Besides the products mentioned, a number of others can be produced from wood sugar, for instance, some special kinds of sugar for pharmaceutical and different technical purposes, glycerin, tanning substances and resins.

By-Products.

Lignin, one of the by-products of the process, consisting of the non-hydrolysable substances of the wood, is produced to the amount of 33 kilograms per 100 kilograms of dry wood substance. As has been mentioned, it can be used for the most varied purposes. Briquetted lignin, for instance, can be turned into a hard and uniform charcoal of good quality and both, lignin briquette and lignin charcoal, being free of acetic acid, are suitable fuels for the modern wood-gas generators.

The other by-product of the process, acetic acid, is recovered to the amount of 2 per cent. when treating coniferous wood and of 5 per cent. when treating wood from foliaceous trees. Technical acetic acid is not only used as solvent and raw material for the production of esters but for various other purposes.

A diagram of the products obtained by the Bergius-Rheinau Process is shown in (Fig. 4).

In judging the economic value of the process, the fact that it recovers, as has been shown, nearly 100 per cent. of the wood treated in form of valuable products, is of considerable importance.

Food Adulteration in the Madras Presidency.

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I PROPOSE to give some account of the working of the "Prevention of Food Adulteration Act in the Madras Presidency". It is a fact that very little information is published as to the working of this and similar Acts in other provinces, and I hope that this short account of the working of the Madras Act may induce Government analysts in other provinces to give a similar account of their activities in their own areas. There is plenty of information available on the working of the Food and Drugs Act in England. All public analysts there are under statutory obligation to publish quarterly reports; in practice most of them publish annual reports as well and preces of these can be found in many scientific journals.

If the reports of analysts in India could be studied, it would be found that the position is entirely different from that of England. In England, analysts usually report some small percentage, say 3 to 5 per cent. of their samples as adulterated. But, if one comes to look further into the matter, one finds that the bulk of this adulteration is due to the infringement of certain rules that have been prescribed in the interests of public health, *e.g.*, certain preservatives in food are prohibited; others may only be used to preserve specified foods and then only subject to a maximum proportion being used. Gross adulteration by shop-keepers, for example, the mixing of margarine (imitation butter) with butter is almost non-existent. In India,—I can only speak for Madras, but I imagine that other provinces show similar results—gross adulteration of staple articles of food is met with in every area in which the Act is worked. The Madras Act is in force in about 60 local areas including the City of Madras. Between 6,000 and 7,000 samples a year are examined and of these more than a third are found to be adulterated. During last year in the Madras Presidency, of 6,581 samples taken the percentage of adulteration was 67·2% in milk, 33·1% in ghee and 10·9% in oils.

Bad as the figures are for ghee and oils, they show a definite improvement on previous years, and one looks forward with some confidence to some further improvement. This is due to a change in policy

in dealing with food adulteration. When the Act was first brought into force seven years ago, it and the Regulations made under it, were based on the English Acts. Thus fairly complicated regulations were prescribed for the labelling of commodities which the vendors wished to sell as mixtures. The Regulations also prescribed that when a vendor was selling such an article to an *illiterate, he must give the same information* by word of mouth. In practice these regulations were a complete failure. It became the practice of ghee merchants to label all their vessels with a notice stating that they guaranteed some trivial proportion of ghee, usually 3 or 5 per cent. As it was obvious by mere taste or smell that actually a large proportion of ghee was present purchasers accepted the vendor's explanation that these labels were meaningless and were simply displayed to meet the requirements of the Regulations. In this way heavily adulterated ghee could be sold as genuine ghee. Similar difficulties arose in connection with gingelly oil which was at one time very heavily adulterated with the cheaper groundnut oil. The requirement that these notices should be explained to illiterates was completely ignored and it was found difficult to obtain witnesses to substantiate a prosecution for infringing the rule. The adulteration of ghee and gingelly oil is now prohibited and mixtures may not be sold or stored for sale under any designation. This rule has been in force for more than a year in connection with oil and adulteration has fallen from 28% in 1933–34 to 11% in 1935–36. A similar rule for ghee was in force for 9 months during the last year for which complete figures are available and ghee adulteration which was at one time as high as 53% fell to 33%.

Milk adulteration remains steady at a very high figure. As milk is sold very largely by itinerant vendors, who, following a conviction, will usually change their district, it is not possible to drive a persistent offender out of business as is possible with residential shop-keepers. I have recommended to Municipalities that they should adopt by-laws requiring registration of milk hawkers whose licence would be liable to withdrawal following a conviction. If my recommendation is accepted it will be interesting to see whether it causes an improvement.

Though the Madras Act can be applied to all food-stuffs I have recommended sampling officers to confine themselves, for the time being, to staple articles of food such as milk, ghee, butter and gingelly oil, and these commodities make up a large proportion of the samples examined here. I propose to give a few notes as to the methods of analysis used in connection *with these and a few other commodities* and the prescribed standards, where they exist.

Milk.—Under the rules it is laid down that buffalo milk should contain at least 9·0% solids-not-fat and 4·5% fat and cow milk 8·5% solids-not-fat and 3·0% fat. There are supplementary standards for nitrogen of 0·53% for buffalo milk and 0·5% for cow milk. These latter standards are intended to be used when decomposition takes place and it is not possible to estimate the proportion of solids-not-fat orginally present with any accuracy. When a sample is decomposed it is treated with a few drops of strong caustic soda, warmed, and mixed. It is then easy to get uniform sample and it has been found that the proportions of fat (estimated by Rose Gottlieb) and nitrogen in such a sample are, for all practical purposes, identical with those in the original milk. In connection with the Madras standards it should be noted that, as with all similar standards, all they do is to transfer the onus of proof of adulteration to the Analyst when the sample complies with the standards. With heavily adulterated samples the proportion of adulteration is calculated from the deficiency below the standard figures, but in the case of border-line samples either above or below the standard, freezing point determinations are made with the Hortvet Cryoscope. This of course gives an exact figure for the proportion of added water, and it is frequently found that samples which by comparison with the standards would be passed as either genuine or but slightly adulterated or actually heavily adulterated. This arises from the fact that milks, and buffalo milk in particular, frequently contain 10 or even a higher percentage of solids-not-fat. When we commenced freezing point determinations one minor difficulty had to be overcome. In Madras, Inspectors are instructed to add a small quantity of formalin (40% formaldehyde) to their samples

to preserve them in transit. Formaldehyde has of course a very low molecular weight and accordingly quite small quantities have a very large effect on the freezing point. To remove the formalin, our procedure is as follows:—About 90 mils. of milk and about 10 grams of paraffin wax (to minimise frothing) are placed in a distilling flask which is counterpoised. About 40 mils. of water is then distilled off. The flask is cooled and brought back to its original weight with water. It is found that all free formalin comes off in the distillate. The residual milk will, on acidification, give colour tests for formalin, but this residual formalin appears to have condensed with the proteins of the milk as it is found that milk evaporated and brought back to its original weight in this way has a freezing point almost identical with that of the original milk.

Ghee and Butter.—In Madras there is a limit of 20% of moisture for butter. The determination of moisture is, of course, analytically very simple. On the other hand, it is laid down that butter and ghee must be prepared exclusively from milk or cream, and further the addition of foreign fat to either commodity is prohibited. To express a confident opinion as to whether a sample of ghee (the same thing applies to butter-fat) is genuine, frequently involves a very large amount of work. Though ghee has an average Reichert value of about 32 or 33 many samples give figures as high as 40; on the other hand, even bulked samples can give figures as low as 28. *N.B.*—In these notes I am ignoring ghee prepared from the small yield of milk given by buffalos which are nearing the end of the period of lactation. From such samples very low figures can be obtained, but, in view of the relatively small yield, the presence of one or two such animals in a herd will have very little effect on the figure for the bulked sample.

When the Act was first introduced samples were normally either unquestionably genuine or heavily adulterated and in the majority of cases a Reichert determination alone was sufficient. The position has now changed entirely. The ghee merchants themselves employ semi-skilled chemists who can make routine analyses, such as the determinations of Reichert Values and Refraction, and who are competent to advise their employers as to the preparation of mixtures which will give the maximum probability of the sample being classed as "border-line" and passed as genuine. In these circumstances and in view of the great variability in the figures for Reichert Value and Refraction, it is obvious that no sample can be passed as genuine without further investigation unless it yields a Reichert of over 30; and even in these cases some further investigation should be done if there is any appearance of lack of correspondence between the Reichert Value and the Refraction. The supplementary figures I rely on mainly are titre of the insoluble fatty acids, melting point of the sterol acetate and a determination of *iso*-oleic acid. An adulterant, which has recently come into popularity is a very much hardened hydrogenated fat. I believe this is popular because it has a lower refraction than the ordinary vegetable fats of moderate consistency. It is also a fact that, due to the high degree of hydrogenation, most of the sterol has been destroyed. Accordingly, if a sample of buffalo ghee having a high Reichert Value is adulterated with a small amount, say 20% of such adulterant, the fact of adulteration will not be detected by the Reichert, Refraction or melting point of the sterol acetate. On the other hand, this particular form of sophistication is easily found out by a determination of the titre of the insoluble fatty acids. The Titre figure for genuine samples of ghee normally lies between 40° and 42°. Figures over 42°·5 are very rare and I have yet to meet a sample with a titre exceeding 43°. On the other hand, the adulterated samples usually give a titre of over 43° and figures up to 45° have been recorded. If, when the presence of this adulterant is suspected, the titre gives a border-line figure, it becomes necessary to determine the proportion of *iso*-oleic acid before one can give a definite opinion. Ordinary vegetable fat of the consistency of genuine ghee increases the Refraction considerably and if this increase is not high enough to be conclusive one can give a definite opinion after determination of the melting point of the sterol acetate, as these substances contain a considerable proportion of phytosterol. The highest melting point obtainable after repeated crystallisation of cholesterol

acetate is 115·2; but using the digitonin method and recrystallising only twice, one normally obtains a figure of 116 or higher when 15 or 20% of vegetable fat is present. This test is, of course, absolutely conclusive, as phytosterol does not occur in animal fat. A note describing the method I use for the preparation of the sterol acetate was published in the *Analyst* of September 1933, page 529. The manipulations involved in this test are not easy. The digitonide must be very carefully prepared and the final product amounts to no more than a few milligrams, the melting point of which has to be determined with great precision. The test should not be entrusted to any one but a highly skilled chemist.

It should be noticed that butter is quite as commonly adulterated as ghee and that those members of the public who believe that they are protecting themselves when they have their ghee made from butter in their presence are living in a false paradise.

In some provinces so-called standards have been prescribed for ghee and butterfat. These usually include a minimum Reichert Value but sometimes figures for Refraction, Saponification value, etc., are included. On my advice no such standards have been prescribed in Madras; I believe them to be worse than useless. Owing to the variation of the figures given by genuine ghee it necessarily follows that there must be many adulterated samples which would satisfy standards based, as such figures must be, on minimum values, and, in such cases, to counter the presumption of genuineness it is necessary for the analyst either to attend Court or to give a lengthy explanation in his certificate which, though understandable to a chemist, can only confuse the mind of a lay Magistrate. I am assuming that no responsible chemist would allow himself to be converted into a kind of chemical sorting machine, passing or condemning samples according as they are inside or outside the prescribed minimum limits.

Oils.—In the Madras Presidency the most popular oil is gingelly oil. This is commonly adulterated with groundnut oil. The estimation is very simple. It is carried out by the method of Franz and Adler, as quoted by Evers in his paper on the determination and estimation of arachis (groundnut) oil, *Analyst* 1912, page 488. Genuine gingelly oil, by this method gives a turbidity at 20°C., arachis at 40° and as the increase in the temperature of turbidity is directly proportional to the amount of arachis oil present it thus supplies a figure from which the latter is easily calculated. Recently a number of samples of coconut oil have been found to be heavily adulterated with mineral oil.

Tea.—Standards for tea are similar to those in other provinces. Their effect is to prohibit foreign leaf and excess amounts of dust and sweepings. At one time tea was heavily adulterated. Now the great majority of samples are genuine. This is probably due to the activities of the Tea Cess Committee which include not only propaganda but also the sampling and examination of a large number of samples.

A common adulterant of tea dust is black gram husk. Leaf tea has been adulterated with foreign leaf. For microscopic examination the tea is boiled with a small quantity of 10% sodium hydroxide and then washed by decantation with hot water. Under the microscope the structure of the leaf then becomes quite clear. The husk of black gram is easily identified by its characteristic appearance. Husk is estimated by the ordinary methods which will be found in text-books under pepper. When foreign leaf is present a determination of caffeine is necessary.

Coffee.—Coffee is largely adulterated. The commonest adulterants are chicory and Bengal gram. Chicory is estimated by text-book methods. Bengal gram is easily identified under the microscope after the sample has been cleared with sodium hydroxide. To estimate it a determination of caffeine is necessary.