impossible for me to sign the Majority Report, as I am unable to agree with the recommendation of an export duty of 2*l.* per ton on palm kernels exported from British West Africa, such duty to be remitted on all kernels shipped to and crushed in any part of the British Empire. While admitting that it may be necessary for Great Britain to alter her present fiscal policy in a drastic manner in the near future owing to the War, the evidence placed before the Committee is not convincing that such proposal will have the desired effect. It would appear to me wiser if the whole question of the rearrangement of tariffs and duties within the British Empire were postponed until the conclusion of the War. They could then be considered as a whole, in consultation with our self-governing Dominions and Colonies, and perhaps to our mutual advantage with the Allies who are now fighting with us. It is known that in France there is a committee of experts now deliberating on oil seeds, so that to deal with the matter piece-meal in this fashion opens up a long vista of difficulties.

No evidence was placed before the Committee showing that similar duties have been imposed in other Colonies. The Secretary of State for the Colonies stated in the House of Commons, on February 22nd last, that "No export duties on the exportation of ore from the Straits Settlements are imposed," but he went on to say, "Royalties on tin and tin-ore and other ores are imposed in the Federated Malay States." Therefore, I consider it an absolutely new departure which should not be taken without the full knowledge and sanction of Parliament.

The following points, shortly summarised, appear to me good reasons for not recommending the proposed export duty :—

(*a*) The depression of prices which is likely to follow the elimination of foreign competition in the buying of kernels must be greatly to the disadvantage of the native producer. Also, as the trade in purchasing kernels is in the hands of comparatively few firms, it follows that there would be considerable temptation for buyers to confer together and arrange prices.

(*b*) Evidence was given that British crushers and extractors were contracting for machinery and plant to deal with palm kernels before the War, showing that they had faith in their power to compete with the German manufacturer even without receiving any tariff assistance. To place the British crushers in a position of having 2*l.* per ton duty in their favour (probably at the expense of the native producer) would doubtless cause general dissatisfaction amongst the unprotected British manufacturers, and might create friction with our French Allies, who are such important consumers of edible oil. There would also be danger of commercial reprisals from friendly neutral countries, who before the War received large quantities of kernels through German ports.

(*c*) There appears nothing to prevent mills on the West African Coast which are now closed from being reopened, or new factories being erected there; these would be in a position partially to prepare the kernels or manufacture oil and feeding cakes and to export them to Germany or other foreign countries, thus avoiding the incidence of the duty on kernels altogether.

(*d*) Before the War one British and one German line of steamers served West African ports, both charging nominally the same rates of freight. With the elimination of foreign purchasers of kernels it appears likely that the British line would obtain a monopoly, and consequently charge higher freights; and as the "primage" system is in vogue, competition from tramp steamers would be almost impossible.

The Majority Report states that if merchants or crushers combine to take advantage of the duty, the "Colonial Government shall have the right to review it from time to time;" but, should the abuse arise, it will be a very difficult matter to decide whether it is the merchant or the crusher or the shipowner who is to blame. Should the duty be abolished or reduced, the position of the British crusher, whose trade it is intended to foster, and who had been induced to make large capital outlay based on the imposition of the duty, would be very seriously jeopardised.

Pending the consideration by Parliament of the whole fiscal system of the British Empire at the conclusion of the War, I suggest the following recommendations should at once be put into force :—

(1) Greater attention should be given to the cultivation of the oil-palm, more care devoted to the manner in which the fruit is gathered, and further substantial financial assistance provided for this purpose by strengthening and increasing the Agricultural and Forestry Departments of the West African Colonies.

(2) The native should be supplied with better means of cracking the kernels and obtaining oil. Steps should also be taken to organise native industry by co-operation.

(3) Maximum rates of freight between West African ports and British ports, as well as port dues and dock charges, should be fixed by the Board of Trade on application from merchants, shippers, or manufacturers. Export business to West Africa has been largely in the hands of Germany, thus finding constant return freight on her steamers; this seems a favourable time for British enterprise to capture it, provided adequate shipping facilities are obtainable. Improved methods for handling kernels should be established by the provision of elevators in the larger West African and British ports.

(4) Legislation should be set in motion to amend the Food and Drugs Act, thus allowing "British made" to appear on the statutory wrapper in which margarine is sold.

(5) A Standing Committee should be formed, consisting of both scientific and commercial experts, who will assist in the development of the industry in all its branches, and also watch the flow of trade.

(6) If the above recommendations should be found inadequate to attract the trade to Great Britain, a Government grant might be considered on the same principle as that made to British Dyes, Limited.

5th May 1916. THOMAS WILES.

Appendix A.

TABLE IV.

Exports in Years shown of Group of Products detailed in Table I. from British West Africa to various Markets (Values in thousand £).

	To United Kingdom.		To Germany.		To France.		To Holland.		To South Africa.		To all Countries.	
	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*
1895	90,219	960	84,118	657	29,581	266	410	3	—	—	206,844	1,900
1900	76,741	809	97,142	1,018	44,488	396	2,312	14	—	—	226,063	2,261
1905	87,164	1,046	128,271	1,301	29,927	206	4,414	34	—	—	250,260	2,597
1910	108,925	2,200	207,083	3,110	55,867	403	10,930	113	—	—	383,004	5,825
1911	123,123	2,242	204,229	3,097	45,349	441	10,226	112	219	3	383,532	5,903
1912	129,310	2,267	206,580	3,232	54,377	453	24,079	253	6,039	107	425,481	6,352
1913	129,362	2,578	226,930	3,869	48,816	495	12,061	130	6,300	120	430,563	7,228

TABLE V.

Exports in Years shown of the principal Vegetable Oils and Oil Seeds from British West Africa to all Countries (Values in thousand £).

	Palm Kernels.		Palm Oil.		Ground Nuts.		Shea Nuts.		Copra.		Benniseed.		Total of foregoing.	
	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*
1895	119,744	866	76,774	974	9,905	56	—	—	—	—	421	4	206,844	1,900
1900	120,973	1,104	68,436	927	35,805	222	—	—	368	3	481	5	226,063	2,261
1905	146,984	1,440	64,086	965	37,399	176	1,356	12	351	3	84	1	250,260	2,597
1910	230,678	3,353	87,610	1,965	59,451	405	4,462	85	755	13	48	3	383,004	5,825
1911	237,527	3,465	88,794	1,898	49,110	455	6,358	64	780	13	963	8	383,532	5,903
1912	255,480	3,866	85,849	1,837	68,403	536	7,706	73	620	14	884	6	419,441	6,332
1913	234,208	4,199	88,997	1,977	86,693	797	9,420	70	726	16	1,250	11	430,563*	7,228*

* Including palm-kernel oil and palm-kernel cake.

TABLE VI.

Exports in 1913 *of the principal Vegetable Oils and Oil Seeds from the various British West African Territories (Values in thousand £).*

	From Gambia.		From Sierra Leone.		From Gold Coast.		From Nigeria.		From British West Africa.	
	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*	Tons.	1,000*l.*
Palm kernels	545	9	49,201	921	9,744	159	174,718	3,110	234,208	4,199
Palm oil	—	—	2,468	57	3,440	66	83,089	1,854	88,997	1,977
Ground nuts	67,404	622	—	—	1	—	19,288	175	86,693	797
Palm-kernel oil	—	—	—	—	—	—	3,857	129	3,857	129
Palm-kernel cake	—	—	—	—	—	—	5,412	31	5,412	31
Shea nuts	—	—	—	—	—	—	9,420	70	9,420	70
Copra	—	—	—	—	629	14	97	2	726	16
Benniseed	—	—	36	—	—	—	1,214	9	1,250	9
	67,949	631	51,705	978	13,814	239	297,095	5,380	430,563	7,228

Appendix B.

MEMORANDUM ON THE RESULTS OF FEEDING EXPERIMENTS WITH PALM-KERNEL CAKE, COCONUT CAKE, AND GROUND-NUT CAKE.

By CHARLES CROWTHER, M.A., Ph.D., Professor of Agricultural Chemistry and Director of the Institute for Research in Animal Nutrition in the University of Leeds.

PART I.—*Preliminary Memorandum on the Criteria of Reliability in Feeding Experiments and the Interpretation of Results.*

Before the results of a feeding experiment can be accepted as conclusive with respect to the specific issue that the experiment was designed to test, it is necessary first to enquire how closely certain criteria of reliability have been satisfied in the planning of the experiment and what degree of variability has been displayed in the records of the individual animals.

In experiments such as those dealt with in Part II., consisting of *comparisons* of the effects upon live-weight or milk production of various foods of similar general character, the essential points to be considered in an analysis of the results are the following:—

(1) The extent to which variable factors other than the one whose effect is to be measured have been eliminated in the plan and conduct of the experiment.

(2) The number, kind, and condition of animals employed.

(3) The nature and amount of each feeding-stuff included in the ration, with special reference to the nature and nutritive value of the "basal ration" to which the foodstuffs under comparison have been added.

(4) The duration of the experiment.

(5) The "probable error" of the final average for each group of animals, this being a measure of the degree of closeness with which the records of the individual animals within the group conform to the average.

The significance of each of these factors is briefly as follows:—

Adequacy of Plan of Experiment.

1. The ideal experiment is obviously one in which the only variable factor is the one under test. This ideal is unattainable in food comparisons with animals, mainly owing to the disturbing complex of inherent or acquired differences between different animals, even of the same breed, which may be collectively referred to as "individuality." This factor is dealt with more fully in the following paragraph. Other possible variable factors such as housing, equality of basal ration for each group, hours of feeding, &c., are more closely under the control of the experimenter, whilst others, such as illness or fluctuations of appetite of individual animals, are more difficult to foresee and prevent. In experiments on milk-production, a further uncontrollable variable factor is introduced by the natural shrinkage in milk-flow and change in composition of the milk with advance of lactation, quite apart from any variations in food supply. Variable factors such as these cannot be entirely eliminated, but their influence upon the final result can be greatly minimised, and it is a necessary preliminary, therefore, in considering the results of any particular experiment, to examine how closely variable factors, other than the one to whose influence the results obtained are ostensibly due, have been eliminated.

Number, kind and condition of Animals.

2. No two animals are exactly alike. Even were two exactly alike, say in live-weight, at one particular moment, this is no guarantee that they will be alike at a later period, even if subjected to identical feeding and general treatment throughout the interval.

According to statistical investigations made at Cambridge and elsewhere, it is an *even chance* that at the later period they would show a difference in live-weight of about 14 per cent. in the case of cattle, or 10–12 per cent. in the case of pigs.

Expressed in different fashion, if for a feeding test two animals (bullocks) of equal weight be selected, the one receiving ration "A" and the other ration "B," it must be borne in mind at the end of the test that any difference in live-weight of the order of 14 per cent. of the average live-weight may just as legitimately be attributed to differences of "individuality" as to the difference in feeding and the experiment must thus be regarded as inconclusive. The greater the difference recorded above 14 per cent. the greater become the odds in favour of the difference in live-weight increase being actually attributable to the difference of feeding, but they do not reach the practical certainty represented by odds of, say, 30 to 1 until the recorded difference in live-weight amounts to about 50 per cent. In other words, if we take the odds mentioned as our standard of the desired degree of certainty in experimental work, assuming that we have only two animals at our disposal, we can only safely compare the merits of two foods if the one is some 50 per cent. superior to the other. We could compare foods of widely different character, say straw and oil-cake, but we could not detect with certainty the differences between different foods of the same class.

The reliability of the experiment can be increased either by repetition or by increasing the number of animals used, or by a combination of the two expedients. According to Professor Wood, in order to measure with certainty a 10 per cent. difference between the fattening effects of two rations supplied to cattle, each group ought to comprise at least 29 animals. This is usually an inconveniently large number, and in practice the desired precision is more conveniently obtained by repeating the trial several times with smaller numbers. Single trials with four or five animals in each group cannot be depended upon to give a reliable measure of differences in feeding value of less than about 25 per cent.

The "condition" of the animals at the outset of the experiment may be a factor of importance affecting the result of the feeding, since an animal in lean condition will offer more scope for nutritive effects than one in moderately fat condition. Such differences will usually be eliminated as far as possible by careful selection of the animals at the outset of the experiment. Similar considerations apply also to the stage of lactation and of pregnancy of cows used in tests of the effects of foods upon milk production.

3. The nutritive effect of a given ration cannot be ascribed to any particular feeding-stuff included in the ration, but must be regarded as due to the ration as a whole. This effect is determined by—

(*a*) the amount of digestible protein (or albuminoid) included in the ration;

(*b*) the total digestible matter supplied;

(*c*) the ease with which the ration is masticated and digested;

(*d*) certain factors only definable with difficulty, such as palatability or possible specific stimulant effects of certain ingredients of the ration.

The supply of digestible protein is fundamentally important since by it alone can certain requirements of the animal be met. Until the requisite minimum amount of protein has been included in the ration, this ingredient remains the "limiting factor" determining the success of the feeding, but this special importance of the protein rapidly diminishes once the supply has been brought above the necessary minimum. In the case of fattening adult animals there is evidence that the value of protein given in excess of the minimum requirements is barely equal to that of carbohydrates. This fact may have an important bearing upon the outcome of a feeding experiment, where the two foods compared differ greatly in protein-content (*e.g.*, palm-kernel cake and decorticated cotton cake). If the "basal ration"—the part of the ration which is the same for each group of animals—be particularly poor in protein the chances are that the results of the experiment will favour the cake that is richer in protein. On the other hand, if the shortage of protein to be made good by the added cake is relatively small, the results of the tests will be determined more by the relative feeding merits of the oil and carbohydrates—or possibly other less prominent ingredients—of the two cakes.

In considering the results of a feeding trial it is thus obviously necessary to scrutinise closely the protein supply. It is also necessary to examine how nearly the total food supply is adapted to the needs of the animal. Generally speaking, the heavier the "basal ration" the less will be the effect of any addition of food, whatever its character. The fact that two foods when added to the same ration produce the same effect does not necessarily mean that they have the same general nutritive value, unless it is clear that the "basal ration" by itself is insufficient to develop fully the capabilities of the animals.

It will rarely happen in experimental work that the "basal ration" is so heavy as to exclude the possibility of further feeding effects by increase of food supply, but it is not infrequently the case that the margin available for results is small. The relative merits of different foods will be brought out most clearly when the "basal ration" is relatively scanty. Similarly the amount of added food must be sufficiently large to ensure a measurable effect under the conditions of the experiment.

In the foregoing the view is implied that the feeding value of a ration is determined by its content of digestible protein, oil, and carbohydrates. This is not strictly correct, since further account must be taken of other factors, for example, of the relative ease or difficulty with which the food is masticated and passed through the alimentary canal. Nutritive matters that are incorporated with tough fibrous material produce less effect than if fed apart from the fibre, since in the former case an appreciable amount of the food is used up to supply the energy required for the passage of the fibrous material through the body. In considering food values, therefore, it is obviously necessary to take into account the fibre-content of the foods where this is a significant quantity, say 10 per cent. or upwards.

Lastly, under this heading it is necessary to draw attention to certain other factors, as yet not fully explored, which may possibly exercise a determinative influence upon the results of a feeding trial. One such factor is the known inadequacy of the proteins of certain food materials (*e.g.*, maize) to meet fully the demands of the animal for protein. A further possibility is the absence from the food of certain ingredients known to be essential, though only in very small amounts, for certain nutritive purposes. So far as "concentrative foods" are concerned, either of these factors is only likely to be operative in practice in cases where the diet consists of only one foodstuff, which itself is only a portion of a natural product (*e.g.*, white flour). Such a case might occasionally be met with in pig-feeding, but would be rare even with pigs, and would never happen in the case of cattle or sheep. The greater the number of different foodstuffs included in the ration the less are complications due to these causes likely to arise.

In experiments with growing animals or milking animals it is also sometimes necessary to examine the supply of lime and phosphoric acid in the rations owing to the relatively large amounts of these materials used up in bone-formation and milk-production respectively.

Duration of Experiment.

4. The duration of the experiment is an important factor for much the same reasons as necessitate the use of relatively large numbers of animals. If daily records are kept it is found that fluctuations occur from day to day which cannot be attributed to differences in feeding. The experimental period must hence be made sufficiently long to ensure that the averages for the period are not seriously affected by these adventitious fluctuations. It is difficult to fix precise limits, but in fattening experiments the period of comparison should probably be not less than six weeks, whilst in experiments on milk-production a period of three weeks will usually suffice.

"Probable Error" of Result.

5. In all experiments the final results should always be accompanied by a statement of the probable degree of reliability which attaches to them. This can be approximately gauged by mathematical computation from the records of the individual animals in each group, and is usually expressed in the form of "probable error." Thus, in a fattening experiment it might be found that Ration A. had given a live-weight increase of ·15 lb. per animal per day greater than Ration B. Before we can accept this result as significant we must have some assurance that the adventitious fluctuations due to factors other than the difference of feeding might not have produced a difference similar to that observed. It is this purpose that is served by the estimate of "probable error." Supposing the "probable error" of the above-mentioned difference (·15 lb.) were found to be ± ·25 lb., this would indicate an *even chance* that if the experiment were repeated on the same lines, the result would fall somewhere between ·10 lb. against Ration A. and ·40 lb. in favour of Ration A. —in other words, that the experiment by itself is quite inconclusive as to the relative merits of the two Rations A. and B. If, however, the "probable error" were found to be ± ·07 lb. it can be shown that this would imply that the chances were about 5 to 1 against the result being due to normal variations, *i.e.*, factors other than the difference in feeding—a much more conclusive result, but still not representing a very high degree of certainty. It is only when the "probable error" falls below about one-third of the result that we secure the high degree of certainty represented by odds of 20 to 1 or 30 to 1 against the result being due to errors of experiment. In other words, if the "probable error" of our hypothetical experiment prove to be but ± ·04 lb., we may feel reasonably safe in concluding that the indicated difference of ·15 lb. represents a real superiority of Ration A. over Ration B.

Briefly summarised, the essential points to be reviewed in considering the results of feeding experiments may be re-stated as follows:—

(1) The general soundness of plan of the experiment.
(2) The number of animals used, and the degree of uniformity in kind and condition at the outset.
(3) The duration of the separate periods of the experiment.
(4) The nature and amount of the "basal ration," and of the total ration, with special reference to protein-content, total food supply, and general suitability for the purpose of the experiment.
(5) The records of the individual animals, with pecial reference to their bearing upon the sreliability of the final results.

PART II.—*Experiments with Palm-Kernel Cake.*

(a) *Experiments with Fattening Cattle.*

Experimental Centre.	Foods used for Comparison.	Number of Animals in each Lot.	Duration of Comparison.
			Weeks
Norfolk Agricultural Station.	Linseed cake	10	8
Cambridge (Howe Hill Farm).	" "	17 and 18.	8
Aberdeen University	" "	10	12
" "	Decorticated cotton cake.	9 and 10.	12
West of Scotland College, Glasgow.	" "	4	14
" "	Bran	4	14
University College, Aberystwyth.	Undecorticated cotton cake.	4	9
East of Scotland College, Edinburgh.	Undecorticated cotton cake (Bombay).	8	16
" "	Dried distillery grains.	8	16

Comparisons with Linseed Cake.

(1) *Norfolk Experiment* (Winter 1914–15).

Description.

This experiment consisted of a comparison of equal weights (3–3½ lbs.) of linseed cake and palm-kernel cake respectively, when fed along with a basal ration (per animal per day) of 90 lbs. swedes, 7 lbs. hay and straw chaff, and 3 to 3½ lbs. undecorticated cotton cake.

The average gain in weight per animal for the eight weeks was as follows:—

	Lbs.
Linseed cake group - - -	125 ± 12
Palm-kernel cake group - -	123 ± 6·4
Difference in favour of linseed cake	2 ± 13·6

The difference in favour of the linseed cake is so much smaller than the probable error of the experiment that it cannot be regarded as significant, and hence the conclusion is drawn that, as nearly as they could be measured in this experiment, the two rations had the same feeding value. It is reported that the animals fed on palm-kernel cake "made slightly more per cwt. " live-weight than those fed on linseed cake, for the " reason that they looked better in their coats and " butchers bid very freely for them."

Commentary.

The initial evenness of the two groups of animals was apparently determined by selection, without any preliminary period in which both lots were fed alike and periodically weighed. The lower probable error of the average for the palm-kernel cake group indicates that the individual records of the animals in this group agreed more closely than in the linseed cake group. The records show that the individual gains in the latter group ranged from 66 lbs. to 233 lbs., whilst in the palm-kernel cake group the range was from 77 lbs. to 173 lbs. It is impossible to say, however, whether this difference operated in favour of, or against, the linseed cake. The probable error (± 13·6 lbs.) of the difference (2 lbs.) in average live-weight increase of the two groups implies an even chance that if the experiment were repeated the result would fall between the limits of 11·6 lbs. (or 9 per cent.) in favour of palm-kernel cake, and 15·6 lbs. (or 12½ per cent.) in favour of the linseed cake. A substantial margin of uncertainty is thus still left for further experiments to elucidate.

Assuming average composition for each food used, I estimate that the average daily food supply per animal would have roughly the appended composition:—

	Digestible Protein.	Digestible Oil.	Digestible Carbohydrates and Fibre.
	Lb.	Lb.	Lbs.
Linseed cake group -	1¼	¾	11¾
Palm-kernel cake group.	1½	½	12¼

The supply of digestible protein, even to the linseed-cake group, is appreciably lower than commonly-used feeding "standards" suggest as desirable for animals such as were used in this experiment, but the satisfactory rate of growth of the animals (2½ lbs. per day) is a sufficient indication that the rations used were adequate. Doubtless any deficiencies in the supply of true protein were well covered by the non-protein nitrogenous matters in the liberal allowance of swedes included in the rations.

The amount of oil in the palm-kernel cake ration is just about the amount which I have previously indicated to the Committee as the limit beyond which no special advantage is to be expected from increasing the oil supply, as distinguished from the supply of carbohydrates.

From the foregoing data for the composition of the two rations, and using the method devised by Kellner, I estimate that theoretically the two rations should have practically the same fattening effect, viz., an effect equivalent to that of 12·5 lbs. of starch. Thus, the result of this experiment, though perhaps surprising to the practical man, is quite in harmony with the indications of present day methods of assessing food values.

(2) *Cambridge Experiment* (Howe Hill Farm, Winter 1914–15).

Description.

In this experiment, 2 lbs. of linseed cake per animal per day were compared with 2 lbs. of palm-kernel cake, each being fed with the same basal ration, viz., 100 lbs. (approx.) " roots," 10 lbs. straw chaff, and 2 lbs. of cotton-seed cake. The linseed cake group comprised 18 animals and the palm-kernel cake group 17 animals.

In eight weeks the former gave an average increase in live-weight of 9·2 stones per head, and the latter 7·9 stones. A difference of 1·3 stone, or roughly 18 lbs. per head in favour of the linseed cake, is thus indicated. In other words, the linseed cake result is about 15 per cent. better than that achieved with the palm-kernel cake.

Commentary.

In the absence of data as to the gains in live-weight made by each individual animal it is impossible to estimate the "probable error" of the result. In a private communication, however, Professor Wood states that "the bullocks were a very miscellaneous lot of all " colours, breeds, and sizes, and the probable error was " very high indeed." With regard to the figures, he says, "I do not place any sort of reliance on their " accuracy. I think the only lesson to be learned from " the experiment is that palm-nut cake is a healthy " food, which produces no ill effects on fattening " cattle."

In face of this expression of opinion it is almost superfluous to discuss the experiment. Taking the figures as they stand, however, it may be pointed out that the average gain of the palm-kernel cake group, amounting to 7·9 stones per head in eight weeks, or slightly under 2 lbs. per day, is only moderate, and may be indicative of a slight shortage of digestible protein in the ration of this group. Assuming average composition for the foodstuffs used, the supply of digestible protein to this group would be about 1 lb. per head per day, whilst the linseed cake group would receive about ¼th lb. more. The element of uncertainty involved in the lack of precise knowledge as to the value as "protein substitute" of the non-protein nitrogenous

ingredients of the swedes (amounting probably to fully 1 lb. of these substances in 100 lbs. swedes) makes it impossible to assert definitely that there was an actual shortage of protein, but the supplies of protein are so much below commonly advocated standards as to justify the suggestion that this may have been the cause of the inferiority of the palm-kernel ration.

(3) *Aberdeen Experiment* (Winter 1914–15).

Description.

In this experiment equal weights of palm-kernel and linseed cakes were compared with groups of 10 animals, each group being made up of four bullocks and six heifers. Cut swedes and straw were fed to each group in equal amounts, which, however, are not clearly defined in the report. The heifers got about 12 lbs. less turnips per head per day than the bullocks. The concentrated foods were given as follows:—

Period I. (4 weeks).—Bullocks, 5 lbs., and heifers 4 lbs. per head per day of a mixture of 3 parts of cake to 2 parts of locust bean meal.

Period II. (4 weeks).—Bullocks 8 lbs., and heifers 7 lbs. per head per day of a mixture of 5 of cake to 3 of locust bean meal.

Period III. (4 weeks).—Bullocks 9 lbs. and heifers 8 lbs. per head of a mixture of 5 of cake, 2 of locust meal, and 2 of oats.

The increases in live-weight for each individual for each period of the experiment are given in the report issued by Professor Hendrick. The average gains per animal for each group are as follows:—

—	Period I. (4 weeks).	Period II. (4 weeks).	Period III. (4 weeks).	Whole Experiment. (12 weeks).
	Lbs.	Lbs.	Lbs.	Lbs.
Linseed cake group	58·5	45·9	50·5	154·9 ± 4·9
Palm-kernel cake group	56·2	60·3	48·0	164·5 ± 7·6
Difference in favour of linseed cake	2·3	−14·4	2·5	−9·6 ± 9·0

It will be noticed that a slight difference in favour of linseed cake is indicated in Periods I. and III., but a marked difference in favour of palm-kernel cake in Period II. This last-named phenomenon is accounted for largely by two animals in this group, which during Period II. showed abnormally large gains. Apart from these two animals the gains in Period II. were relatively low in each group, and it is suggested in the report that this was due to the very poor quality of the turnips used in this period.

If this period be excluded entirely, a difference of 4·8 lbs. per head in favour of the linseed cake is shown for the remaining 8 weeks. Taking the gains over the whole experimental period of 12 weeks, a difference of practically 10 lbs. (or 6 per cent. of the increase) in favour of palm-kernel cake is shown. "Considering, "however, the great variations in live-weight increase "to be found even among animals of the same lot, the "small differences between the live-weight increases "from the different lots do not warrant us in drawing "hard and fast conclusions as to the relative feeding "value of the cakes. As the differences could quite "well be covered by the experimental error, the most "we can say is that the foods have given practically "the same returns in live-weight increase, and that the "choice of the one or the other must be largely a matter "of cost." The net cost of food per cwt. live-weight increase is given as 51*s.* 6*d.* for the linseed cake ration, and 43*s.* 4*d.* for the palm-kernel cake ration, or a difference in favour of the latter of 8*s.* 2*d.* It is concluded that, when fed in the same quantities, palm-kernel cake may be expected to give equally as good a return in live-weight increase as linseed cake, and "at present prices" it gives a better monetary return than the latter. (The prices used in the report are:—Linseed cake, 9*l.* 17*s.* 6*d.* per ton; palm-kernel cake, 6*l.* 10*s.* per ton.)

It is further concluded, that, when fed in mixture with locust bean meal, palm-kernel cake "is taken readily by stock, and no difficulty need be experienced "in storing cake containing a comparatively large "percentage of oil."

Commentary.

Little need be added to the expression of opinion as to the significance of the results which is quoted above. Without the separate data for the consumption of roots and straw it is impossible to form an opinion as to the suitability of the ration, but assuming common Aberdeenshire practice in feeding roots and straw to have been followed, it is probable that the rations were ample in every way.

The bullocks made better gains than the heifers, the separate results in each group being as follows:—

—	Total Increase per Head during Experimental Period (12 weeks).	
	Bullocks.	Heifers.
	Lbs.	Lbs.
Linseed cake group	174·0	142·2
Palm-kernel cake group	193·5	145·0
Difference in favour of palm-kernel cake	19·5	2·8

In each case the palm-kernel cake group shows to advantage, although in the case of the heifers the difference is very small. The much larger difference shown in the case of the bullocks is almost entirely explained by the high increase recorded by one individual, the average of the other three being only 181 lbs.

The linseed cake used was relatively poor in protein, containing only 26·12 per cent. Assuming average digestibility for the two cakes, I should estimate from the analyses given that when incorporated in a ration supplying *in toto* sufficient digestible protein, 100 lbs. of palm-kernel cake as used in this experiment would be equal in nutritive value for fattening purposes to 103–106 lbs. of the linseed cake used, which would imply a difference of only about 1 per cent. in the estimated effects of the two rations. The results taken as they stand are in fair agreement with this assessment.

General deductions from comparisons with Linseed Cake.

Of the three experiments reported upon, two (Norfolk and Cambridge) have given a result in favour of linseed cake, and the third (Aberdeen) in favour of palm-kernel cake, but in each case the differences are so small in comparison with the probable error of the experiment that the only conclusion that can legitimately be drawn is that the two cakes have proved of substantially equal value for the fattening of cattle. If there were actual differences in feeding value, they were too small to be detected by single experiments

with groups of ten animals. If we assume the three experiments to be of equal accuracy and average the results, we find that, whereas 38 animals fed on rations containing linseed cake gave an average live-weight increase per head per week of 14·9 lbs., 37 animals fed on rations identical with the foregoing, but for the replacement of the linseed cake by an equal weight of palm-kernel cake, gave an average increase per head per week of 14·3 lb. If the relatively unreliable Howe Hill Experiment be excluded, the averages for the remaining two are 14·27 lbs. per head per week for the linseed cake, and 14·54 lbs. per head per week for the palm-kernel cake.

The conclusion as to the general equality of the two cakes, when given in satisfactory rations, is in harmony with the estimates of the agricultural chemist based upon the most recently developed methods of assessing food values from chemical composition.

Comparison with Decorticated Cotton Cake.

Aberdeen Experiment (Winter 1914-15).

Description.

This test was carried out simultaneously with the above-described comparison with linseed cake, a third group of 9 similar, carefully selected animals (4 bullocks and 5 heifers) being used for the purpose. The feeding was exactly the same as for the other groups, except for the substitution of decorticated cotton cake for the linseed or palm-kernel cake. The average gains per head for each group were as follows:—

	Period I. (4 weeks).	Period II. (4 weeks).	Period III. (4 weeks).	Whole Experiment. (12 weeks).
	Lbs.	Lbs.	Lbs.	Lbs.
Decorticated cotton-cake group	64·2	43·9	59·0	167·1 ± 7·7
Palm-kernel cake group	56·2	60·3	48·0	164·5 ± 7·6
Difference in favour of decorticated cotton cake.	8·0	−16·4	11·0	2·6 ± 10·8

Commentary.

The results for the whole period show a slight difference, which, however, cannot be regarded as significant, in favour of the cotton cake. This is borne out by the averages of the 1st and 3rd periods, but the puzzling irregularity in Period II., referred to in discussing the comparison with linseed cake, is apparent also in this comparison with decorticated cotton cake. If this period be excluded a difference of 19 lbs. per head in favour of the cotton cake is shown for the remaining eight weeks.

The separate results for bullocks and heifers in each group were as follows:—

	Total increase per head during Experimental Period (12 weeks).	
	Bullocks.	Heifers.
	Lbs.	Lbs.
Decorticated cotton cake group.	186·8	151·4
Palm-kernel cake group	193·5	145·0
Difference in favour of decorticated cotton cake.	−6·7	6·4

It will be seen that the records of the bullocks show a difference in favour of palm-kernel cake, whilst the heifers show better results with the decorticated cotton cake.

We can only agree with Professor Hendrick in disregarding the actual differences recorded and in regarding the experiment simply as a demonstration of the substantial equality in feeding value of the two cakes when used, as in this case, as ingredients of an ample ration. In such a ration the cakes used, assuming average digestibility and the composition given in the report, might be expected to show a difference in feeding value of about 10 per cent. in favour of the palm-kernel cake. Such a difference could not be measured with certainty in a single experiment with groups of ten animals. With only this single experiment to guide us we cannot say, therefore, how closely this expectation might be realised in general practice. We can only say that the one test made favours the idea that the two cakes are, under certain circumstances, of practically equal value.

Comparison with Mixture of Decorticated Cotton Cake and Oats.

Glasgow Experiment (Winter 1914-15).

Description.

This experiment, and the comparison with bran, described next, were conducted at the farm of the Crichton Royal Institution, Dumfries, by Professor Paterson, of the West of Scotland Agricultural College.

At the outset, 16 Ayrshire bullocks were weighed and fed for four weeks on a ration of turnips, hay, straw, crushed oats, palm-kernel cake, and decorticated cotton cake. "The twelve animals that appeared to be most suitable for reliable experimental work" were then selected and divided into three groups of equal live-weight. A daily basal ration of hay, straw, turnips, 2 lbs. decorticated cotton cake, and 2 lbs. crushed oats was fed to each animal, with the following average additions:—

Lot I.—1 lb. decorticated cotton cake + 2 lbs. crushed oats.
Lot II.—3 lbs. palm-kernel cake.
Lot III.—4 lbs. bran.

Throughout the 14 weeks of the experiment proper the cattle were weighed fortnightly. "Being horned cattle they were tied in stalls" for the feeding. The comparison of Lots II. and III. is dealt with in the next section of this memorandum.

The average live-weight gains per head for the whole period of Lots I. and II. are as follows:—

	Lbs.
Lot I. (Decorticated cotton cake + oats)	155·5 ± 10·3
Lot II. (Palm-kernel cake)	113·0 ± 7·2
Difference in favour of Lot I.	42·5 ± 12·6

Commentary.

This may be regarded as a decisive result for the animals and rations compared. In his report Professor Paterson draws attention, however, to the comparatively small gains recorded, these averaging only 1·58 per head per day for Lot I. and 1·15 lbs. per head per day for Lot II., the average weight of the animals being about 7½ cwts. per head.

This may be indicative of deficiencies in the food supply, but no opinion can be formed as to this without detailed information as to the amounts of hay, straw and turnips consumed, which is not given in the report.

Professor Paterson further points out that "although this experiment was conducted under ideal "conditions, too great stress should not be put upon

" the results till they have been confirmed by other " experiments, as only a small number of animals were " employed. Nevertheless, there is good reason for " believing that the results obtained indicate fairly " well the approximate relative values, as measured " by beef production, of the feeding-stuffs employed." The "good reason" is not very obvious. The only safe conclusion to draw from this experiment is that whilst there is little doubt that the better result obtained with the cotton cake and oats was due to the difference in feeding of the two groups, the number of animals used was far too small to warrant any *general* conclusions being drawn as to the average merits of the two foods, and still less as to their "approximate relative values."

It should be noted, however, that the Aberdeen experiment agrees with this in indicating a difference in favour of decorticated cotton cake, although in the latter case the difference is much less.

Comparison with Bran.

Glasgow Experiment (Winter 1914–15).

Description.

Details of the general plan of experiment and of the feeding have been given in the preceding section. The average live-weight gains per head for the 14 weeks were as follows:—

	Lbs.
Lot II. (Palm-kernel cake) -	113·0 ± 7·2
Lot III. (Bran) - - - -	101·25 ± 3·7
Difference in favour of Lot II. -	11·75 ± 8·1

Commentary.

A difference of roughly 10 per cent. in favour of the palm-kernel cake ration is indicated, but the probable error is relatively so high that there is no great certainty that the same result would have been obtained again by repeating the experiment even with the same animals. It should be noted, however, that only 3 lbs. of palm-kernel cake was fed as against 4 lbs. of bran, so that there can be no doubt as to the real superiority of palm-kernel cake over bran in this test. Here again, however, the test is on far too small a scale to be used as a basis for generalisation as to the relative merits of the two foodstuffs.

Comparisons with Undecorticated Cotton Cake.

(1) *Aberystwyth Experiment* (Winter 1914–15).

Two lots of four cattle each were used. After five weeks they showed an average difference in live-weight increase per head of 38 lbs. in favour of the cotton cake, and four weeks later the gains for the whole period of nine weeks showed a difference of 26 lbs. per head in favour of the cotton cake.

It will be clear from the foregoing discussion of experiments conducted on a much larger scale that it would be unwise to attach much significance to the actual numerical results obtained with groups of four animals. What this experiment has demonstrated is that palm-kernel cake is a useful feeding-stuff suitable for fattening cattle. Taken by itself this experiment cannot be used as proof of the superiority of undecorticated cotton cake over palm-kernel cake.

(2) *Edinburgh Experiment* (Winter 1914–15).

In this experiment a uniform basal ration of 100 lb. swedes, 7 lbs. oat straw and 3 lbs. medium wheat bran was used, with which was fed to the one group (8 bullocks) Bombay undecorticated cotton cake at the average rate of approximately 4½ lbs. per head per day, and to the other group (8 bullocks) palm-kernel cake at the average rate of approximately 4½ lbs. per day. The experimental period, during which monthly weighings were made, lasted for sixteen weeks, and was preceded by a preliminary period of four weeks during which the respective groups received the experimental rations.

The average gains in weight per head for the sixteen weeks were as follows:—

	Lbs.
Bombay cake group - - -	197·5 ± 5·9
Palm-kernel cake group - -	228·4 ± 8·0
Difference in favour of palm-kernel cake - - -	30·9 ± 9·9

The estimates of financial returns show a substantial difference in favour of the palm-kernel cake.

Commentary.

The difference in live-weight increase recorded is so substantial and so much greater than the probable error of experiment as to leave little doubt of its significance, although it may not be a *precise* measure of the order of magnitude of the real difference in nutritive value between the two cakes. In other words, this experiment may be taken as demonstrating clearly that the palm-kernel cake used was superior in feeding value to the Bombay cake, but it is not equally certain that the difference in nutritive value was precisely that represented by the 30·9 lbs. (or, roughly, 15 per cent.) difference in average gains. It may have been more, or just as possibly less. The superiority of the palm-kernel cake is all the more obvious in that slightly less of it was fed.

On the basis of the chemical composition of the cakes, as given in the report, assuming for them average digestibility and also average values for the other foods used, I should estimate that the palm-kernel cake ration would produce 15–25 per cent. better results than the Bombay cake ration. The results of the Edinburgh experiment bear out this assessment fairly well, but further experiments are needed to fix more precisely the relative values of these two cakes. The same applies even more to the case of the Egyptian cotton cake, for which we have as yet only the small Aberystwyth experiment.

Comparison with Dried Distillery Grains.

Edinburgh Experiment (Winter 1914–15).

Description.

This test was carried out simultaneously with the above-described comparison with Bombay cotton cake, a third similar group of 8 bullocks being used for the purpose. The feeding of the two groups was precisely alike, except for the palm-kernel cake and dried grains, which were used in equal quantities (4½ lbs.) in their respective rations. The average gains per head for each group for the sixteen weeks were as follows:—

	Lbs.
Palm-kernel cake group - -	228·4 ± 8·0
Dried distillery grains group -	226·4 ± 7·4
Difference in favour of palm-kernel cake - - - -	2·0 ± 10·9

In this case the difference is so small in comparison with the probable error of experiment that we can only describe the result, as is done by Mr. Bruce in the report, as indicating practical equality of the two rations. From the chemical composition of the rations a difference of 6 to 12 per cent. in favour of the palm-kernel cake might have been expected. Such a possibility is not excluded by the above results, but remains to be tested by further experiments.

Summary of Conclusions from Experiments with Fattening Cattle.

The following conclusions with regard to the merits of palm-kernel cake for fattening cattle may safely be drawn from the combined results of the experiments summarised in the foregoing pages:—

(1) It is a suitable food for the purpose.

(2) When fed along with adequate amounts of roots, hay, or straw (or both), and corn (or other concentrated food) it is capable of giving results roughly equal to those given by the same weight of linseed cake, decorticated cotton cake, or dried distillery grains, and

definitely superior to those given by the same weight of Bombay cotton cake or bran.

(3) In rations supplying only relatively scanty amounts of digestible protein it will probably prove inferior to linseed cake and decorticated cotton cake. For this reason the results of comparisons with these foods are likely to vary greatly.

(4) The evidence available is not sufficient to enable a statement of the precise relative feeding-values of these foods to be given.

(b) *Experiment with Sheep.*

Description.

A comparison of palm-kernel cake with linseed cake for sheep-feeding was carried out at the South-Eastern Agricultural College, Wye, for nine weeks from November 9th, 1914, to January 11th, 1915. Two uniform lots, each of 11 Kent wether tegs, were used. For the first four weeks both lots were folded on kale and received in addition (per head per day) ¾ lb. dried grains and ¾ lb. of linseed cake (Lot A.) or ⅞th lb. of palm-kernel cake (Lot B.). For the last five weeks both lots were folded on yellow turnips and received slightly greater amounts of the concentrated foods. The average consumption of the cakes per head per day was ·79 lb. of linseed cake (Lot A.) and ·87 lb. of palm-kernel cake (Lot B.). The sheep were weighed at the outset, again after four weeks, and finally at the end of the ninth week. The total live weight increases per sheep for the nine weeks were as follows:—

	Lbs.	
Lot A. (Linseed cake) -	33·45	
Lot B. (Palm-kernel cake)	28·65	
Difference in favour of linseed cake - -	4·80	= 15·4 % of average live-weight increase.

Commentary.

In the absence of data for the increases of the individual sheep it is impossible to assess the probable error of the result, but if we assume the degree of unavoidable error to be similar to that observed in cattle-feeding experiments we must accept the result as probably significant of a real difference in favour of linseed cake.

It may be pointed out, however, that the circumstances of outdoor feeding experiments, where the animals are exposed to the vagaries of the climate, are such as to give full play to differences of individuality between the animals, and moreover it is impossible to obtain a reliable check upon the actual food consumptions especially as regards the green food consumed. Moreover this lack of precise information as to the total food consumption makes it impossible to form an opinion how far the superior results obtained with linseed cake may be attributed to its greater richness in protein, rather than to other possible specific merits.

(c) *Experiments with Dairy Cows.*

Experimental Centre.	Foods used for Comparison.	Number of Cows in each Lot.	Duration of Experiment.
			Weeks.
Hutton Farm, Lancs. C.C.	Decorticated cotton cake.	6	9
Harper-Adams College.	Decorticated cotton-seed meal.	2	6
Armstrong College	Bombay cotton cake.	5	16
Leeds University -	Egyptian cotton cake.	4	6
University College, Bangor.	Egyptian cotton cake.	8	12

Comparisons with Decorticated Cotton Cake or Meal.

(1) *Lancashire Experiment* (Autumn 1914).

Description.

This experiment consisted of a comparison of palm-kernel cake with decorticated cotton cake, using quantities of each of equal cost, after making due allowances for difference in manure value. Each lot consisted of six recently-calved cows. The general course of the experiment was as follows:—

	Lot A.	Lot. B.
1st week—	Identical rations including both cakes.	
2nd week—	Transition to 3rd week's rations.	
3rd week—	5 lbs. decorticated cotton cake.	7½ lbs. palm-kernel cake.
4th week—	Transition to 5th week's rations.	
5th week—	7½ lbs. palm-kernel cake.	5 lbs. decorticated cotton cake.
6th week—	Transition to 7th week's rations.	
7th week—	4½ lbs. decorticated cotton cake.	6¾ lbs. palm-kernel cake.
8th week—	Transition to 9th week's rations.	
9th week—	6¾ lbs. palm-kernel cake.	4½ lbs. decorticated cotton cake.

Thus the experiment comprised a preliminary week of equal treatment, and four subsequent fortnightly periods in which the two cakes were contrasted. In the first and third fortnights, Lot A received the cotton cake and Lot B the palm-kernel cake, whilst in the second and fourth fortnights the feeding was reversed. In each fortnight the greater part of the first week was taken up with the transition from the one cake to the other. During the first month (2nd week to 5th week) the daily rations per cow consisted of 20 lbs. roots, 5 lbs. mixed meal, 5 lbs. decorticated cotton cake (or 7½ lbs. palm-kernel cake) and hay *ad lib.* During the second month, the meal for each lot was reduced to 4½ lbs. per day, the cotton cake to 4½ lbs. and the palm-kernel cake to 6¾ lbs., the rest of the ration remaining unchanged. The allowance of meal and cake was mixed for the whole group and then divided amongst the animals according to their milk-yield. The yield of milk was noted at each milking. The *yields of milk* during the preliminary week, when the two lots received identical rations, including a mixture of the two cakes, were as follows:—

	Lbs.	
Lot A - - - -	1,162½	
Lot B - - - -	1,220	
Difference in favour of Lot B - - -	57½	or practically 5%.

It is claimed that any normal advantage of Lot B was eliminated by the method of alternating the feeding of each lot, so that any difference in the total amounts of milk obtained by the use of the two cakes may be taken as indicative of difference in their nutritive values without correction for this inequality between the lots. The total amounts of milk produced during 8 weeks were:—

	Lbs.	
From cotton cake - -	8,852	
From palm-kernel cake -	8,743½	
Difference in favour of cotton cake - -	108½	or slightly over 1%.

In view of the fact that for the first week of each fortnight the feeding was transitional, an alternative assessment of the milk-yields is given in the report, by taking the second week's yield in each fortnight, multiplying by two, and regarding the totals thus got as corrected totals for 8 weeks. These "calculated yields" were as follows:—

	Lbs.	
From cotton cake - -	8,767	
From palm-kernel cake -	8,609½	
Difference in favour of cotton cake - -	157½	or slightly under 2%.

Special attention is directed to the fact that a change to palm-kernel cake resulted in every case in a decreased milk yield; whilst a change to cotton cake increased the yield in two cases and decreased it in two others when a different consignment of cake was used.

Determinations of *fat* and *solids-not-fat* in the milk of each cow were made once daily in composite samples representative of the two milkings. For the eight weeks the averages were as follows:—

—	Fat.	Solids-not-Fat.
	%	%
From cotton cake	3·88	9·09
From palm-kernel cake	3·85	8·98

These differences in composition are regarded as "not material." Two churning tests were made and revealed no appreciable difference in the effects of the two cakes upon the quality of the butter.

Commentary.

Judged by the total yields and average quality of the milk the differences recorded in this experiment are too small to be accepted as significant in view of the magnitude of the probable experimental error. The periods of comparison are very short and leave practically no margin for the elimination of "after-effects" of one ration before the next period is entered.

The milch cow requires liberal supplies of protein, and since the decorticated cotton cake contained practically 40 per cent., whilst the palm-kernel cake contained barely 19 per cent., the cotton cake ration, despite the smaller allowance of cake, supplied the needs of the cows for protein more liberally than the palm-kernel cake ration. The extraordinary richness of the cotton cake in oil (17 per cent.; palm-kernel cake, 6·9 per cent.) also favours the cotton cake ration. The fact that so little effect upon the secretion of milk was produced may perhaps indicate that the rations were heavier than required for milk-production solely, and contributed rather to gain in live-weight. No records of the live-weights of the animals are given.

The amounts of cake used, especially of palm-kernel cake (7¼ lbs.), are far higher than would be recommended in practice, but it is interesting to note that the cows ate even this high allowance of palm-kernel cake—though not with the keenest relish—when introduced gradually, and that the quality of the butter was no worse than that obtained by feeding cotton cake.

(2) *Harper-Adams Experiment* (Winter, 1914–15).

Description.

This experiment consisted of a comparison of 2 lbs. decorticated cotton-seed meal with 3 lbs. (equal cost) of palm-kernel cake, using two pairs of cows of similar milk yield. After three weeks the feeding of the two pairs was reversed and the comparison continued further for three weeks.

In the whole six weeks the yields of milk were as follows:—

	Lbs.	
From palm-kernel cake	3,412	
From cotton-seed meal	3,471	
Difference	59	or barely 2 %.

The palm-kernel cake had no detrimental effect upon the colour, taste, or smell of the milk, nor did it affect either the churning qualities of the cream or the texture or flavour of the butter. The butter, however, did not keep so long.

Commentary.

This experiment can only be regarded as a demonstration of the general suitability of palm-kernel cake for dairy cows. It is on too small a scale to enable a reliable estimate of the relative merits of the two foods to be formed.

Comparison with Bombay Cotton Cake.

Armstrong College Experiment (Winter 1914–15).

Description.

This experiment consisted of a comparison of equal weights (6 lbs.) of Bombay undecorticated cotton cake and palm-kernel cake, using two lots of five cows each, selected carefully after preliminary trials. The comparison extended over sixteen weeks, the rations being reversed during the second half of the period. The basal ration consisted of 56 lbs. swedes, 12 lbs. meadow hay, 6 lbs. oat straw, 2 lbs. malt combs, 3 lbs. soya cake, and ½ lb. oat straw chaff. The cows were milked three times daily. The average yield and fat-content of the milk of each group of cows was precisely the same for a preliminary period of three weeks, during which both groups were fed alike. The average results, per lot per day, for the first eight weeks (Period I.) were as follows:—

—	Yield of Milk.	Fat.	Solids—not Fat.
	Pints.	%	%
Lot I. (palm-kernel cake)	105·81	3·78	8·71
Lot II. (Bombay cake)	98·19	3·41	8·66

For the second period of eight weeks (Period II.) the results were as follows:—

Lot I. (Bombay cake)	100·75	3·67	8·79
Lot II (palm-kernel cake)	83·31	3·71	8·76

The effects upon the live-weight of the cows were as follows:—

—	Average Gain (+) or Loss (—) in Live-Weight per Cow.	
	Period I.	Period II.
	Lbs.	Lbs.
Lot I.	— 20·4	+ 20·6
Lot II.	— 12·6	+ 29·8

It is recorded that the cows receiving palm-kernel cake had a better "bloom" than those receiving Bombay cake.

Commentary.

The outstanding fact in the results of this experiment is the gross discrepancy between the indications of the two periods as to the ostensible effects of the two cakes upon the yield of milk. Period I. taken by itself indicates as regards effect upon milk-yield a marked difference in favour of the palm-kernel cake, while Period II. points just as strongly to the opposite conclusion. From this and from observations in the report as to irregularities of individual cows it is clear that any differences in nutritive effects of the two cakes have been completely overshadowed by the disturbing factor of individuality. This disturbance must have extended also to the composition of the milk, so that the significance of the apparent improvement in fat-content by the use of palm-kernel cake must be regarded as extremely doubtful. The experiment demonstrates the general suitability of palm-kernel cake as food for milch cows, but more cannot be claimed for it.

Comparisons with Egyptian Cotton Cake.

(1) *Leeds Experiment* (March–April 1915).

Description.

This experiment, conducted at the Manor Farm, Garforth, consisted of a comparison, using two groups

of four cows each, of equal weights of palm-kernel cake and Egyptian cotton cake, fed along with soya cake, roots, hay, and straw. The number of cows available being very limited it was not possible to secure quite evenly matched groups, and for this reason, and others which led to a premature termination of the experiment, no great weight is attached to the actual numerical results obtained.

The allowance of palm-kernel (or cotton) cake varied from 2 lb. to 4 lb. per cow daily according to the milk-yield. In the first period of three weeks the cows were fed alike, the cake allowance consisting of one part soya cake and two parts Egyptian cotton cake. In the second period of three weeks one lot received palm-kernel cake in place of the cotton cake, a clear week, in which the change was effected, intervening between the two periods. The milk was weighed at each milking and on five days each week samples were taken for the determination of fat. The results are briefly summarised as follows:—

Period I. (Equal feeding):
Group A. gave per day 142·1 lbs. (±·54) milk containing - - - 5·053 lbs. (±·037) fat.
Group B. gave per day 142·7 lbs. (±·55) milk containing - - - 4·757 lbs. (±·061) fat

Period II.:
Group A. (cotton cake) gave per day 130·4 lbs. (±·40) milk containing 4·692 lbs. (±·028) fat
Group B. (palm-kernel cake) gave per day 136·4 lbs. (±·57) milk containing - - - 4·516 lbs. (±·037) fat.

Fall in *milk-yield* (Period I. —Period II.:—
Group A. = 11·7 lbs. ±·67 lbs.
Group B. = 6·3 lbs. ±·79 lbs.
Difference in favour of palm-kernel cake - = 5·4 lbs. ±1·04 lbs.

Fall in *yield of fat*:—
Group A. = 0·361 lbs. ±·046 lbs.
Group B. = 0·241 lbs. ±·071 lbs.
Difference in favour of palm-kernel cake - = 0·120 lbs. ±·085 lbs.

Commentary.

The data as they stand show a slight difference in favour of palm-kernel cake, but it would be unwise to attach much significance to them, especially the difference in fat yield, which is barely greater than the probable error. The experiment demonstrates the general suitability of palm-kernel cake, and suggests that the differences between the two cakes are such as can only be measured by large-scale experiments.

(2) *Bangor Experiment* (Summer 1915).

Description.

No report on this experiment has yet been published, but Professor White has kindly supplied the following information:—"Two lots of eight cows each, as equal "as possible in weight, milk-yield, period of lactation, "and age, were selected, and for a preliminary period "of a fortnight were fed on a mixture of Egyptian "cotton cake and palm-nut cake. One lot was then "gradually changed on to a ration of cotton cake "alone, the other on to palm-nut cake alone. Both "lots had for some little time previously been out at "grass, and, except for milking and feeding periods, "were out at grass the whole time. After being fed "in this way for three weeks the rations were re-"versed, a period of ten days being taken to effect "the exchange. The feeding was then continued for "a month.

"The milk was weighed every night and morning and "tested once a week. The quantity of cake given was "in each case 1½ lbs. for every 10 lbs. of milk produced. "This was a liberal allowance, but was necessitated by "the shortage of grass. The grass was of good quality, "but the cows were thickly stocked.

"I have examined the results from every point of "view, and the only conclusion I can arrive at is that "any differences between the two cakes were well within "the limits of experimental error, but any difference "that did exist was slightly in favour of the palm-nut "cake."

Commentary.

It will be observed that this is a comparison of the two cakes when used to supplement pasturage. In the absence of information as to the milk-yields obtainable on grass alone, it is impossible to form an opinion whether the allowance of cake was excessive or not. If excessive, it is to be expected that the groups would give practically equal yields of milk, whatever the nature of the cake used. To get a full measure of the relative effects of the cakes the "condition" of the cows would need to be taken into account.

General Conclusions from Experiments with Dairy Cows.

The foregoing experiments with dairy cows demonstrate clearly that palm-kernel cake is a suitable food for dairy cows, but in no case do they furnish any reliable guidance as to its precise value in comparison with the other foods used. Taken as a whole, the results available show little evidence of any appreciable specific influence of the palm-kernel cake upon the production of milk-fat. On the other hand, they by no means exclude the possibility of such influence being exerted. In order to decide these points the experiments need to be repeated upon a very much larger scale and with a variety of rations.

Where observations have been made on the quality of the butter produced during the feeding of rations containing palm-kernel cake, even up to 7½ lbs. a day, no appreciable detrimental effect has been noted.

Observations on Palatability of Palm-kernel Cake.

Practically all the various experimenters record that palm-kernel cake is at first not greatly relished by cattle and needs to be introduced gradually into the ration. In the Aberdeen experiment (page 31) the difficulty was successfully avoided by an admixture with locust bean meal. In the majority of cases it is reported that although the cattle soon ate the cake freely, they did not do so with the same evident relish as is displayed towards linseed and cotton cakes.

The evidence as to experience with sheep is conflicting. At Wye (page 34) no difficulty was experienced, whereas at Aberystwyth (page 33) the sheep refused to take palm-kernel cake for more than a fortnight.

A German Experiment with Palm-kernel Cake.

The following co-operative experiment was carried out in 1910 at the instance of the German Agricultural Council ("Landwirtschafts-Rat") by nine experimental stations, following a uniform plan. In all, 186 cows of different breeds were included, and about 17,000 samples of milk were analysed. At each centre groups of at least 10 cows each were employed, except in a few cases where a different procedure was adopted involving the use of only one group of 20 cows. In this latter method the experiment was divided into three periods, the feeding being identical in the first and third. The results for these two periods gave a measure of the normal changes due to advance of lactation, which could then be allowed for in considering the results for the second period, in which the palm-kernel cake was used. In all other cases the experiment followed the usual lines of group tests.

The general conclusions are summarised as follows:—

1. Palm-kernel cake and the meal prepared from it, when compared with a mixture of earthnut cake and maize meal supplying the same amounts of digestible nutrients, proved capable of increasing not only the percentage of fat in the milk, but also the total output of fat, without causing, however, any appreciable increase in the yield of milk.

2. This specific effect of the palm-kernel cake was clearly discernible with the great majority of the cows, but varied greatly in amount. In general the cows giving the highest yields of milk showed the

greatest effects. The highest gain in milk-fat amounted per cow per day to 62–64 grammes (= roughly 2 oz.), whilst the lowest was 13–15 grammes (= roughly ½ oz.). The increases in the percentage of fat ranged from 0·16 per cent. to 0·34 per cent.

The effect was usually discernible very shortly after the palm-kernel cake was introduced into the ration, but the maximum effect was usually not attained until from ten to twenty days had elapsed after the change, since the preceding ration exercised an appreciable after-effect upon both the yield and the fat content of the milk.

3. The palm-kernel cake effected appreciable changes in the *character* of the milk-fat, such as would be consistent with the passage of certain constituents of the palm-kernel oil into the milk.

4. Where practical conditions render necessary the purchase of foods rich in carbohydrates, the use of palm-nut cake and meal at the rate of about 4 lbs. per day per 1,000 lb. live weight is to be recommended if the price be suitable.

The large scale upon which these experiments were conducted makes the results worthy of close attention, and a statistical study of the individual records, to which I have not access at present, is highly desirable.

PART III.—*Experiments with Coconut Cake.*

(a) *An Experiment with Fattening Cattle.*

This experiment was carried out in the winter of 1911–12 by Mr. W. Bruce, of the Edinburgh and East of Scotland Agricultural College, with the object of comparing the feeding value of coconut cake, wheat bran, and linseed cake. For the purpose, 42 cattle were divided as equally as possible into six lots, each containing 7 cattle. "The cattle, which were Irish-bred, "were two-year old bullocks, blacks, blue-greys, reds, "and roans, evidently the progeny of good shorthorn and "Aberdeen-Angus bulls mated with ordinary-grade "cows." Lots I., II. and V. consisted of black and blue-grey bullocks, while Lots III., IV. and VI. consisted of red and coloured cattle of shorthorn type. During a preliminary period of 17 days each lot received a basal ration (per head per day) of 90 lbs. turnips, 12 lbs. oat-straw, and 4 lbs. Bombay cotton-cake; in addition, Lots I. and IV. received 2 lbs. linseed cake, Lots II. and III. 2 lbs. coconut cake, and Lots V. and VI. 2 lbs. medium bran. Subsequently, during the experimental period proper, 4 lbs. each of the cakes and bran were fed. The bran alone was increased to 5 lbs. at the end of the second month and to 6 lbs. at the end of the third, or an average allowance of 4¾ lbs. for the four months. After four months' feeding many of the cattle were fat, and equal drafts were made from each lot and sold. The rest were kept on the experimental diets for another month, but the experiment was regarded as completed at the end of the fourth month (112 days). The coconut-cake was steeped in twice its weight of water, and thereby reduced to a soft condition. All the cattle ate it readily in this form except one bullock "which could "not be induced to touch it, although he took his "allowance in the dry form quite readily and turned "out one of the best." "It seems doubtful whether "this precautionary measure of steeping in water is "at all necessary where bullocks are getting plenty "of turnips; indeed, in the circumstances the additional "water may retard productive processes." The animals were weighed at the start and close of the preliminary period, and subsequently at monthly intervals.

The red and coloured cattle of shorthorn type did uniformly better than the blacks and blue-greys.

Comparison with Linseed Cake.

The results obtained with the lots receiving coconut cake and linseed cake respectively are summarised below:—

Average Increase in Live-Weight per Head.

Fattening Period.	Black and Blue-Grey Cattle.		Red and Roan Cattle.	
	Coconut Cake (Lot II.).	Linseed Cake (Lot I.).	Coconut Cake (Lot III.).	Linseed Cake (Lot IV.).
	Lbs.	Lbs.	Lbs.	Lbs.
1st month - - - -	56·1	63·0	69·1	53·1
2nd month - - - -	47·1	55·9	58·3	80·7
3rd month - - - -	43·1	69·4	58·7	73·7
4th month - - - -	50·1	46·3	44·1	62·6
Total (112 days) - - -	196·4±5·9	234·6±10·7	230·3±10·8	270·1±12·9
Difference in favour of linseed cake -	38·2±12·2		39·8±16·8	

Both types of cattle indicate a marked superiority (roughly 20 per cent.) of the linseed cake over the coconut cake, and moreover the probable errors are so relatively low as to indicate a high degree of certainty not only that the recorded differences are to be ascribed definitely to the differences in feeding, but also that results of the same order would be obtained on repeating the experiment.

Judged by chemical composition, assuming average digestibility, and employing the method of assessment used elsewhere in this memorandum (Kellner's starch-equivalent method), it might have been expected that the coconut cake ration would have given slightly better results than the linseed cake ration. The discrepancy between this expectation and the result actually obtained is not easily accounted for, but may possibly be associated with the protein supply. The method of assessment postulates that the protein supply of the ration shall be ample for the needs of the animal. As suggested by Mr. Bruce, the mode of feeding the coconut cake may also have contributed to lower its effectiveness. In order to evaporate completely at the temperature of the body the 8 lbs. of water in which the coconut cake was soaked a quantity of heat would be required equivalent to more than one-third of the energy which the 4 lbs. of coconut cake was capable of yielding to the animal. In actual fact the water would not be completely evaporated, but there are obvious possibilities of appreciable inroads being made in this way upon the nutritive matters of the coconut cake. It may therefore have been no mere chance that the one bullock which received the coconut cake in the dry state "turned out one of the best." It will be safest therefore to interpret the result of the experiment as indicating a superiority of the order of 20 per cent. of linseed cake when fed dry over coconut cake fed wet—in both cases along with a liberal allowance of roots.

From the results of the experiment Mr. Bruce estimates that, with good average linseed cake at 9*l.* per ton, the value of coconut cake is 6*l.* 1*s.* 8*d.* per ton. On the same basis, if linseed cake cost 11*l.* per ton, coconut cake should be worth 7*l.* 7*s.* 9*d.*

The average prices per cwt. realised on the animals sold were 42*s.* 8*d.* for the linseed-cake lot, and 42*s.* 10*d.* for the coconut cake lot. "The returns show at least "that the foods under trial were not inferior to linseed "cake in putting a finish on the cattle." No distinction

could be made in the quality of the beef, which was uniformly high. It is estimated that the coconut-cake feeding was 5*s.* 3*d.* per head less profitable than the linseed-cake feeding.

Comparison with Bran.

The results of the comparison of coconut cake with bran are summarised below:—

Average Increase in Live-Weight per Head.

Fattening Period.	Black and Blue-Grey Cattle.		Red and Roan Cattle.	
	Coconut Cake (Lot II.).	Bran (Lot V.).	Coconut Cake (Lot III.).	Bran (Lot VI.).
	Lbs.	Lbs.	Lbs.	Lbs.
1st month	56·1	69·4	69·1	65·7
2nd month	47·1	50·6	58·3	51·0
3rd month	43·1	52·0	58·7	56·7
4th month	50·1	48·0	44·1	59·7
Total (112 days)	196·4±5·9	220±8·0	230·2±10·8	233·1±6·1
Difference in favour of bran	23·6±9·9		2·8±12·4	

The comparison with the black cattle shows an apparently fairly decisive result in favour of the bran, but the result with the red cattle is quite indecisive. Moreover, the records of the individual cattle in the black cattle groups show abnormalities in the case of the coconut cake group which tend to depress the average increase, since in the third month one animal (No. 6) gained only 5 lbs., whilst in the fourth month another animal (No. 5) showed no gain at all. If the averages for the other animals in the lot be taken as more reliable averages for these months the average per head for the lot for the whole period is raised to 211 lbs., so that the apparent superiority of the bran lot is then brought almost within the region of the probable error. There were no corresponding abnormalities amongst the bran-fed animals during the periods referred to.

On the whole, therefore, we are impelled to the conclusion that whilst the experiment has given presumptive evidence of a slight superiority of 4¾ lbs. bran over 4 lbs. coconut cake, it cannot by itself be regarded as conclusive on the point. It must be recalled also that the coconut cake was fed wet and the bran presumably dry.

From the chemical composition of the two foods it might have been expected that the coconut cake would give appreciably better results than the bran.

The average price per cwt. realised on the bran-fed animals sold was 43*s.* 4*d.*, and it is estimated that the bran-feeding was 6*s.* 5*d.* per head more profitable than the use of coconut cake. No appreciable difference could be detected in either the general appearance of the lots or the quality of the beef.

(b) *Experiments with Dairy Cows.*

Comparison with Linseed Cake.

Midland Experiment (March—April 1911).

Description.

This experiment was carried out at the Midland Agricultural and Dairy College, using two lots of four cows each. At the outset each lot was receiving a daily ration per cow of 56 lbs. mangels, 7 lbs. straw chop, 14 lbs. hay, 2 lbs. mixed meal (bran, sharps, dried grains), and 5 lbs. undecorticated cotton cake. After one week on this ration the cotton cake was replaced for one lot by 4½ lbs. of linseed cake and for the other lot by 5 lbs. of coconut cake. This feeding was continued for fourteen days and then the rations were exchanged. A fortnight later the linseed and coconut cakes were again replaced by 5 lbs. undecorticated cotton cake, so that the initial and final weeks' rations were identical. The rations proved satisfactory in respect of maintenance both of milk-yield and of live-weight. The cows were weighed every fortnight. Composite samples of the milk of each lot were made up at each milking and tested weekly. The results are briefly summarised below:—

Yield of Milk:

All cows two weeks:— Lbs.

1st and 6th weeks on cotton cake = 2,428¾
2nd and 5th weeks on linseed cake = 2,472½
2nd and 5th weeks on coconut cake = 2,429

Live-Weight Increase: Lbs.

Average gain per cow in two weeks on coconut cake = 15·4
Average gain per cow in two weeks on linseed cake = 4·5

Average Percentage of Fat in Milk:

	Average of four Weeks.	
	Morning.	Evening.
Linseed cake	3·76	4·06
Coconut cake	3·70	4·05

The samples of butter were somewhat variable in appearance, texture, and taste, but "if anything, the "coconut cake fed butter was the firmer." A special chemical examination of the butter was made weekly and led to the conclusion that the coconut cake caused an increase in the ingredients which distinguish butter-fat from other fats. This butter also appeared to have better keeping properties than those possessed by linseed-cake butter.

Commentary.

In view of the small number of cows employed, the shortness of the experimental periods, and the rapidity with which the rations were changed, little significance can be attached to the actual numerical differences in milk-yield and composition recorded. In these respects the experiment shews little more than that "both "linseed cake and coconut cake gave satisfactory "results when fed in a mixed ration to dairy cows." The changes in the composition of the *fat* were sufficiently sharply defined to warrant the conclusion drawn with reference to this point.

Comparison with Undecorticated Cotton and Soya Cakes.

Wye Experiment (April–May 1911).

Description.

In this experiment, conducted at the South-Eastern Agricultural College, three cows were fed for two weeks on a normal ration, then for two weeks on a ration containing coconut cake, and finally for two weeks longer on the normal ration. The basal ration was the same for each cow, except for the cake, which

for one cow consisted of 5 lbs. cotton cake, for another 4 lbs. soya cake, and for the third 3 lbs. soya cake and 2 lbs. cotton cake. During the second period the cakes were gradually replaced by coconut cake in amounts increasing from 2 lbs. to 6 lbs. per day. The coconut cake was soaked in twice its weight of water for four or five hours before use.

Commentary.

The data obtained are set out in the report, but it need only be stated that they show no indication of any marked change being caused by the use of coconut cake. The experiment is made up really of three comparisons, using one cow for each. It is obvious that a very great degree of uncertainty must attach to differences noted under such conditions. More reliance may be placed upon the observation that "the butter obtained "was of satisfactory quality, and was distinctly firmer "than that from the normal rations."

Comparison with mixture of Decorticated Cotton Cake and Oats.

Newton Rigg Experiment (Early in 1915).

Description.

This experiment was conducted at the Newton Rigg Farm School, using two lots of three cows each. The rations fed were estimated to supply equal weights of digestible matter at equal cost, and differed only in that one lot received 3½ lbs. decorticated cotton cake and 3½ lbs. crushed oats, whilst the other received 5¼ lbs. coconut cake and 2¼ lbs. crushed oats. The actual comparison was thus that of 5¼ lbs. coconut cake with a mixture of 3½ lbs. decorticated cotton cake and 1¼ lbs. crushed oats. The experiment lasted for twelve weeks, divided into four periods of three weeks each, and the two lots of cows were fed alternately for three-weekly periods on the two rations. A difference in favour of the cotton cake of about 1¼ per cent. in the yield of milk and of 0·1 in the per cent. of fat is recorded. On cotton cake the cows gained 116 lbs., whilst on the coconut cake ration they lost 11 lbs.

Commentary.

In view of the small scale of this experiment it would be unwise to draw general conclusions as to the relative values of the two foods compared. It can only be said that in this case they proved of substantially equal value.

General Conclusions from Experiments with Coconut Cake.

All the experiments have demonstrated the general utility of coconut cake as food for cattle. The Edinburgh experiment alone has yielded a conclusive result as to the merits of coconut cake relative to the food with which it was compared. This experiment showed that, when used in soaked condition, as is commonly recommended, coconut cake was decidedly inferior to linseed cake. The results of a similar comparison with bran showed a difference in favour of the bran, but the degree of uncertainty attached to this difference is such as to necessitate further experiments before a definite conclusion can be formulated. When fed to dairy cows coconut cake has been found to give substantially the same results in yield and quality of milk as decorticated cotton cake and linseed cake, but in no case has the experiment been on a sufficiently large scale to warrant the conclusion that this experience is what may be commonly expected.

In all cases where observations have been made it is reported that the coconut cake had a beneficial effect upon the texture of the butter.

PART IV.—*Experiments with Earth Nut Cake.*

(a) *Experiments with Fattening Cattle.*

Comparison with Bean Meal.

Woburn Experiment (Winter 1891–92).

The experiment was conducted at the Royal Agricultural Society's Experimental Farm at Woburn, under the supervision of Dr. J. A. Voelcker. One lot of six Hereford bullocks was fed on a ration (per head per day) of 45 lbs. of roots, 15 lbs. of clover-hay chaff and a mixture in equal proportions of beans, oats, and barley—the allowance of the mixture being raised gradually from 6 lbs. to 12 lbs. A second lot of four Hereford bullocks was fed in precisely similar fashion, except that the bean meal was replaced by an equal amount of earthnut cake. The cake used contained 47·44 per cent. of protein, and 8·47 per cent. of oil; "it was also free from rancidity, but was, however, slightly acid." It contained 2·62 per cent. of sand The feeding was continued for 107 days, this being divided into three separate portions of 52 days, 31 days, and 24 days, at the end of each of which the live-weights of the bullocks were taken, "The bullocks "did perfectly well on the cake, and there was no "difficulty whatever in getting them to eat it, nor any "harm from its somewhat acid character."

The average gains in live-weight per head for the whole period were as follows:—

	Lbs.	Lbs.
On bean ration - - - -	214·8	±16·9
On earthnut cake ration - -	235·2	±14·9
Difference in favour of earthnut cake - - - - - -	20·4	±22·5

Dr. Voelcker concludes that the earthnut cake "proved to be a useful feeding material for cattle, and "to have a feeding value just about equal to that of "beans." The former part of this conclusion cannot be disputed, but in view of the large "probable error" with which the indicated difference between the lots is affected, the experiment cannot be regarded as proving the relative feeding values of the two foods.

Comparison with Linseed Cake.

Woburn Experiment (Winter 1891–92).

This comparison was obtained, simultaneously with the one just described, by means of a third lot of six Hereford bullocks which received the same rations, except that linseed cake was substituted for the earthnut cake (or bean-oat-barley mixture.) In all other respects the treatment and procedure were exactly as described in the foregoing section. The average gains in live-weight per head for the whole period were as follows:—

	Lbs.	Lbs.
Earthnut cake ration - -	235·2	±14·9
Linseed cake ration - - -	216·7	±13·1
Difference in favour of earthnut cake - - - - - -	18·5	±19·8

Here again the "probable error" is so large in proportion to the difference between the two lots that no conclusion as to the relative merits of the two foods can safely be drawn.

Comparison with Decorticated Cotton Cake.

Cockle Park Experiment (Winter 1904–5).

This experiment was carried out with two lots each of four cattle which had been bred and reared at Cockle Park by the Galloway cows in the summer of 1904, and had been weaned only a few weeks before the experiments commenced. Each lot consisted of three bullocks and one heifer, two of the animals being shorthorns and two blue-greys. For the first month, which was regarded as preliminary, lot I. received daily per head 28 lbs. turnips, 7½ lbs. meadow hay, and 2¼ lbs. of a mixture of one-third maize meal and two-thirds decorticated cotton cake, whilst lot II. received a similar ration except that earthnut cake was used instead of the cotton cake. For the five succeeding months the average rations were:— 26½ lbs. swedes, 8½ lbs. meadow hay, and 4½ lbs. of the cake and maize mixture (*i.e.*, 3 lbs. cake + 1½ lbs. maize). The cotton cake contained 52·1 per cent. of protein, whilst the earthnut cake contained 48·5 per cent. It is noteworthy also that the latter contained 2·35 per cent. of sand, whereas the cotton cake contained only 0·1 per cent. The average live-weight gains per head for the

whole experimental period of five months were as follows:—

	Lbs.
Lot I. (Decorticated cotton cake) -	290
Lot II. (Earthnut cake) - - -	212
Difference in favour of cotton cake -	78

Taken as it stands, this difference implies that the cotton cake ration was practically 40 per cent. superior to the earthnut cake ration. It is difficult to accept this as even approximately correct. The records of the individual animals are not given in the report, so that it is impossible to assess the degree of reliability of the experimental result. The average increases for each month which are given in the report suggest, however, that it must have been fairly high, since in two of the five months the difference between the two lots is actually slightly in favour of the earthnut cake. In his report upon the experiment Professor Gilchrist suggests that the striking difference between the results given by the two cakes may have been due partly to the higher protein-content of the cotton cake and partly to the relatively large amount of sand present in the earthnut cake. The latter may indeed have been very detrimental to the young animals used in this experiment, but it may be recalled that the older animals used in the Woburn experiment consumed without apparent detriment a cake containing even more sand. Further experiments with materials that are beyond reproach in this respect are obviously required before any generalisations can be made as to the relative merits of the two cakes.

(b) *Experiment with Dairy Cows.*

Comparison with Decorticated Cotton Cake.

Newton Rigg Experiment (Feb.–May 1905).

For the purpose of this experiment four cows in full milk were selected, and were under trial for twelve weeks. For the first three and last three weeks decorticated cotton cake (4 lbs.) was fed along with 42 lbs. swedes (or 35 lbs. mangels), hay (two fodderings), straw (one foddering) and 4 lbs. crushed oats—these being the daily allowances per cow. During the middle six weeks earthnut cake (4 lbs.) was substituted for the cotton cake. The results were as follows:—

—	Milk-yield.	Fat.
	Gallons.	%
First three weeks (cotton cake) -	242	3·2
Middle six weeks (earthnut cake) -	432	3·4
Last three weeks (cotton cake) -	179	3·7
Total milk-yield for cotton cake periods (six weeks).	421	—
Average fat per cent. for cotton cake periods (six weeks).	—	3·45

The cows increased in weight at a uniform rate during the first nine weeks, but fell off considerably during the last three weeks, possibly owing to the substitution of mangels for swedes at the end of six weeks.

It is claimed that "the results show that earthnut "cake, when of good quality, is a good food for milch "cows, and has for this purpose a value not far short "of decorticated cotton cake." The latter generalisation can hardly be accepted on the evidence of only four cows.

From the report it would appear that the earthnut cake used was part of the same consignment as was used for the Cockle Park experiment, and, if so, the results form an interesting contrast.

General Conclusions from Experiments with Earthnut Cake.

Experiments with earthnut cake have been few and on a relatively small scale. Little in the way of definite conclusions of general applicability can be drawn from them, therefore, beyond the broad fact that earthnut cake has proved acceptable to stock, and has, in the main, given reasonably good results.

In his report on the Woburn experiment Dr. Voelcker states as an objection to its use that "it is very liable to turn rancid and become sour." In none of the tests, however, did trouble arise from this cause.

Note on the Assessment of the Relative Values of Feeding-Stuffs from their Chemical Composition, with special reference to Palm-kernel Cake, Coconut Cake, and Earthnut Cake.

In considering the question of the relative values of different foods it is necessary to maintain a clear distinction between the relative values to the animal (or physiological values) and the relative values to the farmer (or money values). The two are by no means necessarily the same.

(a) *Relative Values to the Animal.*

These can only be determined with certainty by means of practical feeding experiments. It will be clear from the summary of such experiments in the preceding pages of this memorandum that to secure reliable average results on these lines is no simple matter. It requires repeated experiments with large numbers of animals and a variety of rations. The most extensive investigations of this kind have been made in Denmark with dairy cows and pigs and have led to the formulation of tables setting out the relative feeding values of the common farm foods, when used for these two classes of stock. For pig-feeding no discrimination is made in the tables between different oil-cakes, all being included in the highest class, equal in feeding-value to barley, maize, or wheat. For dairy cows, earthnut cake heads the list along with decorticated cotton cake, whilst palm-nut cake (or meal) is represented as having a 25 per cent. lower feeding value, and is classed with maize, wheat, barley, and the dry matter of "roots." Coconut cake is not included in the table, but is presumably classed as equal to palm-kernel cake.

Such average values are useful for general feeding practice, but leave unsolved the problem as to how the farmer is to discriminate between different brands of a particular food offered to him at different prices. The most obvious starting point in any effort to obtain guidance on this point is obviously to take into account the chemical composition of the materials, and repeated efforts have been made by agricultural chemists to base thereon a reliable method for assessing relative feeding values.

It is commonly assumed that the feeding-value of a sound, wholesome, and palatable foodstuff will be determined by its content of *digestible* protein, oil, and carbohydrate (including digestible fibre). By scientific experiments of a much higher order of accuracy than the ordinary type of feeding experiments the late Dr. Kellner arrived at the conclusion that for the purpose of fattening oxen the relative values of the above-mentioned food-constituents, taking digestible carbohydrates = 100, *under ideal conditions* were as follows:—

Digestible carbohydrates (starch) -	100
Digestible fibre - - -	100
Digestible oil - - -	241
Digestible protein - - -	95

Using these relative values, and assuming ideal conditions, we can then express the value for fattening purposes of 100 parts of a given foodstuff in the following way:—

"Carbohydrate-Equivalent" (or *Starch Value*) of 100 parts of the foodstuff = [Dig. Protein × ·95) + (Dig. Oil × 2·41) + Dig. Carbohydrates + Dig. Fibre].

By scientific experiments similar to those by which the above relative values were arrived at, and using a variety of oil-cakes, Kellner found that in a few cases, including palm-kernel cake and coconut cake, the

values obtained agreed exactly with those calculated from the composition by the above expression. In most cases, however, the results obtained by actual experiment were slightly *below* those arrived at by calculation. Thus for earthnut cake the calculated result was 2 per cent too high, and for decorticated cotton cake or linseed cake 3 per cent. too high. In other cases the discrepancy was much greater, amounting, for example, to 16 per cent. in the case of undecorticated cotton cake. Expressed in different fashion, on the basis of these experiments we may say that whilst the digestible constituents of palm-kernel cake and coconut cake are fully "available," those of earthnut cake have an "availability" of 98 per cent., of linseed or decorticated cotton cake 97 per cent., and of undecorticated cotton-cake 84 per cent. These "availabilities" represent therefore the corrections which must be applied to the "ideal starch values" given by the above expression, in order to arrive at the actual starch values. Assuming that this method of computing feeding values rests upon a sound basis—and, although it is far from being fully adequate in this respect, I know of no other method that can claim to be based upon more numerous or more reliable data—it is of interest to examine the conclusions to which it leads as to the relative values for fattening cattle of the common oil-cake foods, including the three which form the subject of the present memorandum. For this purpose the average composition (total and digestible) of the oil-cakes may be taken as follows:—

	Palm-kernel Cake.	Coconut Cake.	Earthnut Cake.	Linseed Cake.	Decorticated Cotton-cake.	Undecorticated Cotton-cake.
	Total Percentages.					
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Protein	19	20	46	30	41	22
Oil	6	10	10	10	9	5½
Carbohydrates	46	42	26	35	26	34
Fibre	13	11	3	8	8	20
	Digestible Percentages.					
Protein	16	15½	40	25	34	15½
Oil	5½	9½	9½	9½	8½	5½
Carbohydrates + fibre	47	42	22	33	20	20

Using these data for the percentages of digestible nutrients in each case, and the "percentage availabilities" as given above, the "starch-values" per 100 lb. cake (*i.e.*, weights of starch equivalent for fattening purposes to 100 lb. of the cake) work out as follows:—

	Starch Values per 100 lb. Cake.	Weight of Cake equivalent to 1 lb. of Earthnut Cake.
	Lb.	Lb.
Palm-kernel cake	75	1·08
Coconut cake	79	1·03
Earthnut cake	81	1·00
Linseed cake	77	1·05
Decorticated cotton cake	71	1·14
Undecorticated cotton-cake	40	2·02

This method of assessment thus leads to the conclusion that, with cakes of the composition and digestibility set out above, the earthnut cake should have the highest fattening value, followed closely by coconut cake and linseed cake, then palm-kernel cake, barely 10 per cent. inferior, decorticated cotton cake 14 per cent. inferior, and, lastly, undecorticated cotton cake with barely half the value.

The method is based entirely upon experiments with fattening oxen, and hence, strictly speaking, the results should be regarded as holding good only for the use of the cakes for fattening cattle.

Kellner claims, however, that they may be applied to the case of fattening sheep or pigs, to the feeding of dairy cows, or to the feeding of working horses.

There is good reason to believe, however, that for the feeding of dairy cows the relative value of protein is appreciably higher than for fattening cattle. On the basis of the very extensive data accumulated by the Swedish milk control societies, Hansson claims that for milk-production the results obtained by the starch-value method of assessment agree much more closely with practical experience if the relative value of protein be taken as 1·4 (starch = 1) instead of ·95 as taken by Kellner.

With this amendment, the relative values for milk production prove to be:—

	Starch Values per 100 lb. Cake.	Weight of Cake equivalent to 1 lb. of Earthnut Cake.
	Lb.	Lb.
Palm-kernel cake	83	1·19
Coconut cake	87	1·14
Earthnut cake	99	1·00
Linseed cake	88	1·13
Decorticated cotton cake	86	1·15
Undecorticated cotton-cake	46	2·15

It will be observed that the order of merit is substantially the same, but that the relative superiority of the earthnut cake is increased, except with reference to the decorticated cotton cake.

It was noted above that Kellner found in the case of palm-kernel cake and coconut cake that the digestible nutrients were fully "available," and that hence the "ideal starch value" needed no correction. This is difficult to accept, in view of the relatively large proportions of fibre in these cakes, and it is possible, therefore, that the merits of these two cakes have been over-valued, perhaps by 3 or 4 per cent., in the above calculation. In any case too much stress should not be laid upon the precise numerical result of the calculation. The starch-values have been given above to the nearest unit, and the estimates may be even lower than that approximation suggests. It may, for instance, be undesirable to conclude more than that the palm-kernel and coconut cakes are of substantially equal value, and inferior to earthnut cake for milk-production, but equal to it for fattening. The necessary data for gauging the degree of reliability of the method have not yet been accumulated.

It must be borne in mind further that the realisation of the values deduced by the starch-value method, presupposes that the foods in question are used as part of a ration that is satisfactory in every way, but especially in its supply of digestible protein, for the purpose for which it is intended. If there be any deficiency of protein in the full ration, the foods rich in protein will be relatively more valuable than the starch-value assessment would suggest.

Finally, it must be borne in mind also that the values obtained in this way represent feeding values and not money values.

(b) *Relative Money Values of Foods.*

The statement has already been made that the prices which it is worth while for the farmer to pay for two different foodstuffs are not necessarily closely proportional to their relative values to the animal.

The feeding value is, of course, the dominant factor in the calculation of what is a fair price to pay for one food in comparison with the cost of other foods, but there are at least two other factors which introduce complications into the estimate. These are:—

(1) The special need of the farmer for supplies of digestible protein, rather than oil or carbohydrates.

(2) The diverse manurial values of different foods.

The Special Need for Protein.

It is an axiom of the science of nutrition that every animal must receive in its food a certain amount of protein, the necessary minimum varying according to the individuality and kind of animal, and the particular purpose for which it is being fed. It may be able to utilise profitably more than this minimum amount of protein, but the minimum at least it must have. The further requirements of the animal can be adequately covered by supplies of oil and carbohydrates, or probably—except for a very low minimum amount of oil—by carbohydrates alone. The liberal use of these food-ingredients can reduce the minimum requirement for protein to a certain extent, but never entirely.

For reasons mainly associated with the climate the crops grown in the United Kingdom are mainly relatively poor in protein and rich in carbohydrates. The most highly nitrogenous crops grown here (beans and peas) contain (in the seed) usually not more than 20 to 25 per cent. of protein—a proportion which is regarded as only moderate for foods of the class of seeds. Further, in the case of crops sold off the farm it is usually the part richer in protein that is sold (*e.g.*, grain). The consequence usually is that in the stock of feeding-material that is left for use on the farm, there is a relative deficiency of protein, which can only be remedied by purchasing foodstuffs relatively rich in protein, if wasteful use of the home-grown supplies is to be avoided.

The home-grown crops supply also only relatively canty amounts of oil; but, as mentioned above, this is not as fundamentally serious as a shortage of carbohydrates.

Obviously then it is a shortage of protein in his home supplies that, consciously or unconsciously, brings the farmer to the market as a purchaser of feeding-stuffs. He has no option in the matter if he is to make the utmost of his home supplies and hence may be justified in paying for it at a higher rate than would be warranted if there were no element of compulsion about the purchase.

It must be admitted that many farmers—perhaps the majority—do not regulate their purchases consciously by such considerations, but they nevertheless represent the facts of the case, and must be taken into account by the agricultural expert in giving advice on prices.

According to the investigations referred to in the preceding section, once the minimum requirements of the fattening animal for protein have been satisfied, any additional protein given to it produces an effect barely equal to that of an equal weight of digestible carbohydrate. Below the protein-minimum, however, there can be no comparison between the two, since a further supply of protein is then absolutely essential, and carbohydrate cannot take its place.

In the present state of knowledge it is quite impossible to furnish precise guidance as to the amount which the farmer is justified in paying for protein over and beyond the price which a consideration of relative feeding values alone would suggest as fair in comparison with the cost of an equivalent amount of carbohydrates in the market. The matter can only be left to individual judgment based upon available supplies of home-grown foods, prices of produce, and other considerations. Generally speaking, however, in choosing between foods of apparently equal cheapness as judged by feeding value, preference should be given to the one richer in protein.

The case of oil is simpler to deal with since no element of compulsion enters into the purchase here. There can be no doubt that, within the narrow limits within which it can be satisfactorily used, the feeding-value of oil is practically 2½ times that of carbohydrates, and this factor can be used in estimations of money values of foods. It is true that many practical feeders hold that for certain purposes oil produces effects which cannot be attained with carbohydrates, but the results of physiological investigations afford little support for this belief, and it must be left to the individual to determine what extra cost, beyond that which the above proportion would indicate, he is prepared to give in order to secure oil rather than carbohydrate.

The Manurial Values of Foods.

In purchasing foods an important factor affecting the price which may reasonably be paid is the fact that manurial residues (both solid and liquid) of appreciable value will be left on the farm as a consequence of the consumption of the foods by stock. It is known that the value of these residues is not the same for all foods, and hence this must be taken into account in assessing the values of foods. Generally speaking, the value of the manurial residues will be greater, the richer the food is in nitrogenous matter (protein), so that another reason is furnished thereby for paying more liberally for protein in foods than relative feeding-values alone would warrant.

In one method of assessing the relative money-values of foods, which is widely used in this country, the allowance for manurial values is dealt with in this way (*i.e.*, by putting an increased value upon the protein) (*see* next section). If a more precise discrimination is desired, allowance must be made not only for differences in nitrogen-content between different foods, but also for differences with respect to the other constituents of manurial value, viz., phosphates and potash. The full allowance for manurial values, taking all ingredients into account, and allowing for waste at the farm and other considerations, can be deduced from tables drawn up by Hall and Voelcker in 1902 and revised in 1913. These tables are being increasingly adopted by valuers as the basis of their allowances on the expiration of a tenancy for the unexhausted manurial values of purchased foods consumed on the farm.

Methods of Assessing Money Values of Foods.

Various methods of assessing the money values of foods have been suggested from time to time, and there is consequently considerable diversity of practice. All the methods, however, are based upon the same principle, in that they start with the composition of the food with respect to protein, oil, and carbohydrates. The difference between the methods lies essentially in the relative values placed upon these three ingredients. If an estimate of the absolute value of a particular food-stuff is required, a price must be placed on one or other of the three ingredients, usually the carbohydrate. This must be done more or less arbitrarily since it is impossible to say precisely what is the exact value of a pound of, say, carbohydrates as met with in cattle foods. In practice it is usually sufficient to make an estimate of the relative money value in comparison with some widely used food which stands at a price which is commonly regarded as reasonable. Two methods of making such an estimate are described below.

(a) *Old Method.*

The first method, which may be described as the old and still most frequently used method, is based upon the assumption that digestible protein and digestible oil are of equal money value, and each worth 2½ times as much as digestible carbohydrates. Hence

an expression for the value of the food in terms of carbohydrate value is obtained from the composition (digestible) as follows:—

"Carbohydrate Value" = (Digest. Protein + Digest. Oil) × 2½ + Dig. Carbohydrates.

The total thus obtained is commonly referred to as the "food units," and on dividing into the price per ton of the food, the cost per "unit" is obtained. This may then be compared with the cost of a "unit" in other foods, as arrived at in the same way from composition, digestibility, and market price.

In this method the high value placed upon the protein in ranking it equal with oil, is supposed to include due allowance for manurial value and any other consideration that tends to increase the relative value of protein. The allowance is purely arbitrary, however, and it is difficult to say why the protein should be placed exactly on the same footing as the oil. For this reason the method must be regarded as empirical, and chiefly recommended by the fact that in the main it leads to conclusions which the practical man has usually little difficulty in accepting. The opinions given in my evidence before the Committee were based upon assessments made by this method, adopted at the time solely as being the commonly-used method.

New Method.

The nett cost of a food to the farmer is arrived at by deducting the manurial value per ton from the gross cost per ton. Thus, although the farmer may pay 11*l.* per ton for linseed cake, the real cost to him is only about 9*l.* 4*s.* per ton, since he obtains by consumption of the ton of cake manurial residues valued at about 36*s.*

If now this nett cost be divided by the "starch-value" of the food as assessed by the method outlined earlier in this Appendix, the cost of one "starch-value unit" is obtained. In similar fashion the cost per "starch-value unit" of other foods may be arrived at, and we thus obtain the costs in each food of quantities estimated to be of equal nutritive value. If one food be taken as standard, its cost per "starch-value unit" can be taken as the standard by which the "fair price" for other foods can be assessed as follows:—

"Fair Price" per ton of Food = (Starch Value of Food × Standard Cost per Starch Value Unit) + Manurial Value of Food.

The method may be illustrated by taking the foods whose composition and starch-value were given earlier in this Appendix (p. 41). If linseed cake at 11*l.* per ton be taken as our standard, the "standard cost per starch-value unit" is arrived at as follows:—

	£	s.	d.
Gross cost of linseed cake per ton	11	0	0
Manurial value	1	16	0
Net cost	9	4	0

Starch value (for fattening), per cent. - 77

Cost per starch-value unit (for fattening) $= \frac{9l.\ 4s.}{77} = 28{\cdot}7d.$

The corresponding cost, if the cake be used for milk production, is $\frac{9l.\ 4s.}{88}$, or 25·1*d.*

The estimated "fair price" per ton for, say, palm kernel cake, as compared with linseed cake at 11*l.* per ton, is now obtainable, as follows:—

For Fattening:

Starch value = 75.
Estimated "fair net cost" = 75 × 28·7*d.*
= 8*l.* 19*s.* 4*d.*
Add manurial value = 22*s.*
Estimated "fair price" = 8*l.* 19*s.* 4*d.* + 1*l.* 2*s.*
= 10*l.* 1*s.* 4*d.*

For milk production, the price of 9*l.* 15*s.* 7*d.* is arrived at. Proceeding on the same lines, the following results (to nearest shilling) are obtained for the "fair price" of the different cakes when linseed cake stands at 11*l.* per ton:—

	"Fair Price" per Ton.					
	For Fattening Purposes.			For Milk Production.		
	£	s.	d.	£	s.	d.
Palm-kernel cake	10	1	0	9	16	0
Coconut cake	10	18	4	10	11	0
Earthnut cake	12	8	0	13	1	0
Decorticated cotton cake	11	3	0	11	13	0
Undecorticated „ „	6	8	0	6	8	0

These figures throughout are appreciably higher than those arrived at by the old method. For palm-kernel cake and coconut cake they are probably 5 to 10 per cent. too high, owing to the starch-values used for these foods being uncorrected for "availability." In all cases it must be remembered that the estimates are largely theoretical, and represent simply the best that can be done in the existing state of knowledge.

CHARLES CROWTHER.

The University, Leeds,
December 4th, 1915.

Appendix C.

Statement showing, according to the latest information available in the Commercial Intelligence Branch of the Board of Trade, the duty leviable on Vegetable Oils, Margarine, and Oilcake in the undermentioned countries.

FRANCE.

Linseed oil	6 frs. per 100 kgs. (2*s.* 5½*d.* per cwt.).
Cotton seed and sesame and groundnut oils intended for the manufacture of soap or alimentary fats (under certain conditions).	6 frs. per 100 kgs. (2*s.* 5½*d.* per cwt.).
Other cotton seed, groundnut, and sesame oil	12 frs. per 100 kgs. (4*s.* 10½*d.* per cwt.)
Rape seed oil	15 frs. per 100 kgs. (6*s.* 1½*d.* per cwt.).
Soya and maize oil intended for the manufacture of soap (under certain conditions)	6 frs. per 100 kgs. (2*s.* 5½*d.* per cwt.).
Soya and maize oil, other	16 frs. per 100 kgs. (6*s.* 1½*d.* per cwt.).

Olive oil:	
Intended for manufacture of soap (under certain conditions)	3 frs. per 100 kgs. (1s. 2¾d. per cwt.).
Other	10 frs. per 100 kgs. (4s. 0¾d. per cwt.).
Palm oil, coconut, toulouconna, illipé and palmetto (*palmiste*) oils	1 fr. per 100 kgs. (4¾d. per cwt.).
Castor and pulghera oils	5 frs. per 100 kgs. (2s. 0½d. per cwt.).
Fixed oils, pure, not specially mentioned	15 frs. per 100 kgs. (6s. 1¼d. per cwt.).
Oilcake, containing:	
Less than 12 per cent. of oil	Free.
From 12 up to 16 per cent. of oil	75 centimes per 100 kgs (6s. 1¼d. per ton).
More than 16 per cent. of oil	1·50 frs. per 100 kgs. (12s. 2½d. per ton).
Margarine	25 frs. per 100 kgs. (10s. 2d. per cwt.).
Alimentary vegetable fats	25 frs. per 100 kgs. (10s. 2d. per cwt.).

GERMANY.

Fatty oils:—	
(*a*) In casks:—	
Colza and rape seed oils	12 marks per 100 kgs. (6s. per cwt.).
Linseed oil	4 marks per 100 kgs. (2s. per cwt.).
Beechnut, earthnut, poppy seed, niger, sesame, and sunflower oils	10 marks per 100 kgs. (5s. per cwt.).
Olive oil, pure	Free.
Cotton seed oil	12.50 marks per 100 kgs. (6s. 3d. per cwt.).
Castor, cotton seed, and sesame oils, officially denatured	2 marks per 100 kgs. (1s. per cwt.).
Wood oil	4 marks per 100 kgs. (2s. per cwt.).
Castor oil	2 marks per 100 kgs. (1s. per cwt.).
Fatty oils, not specially mentioned	9 marks per 100 kgs. (4s. 6d. per cwt.).
Fatty oils, not specially mentioned, officially denatured	4 marks per 100 kgs. (2s. per cwt.).
(*b*) In other receptacles:—	
Pure olive oil	10 marks per 100 kgs. (5s. per cwt.).
Cotton seed, beechnut, earthnut, poppy seed, and other fatty oils not enumerated, including castor oil not specified below.	20 marks per 100 kgs. (10s. per cwt.).
Castor oil in tins, weighing, with the tin, at least 15 kgs.	2 marks per 100 kgs. (1s. per cwt.).
Cocoa butter (cocoa oil)	35 marks per 100 kgs. (17s. 6d. per cwt.).
Cotton stearine oil	12.50 marks per 100 kgs. (6s. 3d. per cwt.).
The same, for manufacture of soap or candles, under conditions and officially denatured.	5 marks per 100 kgs. (2s. 6d. per cwt.).
Palm oil, palmnut oil, coconut oil, and other vegetable greases such as shea-butter, unfit for consumption.	2 marks per 100 kgs. (1s. per cwt.).
Residuum, solid, from the manufacture of fatty oils, whether ground or in the form of cakes (oil cake) or not.	Free.
Margarine (preparations similar to butter or to butter fat, the fatty contents of which are not exclusively derived from milk).	20 marks per 100 kgs. (10s. per cwt.).

BELGIUM.

Seed oils and vegetable oils	Free.
Oil cake	Free.
Margarine	20 frs. per 100 kgs. (8s. 1½d. per cwt.).

DENMARK.

Hempseed oil	Free.
Rape seed oil and linseed oil	7 öre per kilog. (3s. 11½d. per cwt.).
All other seed and vegetable oils	5 öre per kilog. (2s. 9¾d. per cwt.).
(Vegetable oil for use as food enters duty-free as "Edible goods" when it is of the consistency of ordinary fat, and imported in packages of not more than 1 kilog. each for retail sale.)	
Oil cake and oil-cake meal	Free.
Margarine	Free.

NETHERLANDS.

Coconut oil, palm oil	Free.
Linseed, hemp seed, cotton seed, rape seed, and other seed oils and vegetable oils	55 cents per 100 kgs. (5½*d.* per cwt.).
Oil cake, viz.: groundnut, hemp, poppy, rape, and linseed, also linseed meal cake	Free.
Margarine	Free.
Castor oil (required as an auxiliary in factories and workshops)	Free.

RUSSIA.

Vegetable oils and glycerine, unrefined:	
(1) Fatty oils (olive, laurel, cotton seed, &c.), not specially mentioned, boiled oil, siccative oil ("Olifa").	3·10 roubles per poud (1*l.* 0*s.* 5*d.* per cwt.).
(2) Castor oil	4·36 roubles per poud (1*l.* 8*s.* 8½*d.* per cwt.).
(3) Coconut and palm oils	1·815 roubles per poud (11*s.* 11*d.* per cwt.).
(4) Glycerine, unrefined	1·65 roubles per poud (10*s.* 10*d.* per cwt.).
Margarine products	Prohibited.
Specially prepared cattle foods	19⅛ copecks per poud (1*l.* 6*s.* per cwt.).
Cattle feed, consisting of waste or by-products from factories	Free.

SWEDEN.

Linseed oil:—	
Raw (also linseed oil acid)	7 öre per kilog. (3*s.* 11½*d.* per cwt.).
Boiled, including bleached linseed oil and so-called "Standolja" (boiled linseed oil for making printing inks).	10 öre per kilog. (5*s.* 7¾*d.* per cwt.).
Turnip and rape seed oils	7 öre per kilog. (3*s.* 11½*d.* per cwt.).
Olive oil, groundnut oil, sesame oil and cotton seed oil:—	
In casks of any size	Free.
In other vessels (including the weight of the vessel)	5 öre per kilog. (2*s.* 9¾*d.* per cwt.).
Other vegetable fatty oils (including castor oil, hemp oil, maize oil, soya bean oil)	Free.
Margarine	15 öre per kilog. (8*s.* 5¾*d.* per cwt.).
Oil cakes, cakes made of compressed maize meal	Free.
Vegetable fats, such as palm oil, palm-nut oil, coconut oil, and other vegetable fatty substances, which under ordinary temperature do not as a rule assume liquid form.	Free.

NORWAY.

Olive oil	1 öre per kilog. (6¾*d.* per cwt.).
Rape seed and hemp seed oil, unboiled linseed oil, cotton seed oil, palm oil, coconut oil, maize oil, and other similar oils.	4 öre per kilog. (2*s.* 3*d.* per cwt.).
Boiled linseed oil	6 öre per kilog. (3*s.* 4½*d.* per cwt.).
Margarine	15 öre per kilog. (8*s.* 5¾*d.* per cwt.).
Oilcake and oilcake meal	Free.

Appendix D.

MEMORANDUM BY MR. G. A. MOORE AS TO THE OUTWARD FREIGHT OBTAINABLE BY STEAMERS CARRYING PALM-KERNELS FROM THE WEST COAST OF AFRICA TO HAMBURG.

After a careful and exhaustive examination of all the circumstances the Committee have made a recommendation which it is hoped will have the desired effect of transferring the palm-kernel trade from Germany to the United Kingdom.

As a means of adding to this effect it is suggested that steps should be taken with a view to curtailing the outward cargo available from the Continent to West Africa, return freights being an important factor in determining the destination of shipping.

It is well known that this outward cargo consists almost exclusively of cased spirits, which are already subject to a high rate of duty in the West African Colonies.

These spirits are shipped from the Continent on account of their low price and this is due to several causes:—

(1) The restrictions placed upon the manufacture of alcohol in this country by the Excise authorities.
(2) The absence of modern and economical plant for the manufacture.
(3) The extra cost of bottles and cases if made here.

The first two reasons are to a large extent removable and one object of this memorandum is to call attention to that fact.

The step which, in the opinion of the undersigned, should be taken to direct this trade to the United Kingdom, is merely that, when the Colonial Authorities see fit to make a further increase in the rate of duty on spirits imported into the Crown Colonies of West Africa, such an increase should apply only to those shipped from the Continent or other country than the United Kingdom.

The various Governments of our West African Colonies have steadily raised the rate of duty on imported spirits as they were able to do so without causing the natives to turn to the production of fermented drinks, a result which would be disastrous to the future of these territories. It is therefore suggested that the next *increase* should be made the occasion for the introduction of a differential tariff.

The advantages to be derived from such a diversion are numerous; they include:—

(1) The erection of up-to-date distilleries.
(2) The production of cheap industrial alcohol and the stimulation of the numerous manufactures dependent thereon.
(3) The introduction of a large bottle- and case-making industry.

This suggestion has been unanimously approved by the Committee of the West African Section of the Liverpool Chamber of Commerce.

G. A. MOORE.

The SECRETARY OF STATE to the GOVERNOR-GENERAL OF NIGERIA and the GOVERNORS OF SIERRA LEONE and the GOLD COAST.*

Downing Street,
1st June 1916.

SIR,

IN my telegram of the 22nd of July 1915 I informed you that I had appointed a Departmental Committee to consider the position of the West African trade in palm kernels and other edible and oil-producing nuts and seeds, and to make recommendations for the promotion in the United Kingdom of the industries dependent thereon. I now have the honour to transmit to you copies of the Report which has been presented by the Committee as a result of their deliberations.

2. The Committee's recommendations are four in number: the imposition for a period of years of an export duty on palm kernels, to be remitted if the kernels are brought to the United Kingdom and crushed there; the popularisation of palm kernel cake as a feeding stuff for cattle and other live-stock; the amendment of the Food and Drugs Act so as to allow the addition of the words "British-made" to the word "margarine" on the statutory wrapper; and the further investigation of the properties and cultivation of the oil palm in the Colonies.

3. I have considered carefully the report which the Committee have presented and I see no reason why their proposals should not be adopted forthwith. Of their four recommendations, the first and last alone call for action on the part of your Government, and as regards the investigation into the properties of the oil palm you will no doubt direct the Agricultural and Forestry Departments of your Government to continue, and to pay increased attention to, this particular branch of their work. It appears to be clear that more information is desirable as to the palm tree and the most advantageous methods of working it commercially, and, in view of the great importance of the industry, you will, I am sure, cause the necessary action to be taken.

4. As you will observe from the opening paragraphs of their report, the Committee concentrated their attention upon the trade in palm kernels and did not think

* The Governor of the Gambia has been sent a copy of this despatch and requested to take similar action.

it necessary to make any recommendations concerning the other oil-producing nuts and seeds from West Africa. It is not necessary here for me to recapitulate the facts as to the palm kernel trade, which are set forth exhaustively in the Committee's report. It is enough to observe that, for a variety of reasons, the trade in this important article of commerce was, at the outbreak of the present War, almost entirely controlled by enemy merchants and seed crushers, and that British firms were not in a position to deal satisfactorily with the annual crop.

5. You will, I have no doubt, agree with me that such a state of affairs ought not to be allowed to occur again, and that any practicable measures should be taken to keep this trade in the hands of British seed-crushers. To this end, I consider that the Committee's recommendation of an export duty, to be fixed provisionally at 2*l.* per ton of palm kernels and to be remitted on production of proof that the kernels have been delivered to, and crushed by, a seed crusher in the United Kingdom or any part of the British Empire, is a practicable proposal which should be adopted.

6. It will therefore be necessary to introduce legislation in the West African Colonies to impose such an export duty upon palm kernels and to provide for its remittance when proof is produced of the crushing of the kernels in this country, or in some other British possession, and I should be glad to have an expression of your views as to the manner in which the necessary legislation should be framed so as to cause the least trouble to the merchants dealing in palm kernels, and, at the same time, to ensure that kernels shipped to foreign destinations do not escape payment of the duty. You will realise that uniformity is desirable, and I think it best that I be afforded an opportunity of considering your proposed legislation in draft form.

7. In this connection, I would draw special attention to the Committee's suggestion that a system be introduced whereby the exporter will give a bond for the amount of the duty, such bond to be cancelled on production of the necessary certificate from a seed-crusher within a specified period. This period must not be too short, in view of the delays which may occur in the transit and delivery of kernels in this country or elsewhere.

8. The Committee, as you will observe, suggest a duty of 2*l.* per ton, in the first instance, as a tentative measure. If this amount proves inadequate for its purpose it should be raised, and it may therefore be expedient that power should be taken in the Ordinance to modify the amount of the duty by Order of the Governor in Council, which is a more expeditious process than fresh legislation. It will be necessary that the course of the trade should be carefully watched, at any rate for some years after the conclusion of hostilities.

9. The Committee do not anticipate that the native producer of palm kernels will suffer as a consequence of the action which they recommend, since they believe that the increase in the demand within the Empire will be adequate to counterbalance the loss of the German market, assuming that the imposition of the export duty proves sufficient to effect the purpose for which it is intended. This matter, also, will require close scrutiny. The prices paid to the producers on the West Coast of Africa had been increasing prior to the outbreak of war, when they dropped. Prices in Europe are now very high, partly owing to increased freights and partly owing to the shortage of tonnage, but, so far as I am aware, the prices paid to the native producer are below the pre-war prices, or, at any rate, no higher. It will, in my opinion, be advisable to watch carefully the course of local prices for palm kernels and, if possible, to avert anything in the nature of a combination of merchants to depress prices artificially for their own profit.

10. I shall be glad if you will take the report into consideration and cause the legislation necessary to carry it into effect to be drafted as soon as practicable. The Committee recommend that the export duty should be levied for the period of the War and for five years thereafter, and it will be necessary to review the position again at that date in order to decide whether to maintain the duty or not.

I have, &c.,

A. BONAR LAW.