Onderstepoort Journal of Veterinary Science and Animal Industry, Volume 24, Numbers 1 and 2, April, 1950.

Printed in the Union of South Africa by the Government Printer, Pretoria.

Studies on Wool Grease and Suint. I.—The Refractive Index of Wool Grease.

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Of the Union's wool clip approximately 17 per cent. consists of wool grease and 10 per cent. consists of suint. Both the proportions and properties of these fleece constituents vary considerably over the fleece and from fleece to fleece, and they are consequently of the utmost importance to the wool producer as they affect the yield and quality of the fleece. At the same time the by-products of the fleece are assuming an increasing commercial and industrial importance, so that a study of their properties has become essential.

The present paper is concerned with the refractive index of wool grease. Very few figures for the refractive index of lanolin and especially of raw wool grease appear to be available, and some are even given without reference to temperature. Utz (1906), (through Ubbelhode's Handbuch), gives some figures varying from 1·4781 to 1·4822 for crude and purified wool grease at 42° C., in agreement with values obtained in the present study at the corresponding temperature. (Table 2.).

The primary aim of the work recorded here was to obtain values for the refractive index of natural wool grease, and to establish a suitable temperature for its determination. Applications of the work may lead to valuable differentiation, especially in South Africa where climatic and pastoral conditions vary extensively, and different wool types are bred within the Merino. Further, the determination of refractive index is often a rapid method of indicating chemical constitution and even physical orientation. In view of the increasing commercial recovery of wool grease in the Union, refractive index determinations may develop into a quick analytical method of controlling and estimating quality.

Material and Methods.

The material comprised 23 samples of greasy Merino wool drawn from different parts of the Union. The grease was extracted by the method described by Rossouw (1938) where the wool was first well dried at 65° C. at 30 mm. Hg. pressure, and then soxhlet extracted with pure, low-boiling-point petroleum ether.

The refractive index was determined with an Abbé refractometer, reading to four decimal figures. The temperature of the grease was thermostatically controlled to within 0·1° C., and readings were taken after being constant for at least ten minutes.

Commencing at 30° C. or in a few cases at 25° C., the temperature was raised and readings were taken successively at intervals of one degree up to 50° C., which appeared to be a sufficiently high temperature for the purpose of the investigation. The temperature was then progressively lowered and the refractometer readings taken at the same temperatures as before.

Received for publication on 27th May, 1948.—Editor.

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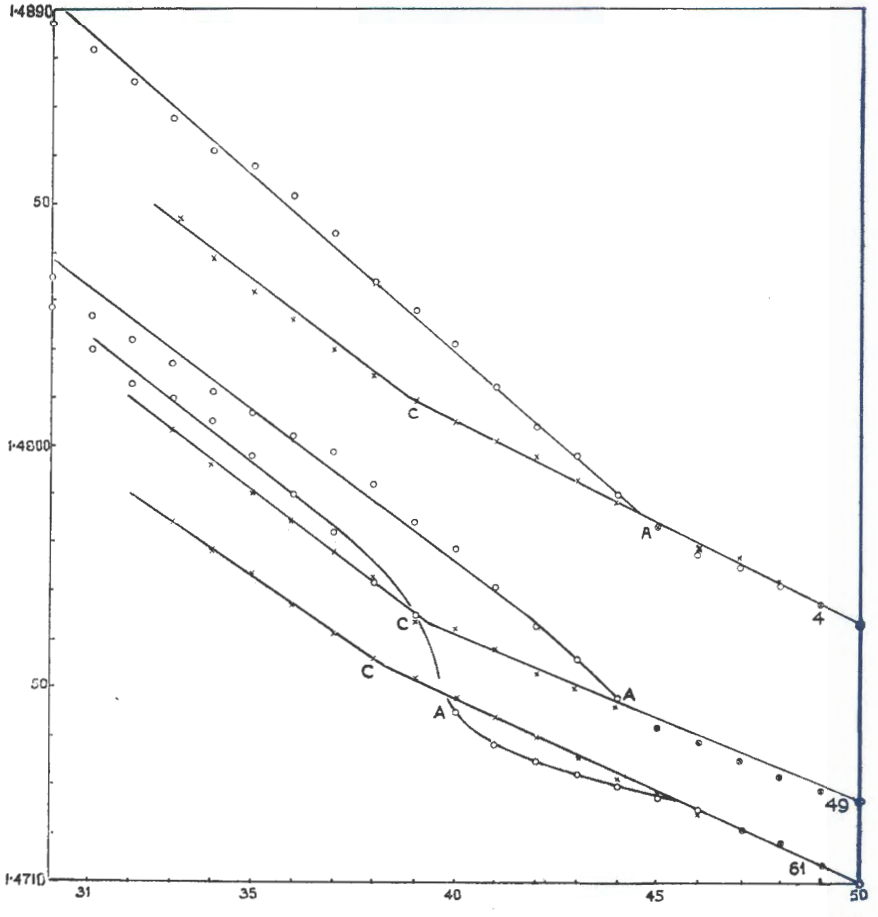
Results.

The results of the measurements are given in Table 2, of which three typical cases have been plotted in the figure. With rise of temperature the refractive index diminished in a manner which was on the whole linear down to a point A, although slight departures from linearity occurred in many cases. At the point A the slope changed abruptly to a lower value, and up to 50° C. the relationship was truly linear. The temperature given by the point A was consequently regarded as the final melting point of the grease.



On cooling, the latter portion of the curve was retraced, but it continued beyond A to a point C where the slope increased to approximately its initial value. The temperature at C was consequently the final solidification point. The microscopic determination of the melting and solidification points is beset with considerable difficulty while the determination of the refractive index enables these points to be determined with a considerable degree of precision.

On leaving the grease in the refractometer for a few days at room temperature (25° C.), the refractive index returned to approximately its initial value, and practically the original curve was again obtained. It was thus evident that the final crystallisation proceeded rather slowly.

Chénéveau (1917) found similar indications of linear dependence of refractive index on temperature in the case of non-drying and semi-drying oils and fats, but his determinations were confined to five temperatures only.

Sample 61 (see figure) represents an extreme case of a type of curve occasionally obtained. No satisfactory explanation of its shape has been forthcoming.

Data derived from the experimental results are collected in Table 1. The temperature coefficients, i.e. the diminution in refractive index for each degree Centigrade rise in temperature, have been calculated for the liquid state, designated α and for the solid state in the process of cooling (beyond C) designated β.

The final melting point of the grease varied from 40° C. to 47° C. with an average of 43° C. The solidification point varied from 36° C. to 41° C. with an average of 38° C. The range between the melting and solidifying points varied from zero to 11° C. with an average of 5° C.

Since the refractive index beyond the final melting point is independent of whether the temperature is rising or falling, and the relationship is truly linear, it is desirable that the refractive index should be determined at some temperature beyond the melting point. It is recommended that 50° C. should be adopted as the standard temperature at which to measure and specify the refractive index of wool grease.

As regards the solidification point, it is of interest to note that the average body temperature of a merino sheep is 39° C., and under abnormal conditions may rise to over 42° C. As is to be expected the wool grease is consequently exuded from the sebaceous glands in the form of a liquid, but it is significant that the solidification point is only slightly lower than the temperature of extrusion.

Up to the point A a definite second line was always visible in the refractometer, although rather indistinct in some cases. This line usually coincided with the cooling curve, and at A merged with the original line. This dual refraction was also noticed by Rohmann (1921) in the case of lanolin, but he was unable to continue his interesting work. It is felt, however, that this direction of the problem should be investigated in a suitably equipped laboratory. Rohmann worked at 20° C. and from his work it seems clear that the dual refraction is due to crystallisation. He isolated a crude concentrate of the substance responsible for the second line and confirmed its refractive index. It is still uncertain what this substance actually was. Cholesterol esters are known to behave in this way, and considering that wool grease contains fair amounts of cholesterol and similar esters, it may be assumed that these substances are mainly responsible for the dual refraction.

Pickering and Cowlishaw (1921) working on the refractive index of fats and oils established some interesting relationships between the refractive index and the chemical characteristics. Their work was confined to glycerides, and is consequently not directly applicable to the present study. They found that the refractive index was affected by such factors as molecular weight, free fatty acids and hydroxylated acids, and were able to calculate the refractive index from the iodine value.

In Schönfeld (1938) it is stated that the gradual saturation of fats with oxygen lowers the refractive index. At the same time it is known also that ageing increases the refractive index of fats. In the case of wool grease it is probable that ageing will produce less change than in the case of these, although the gradual formation

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of small amounts of free fatty acid should affect the refractive index somewhat. Wool grease consists of a mixture of chemical compounds in the form of esters of very high molecular weight, averaging about 700. Most of the fatty acids are of the anteiso series having the general formula of $CH_3\ CH_2\ \underset{\displaystyle CH_3}{\underset{|}{CH}}.\ (CH_2)_n\ COOH$.

On the other side of the molecule may be found higher alliphatic alcohols, cholesterol and the triterpenes agnol and lanol. Most of these substances are very stable and from their constitution it can be deduced that very little change in refractive index will take place on ageing. On the other hand, very little is known about the physical characteristics and behaviour of the anteiso fatty acids, agnol and lanol.

Analysis of Results.

Apart from the obvious dependence of refractive index on temperature, no relationships between the data of Table 1. are apparent. A correlation coefficient of +0·32 exists between the refractive index at 50° C. and the temperature coefficient α but it is probably too small to be of practical significance.

Summary.

1. The refractive index of 23 samples of wool grease from different sources of raw wool has been determined over a temperature range from 25° C. to 50° C.

2. Curves plotted from the data show a definite form of considerable similarity.

3. It is recommended that 50° C. should be adopted as the temperature at which the refractive index of wool grease should be determined.

4. Compared with other fats and oils the refractive index of wool grease varies considerably. The average value obtained is 1·4752 at 50° C.

5. From the shape of the curves the refractive index at temperatures outside the melting range can be calculated with a fair degree of accuracy.

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TABLE 1.

Sample No.	Refractive Index at 50 °C.	Temperature Coefficient.		Melting Point °C.	Solidification Point °C.	Range between M.P. and S.P °C.
		Liquid.	Solid. (Cooling).			
		α	β			
30	1·4814	·000474	·000850	47	36	11
18	1·4813	426	811	46	40	6
50	1·4800	393	658	46	41	5
2	1·4797	344	760	45	38	7
5	1·4792	337	850	45	38	7
1	1·4792	427	496	45	40	5
69	1·4773	367	570	45	38	7
65	1·4772	347	490	43	37	6
3	1·4768	389	670	42	37	5
63	1·4766	363	844	40	40	0
4	1·4763	395	637	44	38	6
6	1·4751	325	640	44	37	7
26	1·4750	356	720	43	38	5
60	1·4738	398	807	43	39	4
64	1·4736	354	720	40	36	4
44	1·4730	402	750	43	38	5
49	1·4726	325	625	44	39	5
48	1·4724	423	610	46	38	8
66	1·4718	382	640	42	38	4
61	1·4710	365	563	41	38	3
56	1·4700	346	570	39	38	1
62	1·4694	335	700	42	38	4
47	1·4681	395	574	40	39	1
MEANS	1·4753	·000376	·000676	43	38	5

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Table 2

Refractive Index of Wool Grease at Different Temperatures

Temperature.....	30°	31°	32°	33°	34°	35°	36°	37°
No.								
30.....	1·4957	1·4949	1·4940	1·4930	1·4922	1·4914	1·4906	1·4898
18.....	1·4954	1·4946	1·4938	1·4932	1·4927	1·4918	1·4911	1·4902
50.....	1·4923	1·4917	1·4910	1·4903	1·4897	1·4889	1·4880	1·4872
2.....	1·4929	1·4921	1·4912	1·4908	1·4902	1·4894	1·4888	1·4880
5.....	1·4932	1·4921	1·4910	1·4902	1·4892	1·4882	1·4872	1·4862
1.....	1·4918	1·4911	1·4904	1·4896	1·4887	1·4875	1·4867	1·4858
69.....	1·4884	1·4877	1·4870	1·4863	1·4858	1·4851	1·4844	1·4831
65.....	1·4879	1·4872	1·4867	1·4860	1·4853	1·4847	1·4840	1·4835
3.....	1·4894	1·4885	1·4878	1·4871	1·4863	1·4855	1·4848	1·4840
63.....	1·4900	1·4892	1·4888	1·4881	1·4874	1·4867	1·4859	1·4849
4.....	1·4838	1·4882	1·4875	1·4868	1·4861	1·4848	1·4851	1·4844
6.....	1·4879	1·4869	1·4863	1·4855	1·4844	1·4837	1·4830	1·4823
26.....	1·4881	1·4873	1·4867	1·4858	1·4850	1·4840	1·4831	1·4821
60.....	1·4868	1·4862	1·4857	1·4851	1·4845	1·4840	1·4829	1·4822
64.....	1·4845	1·4839	1·4833	1·4826	1·4821	1·4813	1·4806	1·4799
44.....	1·4860	1·4850	1·4843	1·4838	1·4830	1·4822	1·4817	1·4810
49.....	1·4835	1·4827	1·4822	1·4817	1·4811	1·4807	1·4802	1·4799
48.....	1·4840	1·4833	1·4827	1·4820	1·4815	1·4809	1·4802	1·4793
66.....	1·4830	1·4822	1·4813	1·4808	1·4802	1·4798	1·4792	1·4788
61.....	1·4829	1·4820	1·4813	1·4810	1·4805	1·4798	1·4790	1·4781
56.....	1·4798	1·4790	1·4783	1·4781	1·4775	1·4766	1·3758	1·4748
62.....	1·4820	1·4812	1·4805	1·4801	1·4792	1·4785	1·4770	1·4766
47.....	1·4738	1·4786	1·4779	1·4773	1·4769	1·4761	1·4742	1·4734
AVERAGE.....	1·48752	1·48677	1·48607	1·48544	1·48476	1·48403	1·48320	1·48241
Difference per degree $\times 10^{-4}$.....	7·5	7·0	6·3	5·8	7·3	8·3	7·9	7·7

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361-362a

Table 2 cont.

Refractive Index of Wool Grease at Different Temperatures

38°	39°	40°	41°	42°	43°	44°	45°	46°	47°
1·4892	1·4888	1·4878	1·4872	1·4863	1·4856	1·4849	1·4841	1·4836	1·4830
1·4899	1·4886	1·4875	1·4865	1·4855	1·4848	1·4841	1·4837	1·4830	1·4825
1·4865	1·4859	1·4852	1·4846	1·4840	1·4832	1·4827	1·4820	1·4816	1·4811
1·4872	1·4864	1·4853	1·4844	1·4834	1·4830	1·4824	1·4815	1·4811	1·4807
1·4857	1·4852	1·4842	1·4835	1·4829	1·4821	1·4817	1·4809	1·4805	1·4802
1·4850	1·4847	1·4840	1·4836	1·4831	1·4823	1·4822	1·4814	1·4810	1·4807
1·4825	1·4818	1·4813	1·4809	1·4803	1·4800	1·4796	1·4791	1·4787	1·4783
1·4829	1·4822	1·4814	1·4808	1·4803	1·4798	1·4793	1·4789	1·4786	1·4782
1·4834	1·4828	1·4818	1·4811	1·4802	1·4797	1·4792	1·4788	1·4783	1·4779
1·4839	1·4830	1·4805	1·4797	1·4793	1·4790	1·4788	1·4784	1·4781	1·4778
1·4834	1·4828	1·4821	1·4812	1·4804	1·4798	1·4790	1·4783	1·4778	1·4775
1·4817	1·4808	1·4802	1·4794	1·4787	1·4780	1·4774	1·4767	1·4764	1·4760
1·4811	1·4803	1·4797	1·4791	1·4782	1·4775	1·4769	1·4767	1·4764	1·4761
1·4813	1·4808	1·4798	1·4790	1·4775	1·4767	1·4762	1·4759	1·4754	1·4750
1·4790	1·4780	1·4772	1·4766	1·4763	1·4761	1·4757	1·4754	1·4750	1·4747
1·4800	1·4793	1·4788	1·4780	1·4770	1·4760	1·4755	1·4750	1·4746	1·4742
1·4792	1·4784	1·4779	1·4773	1·4763	1·4756	1·4748	1·4742	1·4739	1·4735
1·4784	1·4776	1·4770	1·4765	1·4760	1·4755	1·4750	1·4746	1·4741	1·4737
1·4781	1·4773	1·4766	1·4757	1·4750	1·4745	1·4740	1·4737	1·4733	1·4729
1·4772	1·4765	1·4745	1·4739	1·4735	1·4733	1·4730	1·4728	1·4725	1·4721
1·4743	1·4741	1·4738	1·4733	1·4730	1·4725	1·4720	1·4717	1·4713	1·4710
1·4759	1·4750	1·4740	1·4730	1·4721	1·4718	1·4714	1·4711	1·4708	1·4704
1·4724	1·4720	1·4717	1·4713	1·4710	1·4708	1·4705	1·4701	1·4697	1·4693
1·48164	1·48098	1·48010	1·47941	1·47871	1·47818	1·47767	1·47717	1·47677	1·47638
8·6	8·8	6·9	7·0	5·3	5·1	5·0	4·0	3·9	3·9

← 361-362b 361-362b 361-362c →

Table 2 cont.
Refractive Index of Wool Grease at Different Temperatures

48°	49°	50°	49°	48°	47°	46°	45°	44°	43°
1·4825	1·4820	1·4814	1·4818	1·4823	1·4827	1·4830	1·4835	1·4839	1·4844
1·4821	1·4817	1·4813	1·4818	1·4821	1·4824	1·4830	1·4832	1·4835	214840
1·4807	1·4803	1·4800	1·4803	1·4 07	1·4811	1·4814	1·4818	1·4821	1·4824
1·4803	1·4800	1·4797	1·4801	1·4804	1·4807	1·4811	1·4813	1·4818	1·4822
1·4799	1·4796	1·4792	1·4796	1·4798	1·4802	1·4806	1·4809	1·4812	1·4817
1·4800	1·4797	1·4792	1·4797	1·4800	1·4806	1·4810	1·4812	1·4817	1·4820
1·4779	1·4776	1·4772	1·4776	1·4780	1·4783	1·4787	1·4790	1·4793	1·4797
1·4779	1·4775	1·4772	1·4775	1·4779	1·4782	1·4786	1·4798	1·4793	1·4797
1·4775	1·4771	1·4768	1·4772	1·4774	1·4778	1·4782	1·4787	1·4791	1·4797
1·4773	1·4770	1·4765	1·4769	1·4772	1·4776	1·4779	1·4783	1·4787	1·4790
1·4771	1·4767	1·4763	1·4767	1·4772	1·4777	1·4779	1·4783	1·4789	1·4793
1·4757	1·4754	1·4751	1·4754	1·4757	1·4760	1·4764	1·4767	1·4771	1·4774
1·4757	1·4753	1·4750	1·4753	1·4757	1·4760	1·4764	1·4763	1·4771	1·4775
1·4747	1·4742	1·4738	1·4741	1·4746	1·4749	1·4753	1·4757	1·4761	1·4765
1·4743	1·4740	1·4736	1·4739	1·47-2	1·4747	1·4750	1·4753	1·4758	1·4761
1·4738	1·4734	1·4730	1·4733	1·4738	1·4742	1·4745	1·4750	1·4753	1·4757
1·4732	1·4729	1·4725	1·4729	1·47s2	1·4735	1·4739	1·4742	1·4746	1·4750
1·4732	1·4728	1·4724	1·4728	1·4732	1·4737	1·4740	1·4744	1·4747	1·4750
1·4725	1·4721	1·4718	1·4721	1·4725	1·4729	1·4733	1·4736	1·4740	1·4744
1·4718	1·4713	1·4710	1·4713	1·4718	1·4721	1·4724	1·4728	1·4731	1·4736
1·4706	1·4703	1·4700	1·4704	1·4708	1·4711	1·4714	1·4718	1·4721	1·4724
1·4701	1·4698	1·4694	1·4698	1·4701	1·4704	1·4708	1·4711	1·4715	1·4719
1·4689	1·4685	1·4681	1·4685	1·4689	1·4692	1·4696	1·4701	1·4705	1·4708
1·47599	1·47562	1·47524	1·47561	1·47598	1·47635	1·47671	1·47707	1·47745	1·47784
3·7	3·8	3·7	3·7	3·7	3·6	3·6	3·8	3·9	3·9

← 361-362b 361-362c 361-362d →

Table 2 cont.
Refractive Index of Wool Grease at Different Temperatures

42°	41°	40°	39°	38°	37°	36°	35°	34°	33°
1·4849	1·4853	1·4857	1·4861	1·4867	1·4871	1·4875	1·4880	1·4888	1·4897
1·4843	1·4847	1·4851	1·4858	1·4864	1·4872	1·4880	1·4889	1·4897	1·4906
1·4830	1·4833	1·4839	1.4844	1·4850	1·4858	1·4864	1·4870	1·4877	1·4885
1·4826	1·4832	1·4835	1·4838	1·4843	1·4848	1·4855	1·4863	1·4871	1·4878
1·4821	1·4823	1·4827	1·4831	1·4838	1·4842	1·4850	1·4857	1·4867	1·4876
1·4823	1·4827	1·4830	1·4836	1·4841	1·4847	1·4851	1·4856	1·4861	1·4866
1·4801	1·4804	1·4808	1·4811	1·4816	1·4820	1·4825	1·4832	1·4838	1·4843
1·4800	1·4803	1·4807	1·4811	1·4814	1·4820	1·4822	1·4828	1·4833	1·4839
1·4800	1·4803	1·4808	1·4811	1·4815	1·4819	1·4826	1·4832	1·4839	1·4846
1·4793	1·4798	1·4805	1·4811	1·4819	1·4827	1·4834	1·4843	1·4853	1·4865
1·4798	1·4801	1·4805	1·4809	1·4815	1·4820	1·4826	1·4832	1·4839	1·4847
1·4778	1·4781	1·4786	1·4790	1·4794	1·4798	1·4804	1·4810	1·4816	1·4824
1·4779	1·4782	1·4787	1·4791	1·4794	1·4800	1·4808	1·4814	1·4822	1·4830
1·4769	1·4772	1·4778	1·4783	1·4791	1·4799	1·4808	1·4814	1·4823	1·4832
1·4765	1·4769	1·4772	1·4776	1·4781	1·4784	1·4789	1·4794	1·4800	1·4811
1·4760	1·4760	1·4768	1·4772	1·4779	1·4785	1·4792	1·4799	1·4807	1·4815
1·4753	1·4758	1·4762	1·4764	1·4773	1·4778	1·4784	1·4790	1·4796	1·4803
1·4754	1·4758	1·4762	1·4766	1·4771	1·4776	1·4782	1·4788	1·4795	1·4800
1·4748	1·4752	1·4756	1·4760	1·4766	1·4771	1·4778	1·4783	1·4790	1·4797
1·4720	1·4744	1·4748	1·4752	1·4756	1·4761	1·4767	1·4773	1·4778	1·4784
1·4729	1·4733	1·4738	1·4742	1·4747	1·4750	1·4756	1·4762	1·4767	1·4773
1·4722	1·4727	1·4732	1·4737	1·4741	1·4746	1·4752	1·4760	1·4766	1·4774
1·4711	1·4713	1·4718	1·4722	1·4726	1·4731	1·4737	1·4741	1·4750	1·4754
1·47823	1·47858	1·47904	1·47946	1·48000	1·48053	1·48115	1·48178	1·48249	1·48324
3·5	4·6	4·2	5·4	5·3	6 2	6·3	7·1	7 5	—

← 361-362c 361-362d