A REVIEW OF THE CHEMISTRY AND PHYSIOLOGY OF TISSUE FATS

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Actually we realize that bourbon and beef are by-products of the same underlying grain when we get right down to it. The subject that we have here, the chemistry and physiology of fatty tissues, could very well be the subject of a five-hour one-semester course that any of you might teach. We are trying to go over the highest of high spots in just the matter of 15 minutes here and so to get down to business let us have the first slide, please.

(Slide) This slide was developed merely to emphasize a fact that you already know, namely, that the fats or the triglycerides with which we are dealing are esters of glycerols. Here we see on your left a molecule of glycerol and on your right a molecule of fat or triglyceride, and down below we see the key to the entire picture, namely, the fatty acid. We have a sort of grid of these fatty acids, and in all the cases with which we will be concerned this N is an even number. This is rather interesting in the philosophy of the thing. Why should this N be an even number? We will not go into this now, however. At any rate, water is split out between the fat as hydroxyl and glycerol to give us triglyceride. As an example of a triglyceride let us see the next slide.

(Slide) To add to the over-all joy of the thing, virtually all the triglycerides that we will ever encounter are mixed triglycerides. In fact, throughout the whole of nature with the exception of the spinifex of Australia the triglycerides are mixed. At the top there you have the stearic acid, for the middle carbon there you have oleic acid, and for the lower carbon you have linoleic acid. Now I realize that for people who are not regularly working with fatty acids these names come rather fast and actually it is very difficult to keep your ears in tune to the difference between oleic acid and linoleic acid. As a consequence we will merely call the acid by the number of carbons it has and by the location of the double bonds. That will simplify matters to a certain extent. In other words, stearic acid is a C18 acid saturate, with no double bonds, and oleic acid is a C18 acid with one double bond between 9 and 10 carbons. We start numbering here from the carbon that is nearest the glycerol. That will be 1. Then 7 more make 8, and the next one is 9. So the double bond there is between carbons 9 and 10. The same way with the linoleic acid at the bottom. There we have two double bonds, that is a C18 acid with two double bonds. As we go a little further into this we will realize that it is these double bonded fatty acids that are the bases of many of our unique problems with animal fats.

Now we have to limit this some way and throughout the animal and vegetable kingdom we have a tremendous number -- not a tremendous number but a relatively large number of fatty acid residues that go into our
tryglycerides. As a consequence let us cut this down and consider only the fatty acids that are common to lard and beef tallow.

(Slide) The next slide will give you a rough concept of the most important fatty acids that go into lard and beef fat and a rough idea as to the range in which we find these in these various products. For example, we have in lard a relatively small amount of saturated fatty acid with less than 16 carbons. Actually most of that is with 14 carbons. Then we have the 16 and 18-carbon fatty acids as being the main saturated fatty acid components. On the unsaturated side we have 16, 18 and 20 numbered carbon atoms in the fatty acid molecules with 1, 2, 3 and ultimately 4 double bonds. Now we see what this can make for us. This makes this nice simple little problem of just a relatively few fatty acids tremendously complicated because practically all of them are mixed. We have this problem of these fatty acids within the limiting proportions indicated here and we have virtually all combinations of these. In other words, if we consider the breakdown just between saturated and unsaturated, let us say, U stands for unsaturated and S stands for saturated. With our three fatty acids listed there we have a possibility for S, S, S; SSU, SUU and UU as various mixtures between the saturated and the unsaturated fatty acids.

Consider that we have five major unsaturated fatty acids and two or three major saturated ones and we have the possibility of a tremendous number of these fatty acids, and it is the properties of the fat that result from the presence of these various fatty acids. One exception you might say would be color which is the result of non-fatty material, and another thing is that in a finished solid, lard is perhaps textured which is in great measure due to how fast the fat was cooled and how it was whipped with the gas. Aside from those properties, most of the properties by which we know these fats are the result of these various fatty acids.

(Slide) The next slide will give us a rough idea as to the major tests by which we characterize objectively some of these fatty acids. Let us consider first the melting point. Due to the fact that all of these fatty acids are mixtures, the melting points are very likely to be quite irregular. We find, for example, a surprising difference in beef between the melting point of subcutaneous fat which melts in the vicinity say of 90 to 110 and kidney fat which melts in the neighborhood say of 104 to 122. We find an analogous picture in pork between fatback which melts between 86 and 104 Fahrenheit and leaf fat which melts at 110 to 118 Fahrenheit.

By and large, as a generalization, these unsaturated fatty acids give rise to lower melting point fats. The titer is more or less precisely a matter of the melting points of the mixed fatty acids that we have present in the fat. In other words, we saponify the fat when we react it with a strong alkali to produce the sodium salt of the acid, the glycerol. Then we separate out the free, unsoluble fatty acid and take the melting point on that and that gives us the picture of our titer. By and large our titer runs rather parallel to the hardness or the melting point of the fat.

Another test that we run in order to characterize these fats objectively is the free fatty acids. The free fatty acids to some extent, or
perhaps to quite an extent, represent the handling that the fat has received. If the fat has been held at a relatively warm temperature, a relatively satisfactory temperature for enzyme action, the amount of free fatty acid is likely to be quite high. The free fatty acids represent three fat groups that have split off of the glycerol molecule. In the fats which are developed on the killing floor and on the cutting floor that is likely to be quite a problem inasmuch as they must not be held at too high a temperature before they are brought up to a temperature which inactivates the fats because actually with the fat you have a considerable amount of tissue and this tissue contains lipase which hydrolyzes the fat, and some of the tissue, especially pancreatic tissue, is extraordinarily high in lipase and results in a great deal of diluting of fatty acids.

The smoke point is fairly closely related to the fatty acid content. In other words, we would feel that lard can be prepared that can go up, say, to around 400 without serious smoking. On the other hand, if the fat has been mistreated either by overheating or by enzymic splitting the fats will smoke at a much lower temperature and that, in an era of so much deep-fat fried material, is a serious disadvantage to fat.

The iodine value is another measure of the degree of unsaturation of these fats. The more double bonds the more iodine that you will have absorbed, and the iodine value is merely an index of the iodine absorption that you get from double bonds which again are a reflection of the unsaturated aspect of the fat. The iodine value or the unsaturated value of the fat depends to some extent on the diet of the animals. For example, we know that peanut fed hogs tend to have a much softer fat and this is again reflected in the iodine value which runs around 90 to 100, while the iodine value in corn fed hogs runs from 70 to 72 or around that neighborhood.

The peroxide value is an index at least of the start of rancidity. After rancidity progresses beyond a certain point the validity of this index seems to deteriorate a bit but by and large that gives you an idea as to how the fat has started down the road toward rancidity. It is essentially a measure of fat as an oxidizing agent, how much iodine can be liberated from something like potassium iodide which is a property again of the oxygen uptake of the fat.

Then we come lastly to a kind of over-all index which is frequently used to evaluate the stability of fats, namely, this active oxygen method which involves merely putting the fat into a tube and blowing air through it at a prescribed rate. The tube is in a water bath which is held at around 110 centigrade or 100 centigrade. Two temperatures are used, and that is kept up until somebody with a really sensitive nose walks up and smells it and notices that rancidity has started. To be slightly more objective about that you can take the thing off at any prescribed time and run a peroxide value on it which again will reflect the resistance of the fat toward the development of rancidity. From this active oxygen method it is possible to predict with a fair degree of validity the length of time that a fat will stand storage without becoming conspicuously rancid.

Now we have said as yet really nothing about the physiology of fat and, as you realize, fat is primarily a matter of energy storage. Fat
represents roughly 9 calories per gram in comparison with carbohydrate and protein which represent around 4 calories per gram. But there is something even more spectacular than that. That is that fat in some of the deposits in animals may run up to 93 or 97 per cent pure fat while protein rarely, if ever, gets over 22 per cent protein and the rest is moisture. But in beef kidney fat, for example, you see the figure of around 94 or 95 per cent pure fat, 2 or 3 per cent water, and 1/2 to 1 per cent protein. Now that represents a highly concentrated reservoir of energy for the animal. Beef brisket fat only runs around 70 per cent fat, around 20 per cent water and, say, 5 per cent protein, a much less concentrated source.

Fat may in certain creatures exposed to environmental stress serve also as padding. It may also serve as insulation against cold stress. We realize that there is a considerable difference between the ability of animals to produce fat. There is a considerable difference between various diets and the type of fat that they produce. We mentioned a while ago that peanut fed hogs have a substantially different fat from corn fed hogs. There is also a difference in the fat that is produced within the tissue of the same animal. The leaf fat in a hog, for example, or the kidney fat in beef tend to run a much higher per cent saturated fats or a much lower per cent unsaturated fatty acid residue than does the subcutaneous fat.

Now the fat is laid down in tissues -- well, the cells resemble very closely undifferentiated fibroblasts. Follow these things histologically and you have a relatively small cell -- I am sorry I don't have a slide to show this -- you have a relatively small cell that develops fatty droplets. You see the formation of fatty droplets. These fatty droplets increase in number and in size. They get bigger and bigger. The cell swells and finally you get a very large, swollen cell which runs a very high per cent fat. Histologically we associate these fats with almost all types of connective tissue, and adipose tissues represent merely those tissues in which we have the highest concentration of these fat depositing cells.

In closing I want to set out one point which I feel would be a very challenging thing for research, and that is we have these fat cells or these connective tissue cells which store fat. The histologists assure us, or at least tell us, that these fats are essentially the same. Actually we find that these cells store considerably different fats. Now what could be the metabolic difference, the difference in mechanism, by which these apparently identical fat cells function in order to produce rather surprisingly different types or percentages of fatty acids?

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MR. SULZBACHER: Thank you, Max.

I should like to warn all of you fellows that this is not the last of the subject that Max has been covering and we will hear more about it before the morning has past. But our thought was that we
would follow this procedure: Max would tell us a little about the chemistry of fat, the way in which it is deposited in the animal, and then we would consider how the meat packer or the processor, whoever he might be, gets this fat out of the tissue and into a form acceptable to commerce. My old boss, O. G. Hankins, used to be fond of saying that we are in the research business, and there are also a lot of businesses that are in research.

One of the men in such a business who has to my mind done a very remarkable amount of thinking about this whole subject and has a tremendous grasp of it is John Thompson who is president of the Reliable Packing Company here in Chicago. He has for many years been interested in trying to develop better means by which the packer -- particularly the small packer -- can get his lard out of the fatty tissue and produce it in an economical manner and turn out a product that is superior with respect to some of the qualities that Mr. Brockmann mentioned.

So I think that since many of you people already know John Thompson I will simply now turn the program over to him. I know that he will do a particularly able job in telling you fellows just how this is managed. John, it is all yours. (Applause)

MR. JOHN E. THOMPSON: Thank you, Bill, for that expression of confidence.

Ladies and gentlemen, I realize that you folks are professionals in this meat business. I have no intention here of talking down to you but I am going to warn you now that I intend to paint with a very broad brush, and if there are specific questions later I will make a sincere attempt to answer them for you.