MEASURING THE OIL-BINDING CHARACTERISTICS OF FLOUR[1]

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ABSTRACT

Cereal chemists are well aware that different flours may exhibit wide variations in water absorption capacities. That flour can exhibit a strong affinity for fats is also generally recognized by the difficulty of extracting fat from doughs and baked products without resort to acid hydrolysis. Two methods for measuring oil-binding characteristics of flour are described. With increasing protein content, oil-binding capacity increases. That this effect is not entirely explained by an interaction between protein and oil is demonstrated by an experiment in which the oil-binding capacity of wheat starch was increased by a chlorine bleaching treatment.

That the phenomenon is physical rather than chemical is demonstrated by the observation that comparable oil-binding measurements are obtained regardless of whether the oil is a comparatively unsaturated triglyceride, a saturated triglyceride, or a hydrocarbon (mineral) oil.

That different flours may exhibit wide variations in water absorption capacities is well known by cereal chemists. Also, that flour can exhibit a strong affinity for fats is also generally recognized by the difficulty of extracting fat from doughs and baked products without resorting to acid hydrolysis. Olcott and Mecham (2) showed that the amount of lipid no longer available by ether extraction which can

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be bound by a dough prepared with an excess amount of flour lipids is approximately three times the amount of lipid in the original flour. Mecham and Weinstein (1) indicate that different wheats bind different amounts of lipids which may be due in part to the protein content.

Techniques for measuring the oil-binding properties of flour are not generally employed. The following paper describes two methods which may be used for measuring the oil-binding characteristics and/or capacities of flours.

Materials and Methods

Babcock and Centrifuging Method. One gram of flour (14% m.b.) is weighed into a "milk"-type Babcock test bottle. Oil (1 ml.) and distilled water (15 ml.) are added to the Babcock bottle. The weight of oil introduced into the Babcock bottle should be about 0.2 to 0.5 g. in excess of the weight of oil which the flour will bind or absorb in the course of the test. The flour-water-oil system is thoroughly mixed by rotating the Babcock bottle swiftly in a to-and-from direction, using the neck of the bottle as the axis of rotation. The suspension is agitated for 15 seconds every minute for 10 minutes. At the end of this 10-minute period, 25 ml. of water are added to the Babcock bottle. Again the suspension is agitated for 15 seconds every minute for 5 minutes. At the end of the second agitation period, the suspension is centrifuged for 10 minutes at 1,200 r.p.m. Immediately after centrifuging and with the least possible agitation, an additional amount of water is introduced into the Babcock bottle to the highest graduation on the bottle. The suspension is then centrifuged for 5 minutes at 1,800 r.p.m. Immediately after the second centrifuging the volume of oil at the top of the bottle is read. Also, the volume of the layer of sludge immediately below the oil layer and above the water layer is recorded. The weight of oil absorbed per g. of flour is then calculated.

Amylograph Method. The heating elements of the amylograph are turned off. One-hundred and fifty grams of flour (9.5% m.b.) and 140 ml. of the light-weight mineral oil are used. Other oils may be used if desired. The mineral oil (approximately half the amount) is introduced into the amylograph bowl. The flour is added on top of the oil and the remainder of the oil is added. The slurry is mixed with a spatula in the bowl. The amylograph is run for 2 minutes, and the slurry is again mixed with a spatula to make sure all of the flour has been wetted with the oil. The sample is run for an additional 15-minute period. The readings of the height of the curve are recorded at the desired time intervals. Five-, ten-, and fifteen-minute intervals give a good profile of the curve.

Results and Discussion

Figure 1 demonstrates the difference in oil-binding capacities of two flours. Sample A absorbs or binds more oil than sample B and is a stiff puttylike mass. Sample B is soft and more flowable. In each case the same weight of flour and the same amount of oil was used.

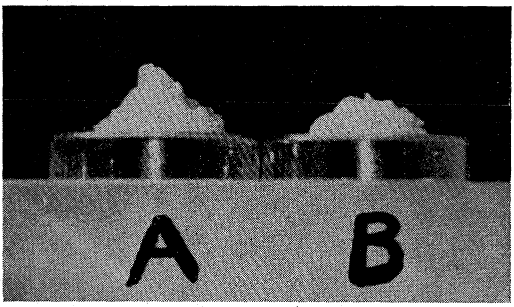

Fig. 1. The oil-binding capacities of two flours. Same weight of oil and flour used. Flour A, stiff puttylike mass. Sample B, soft flowable mass.

In Fig. 2 are shown four different flour samples which have been tested in the Babcock bottles. It can be seen that samples 1 and 2 absorbed less oil and had less sludge than samples 3 and 4 which absorbed more oil but had a greater amount of sludge.

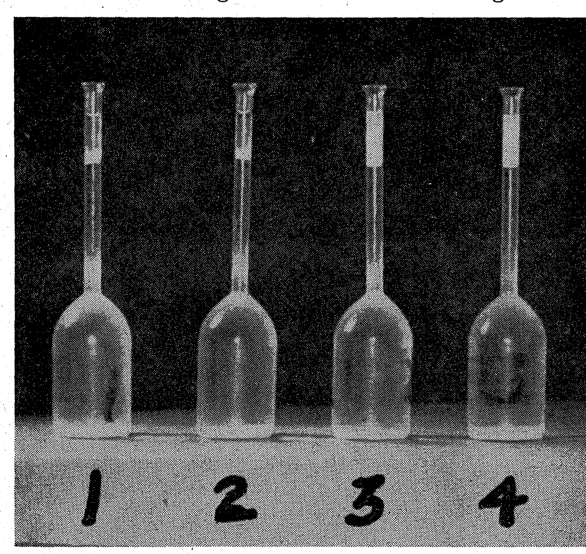

Fig. 2. Samples after final centrifuging in "milk"-type Babcock test bottles. Layers in neck: top, oil not bound; middle, sludge (mixture oil-water-flour); bottom, water. Layers in base: top, water; bottom, flour with absorbed water and oil. Sample 1, 0.336 g.; sample 2, 0.379 g.; sample 3, 0.658 g.; and sample 4, 0.717 g. of oil bound per g. of flour.

Flour type, as well as the amount of protein, affects the amount of oil absorbed. Figure 3 shows the amount of oil absorbed for different types of flours at different protein levels. Also shown is a wheat starch to which various increments of vital gluten were added to adjust to different protein levels. These data show that protein content has a definite influence on the amount of oil absorbed or bound.

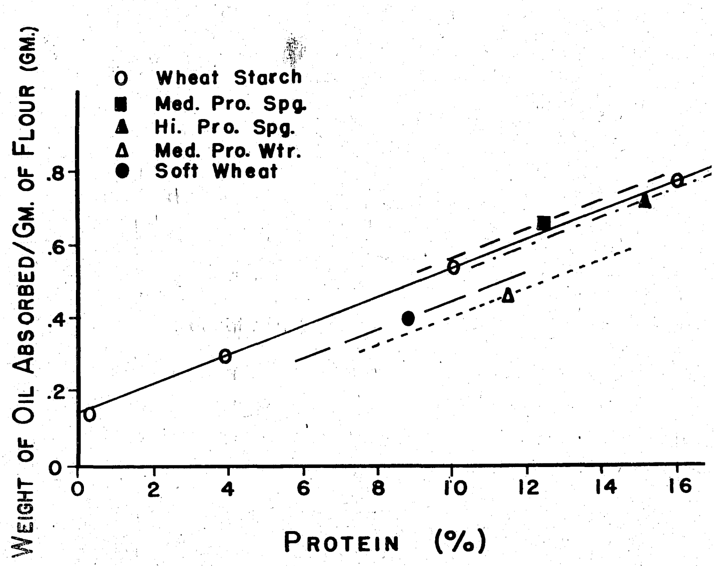

Fig. 3. Relationship of oil absorbed to flour protein content and types of flour.

In Figure 4 is shown a similar wheat starch-vital gluten series run on the amylograph. The data show that the amount of oil absorbed increases with increased protein content and that there is a curvilinear relationship between the viscosity of the oil-flour slurry and the protein content.

The effect of chlorine bleaching upon the oil absorption characteristics of the flour is shown in Fig. 5. A sample of soft wheat flour was bleached with various increments of chlorine. These data show that the amount of oil absorbed per g. of flour is increased with applied chlorine.

Figure 6 shows actual amylograms, superimposed, of oil-flour slurries for a chlorine-bleached soft wheat flour. The viscosity of the slurry increased with added increments of chlorine, showing that there is an increase in the oil-binding capacity of the flour with the addition of chlorine bleach. A plot of the viscosities vs. chlorine is similar to that shown in Fig. 5 and there is a curvilinear relationship.

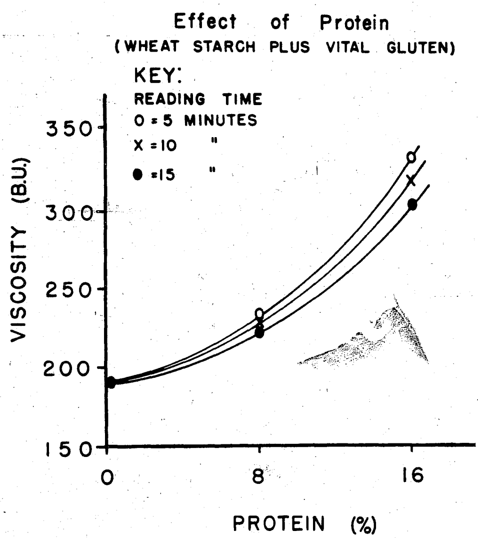

Fig. 4. Relationship of amylogram viscosities to flour protein content for oil-flour slurries.

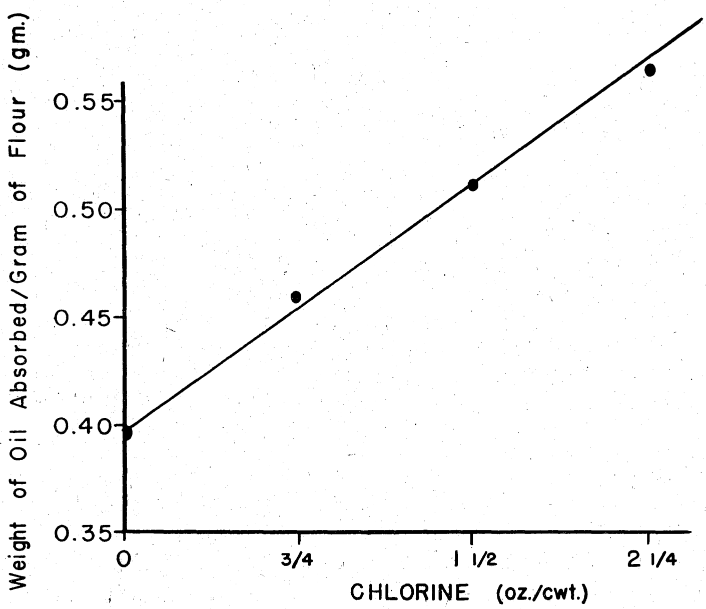

Fig. 5. Relationship between oil absorbed and amount of chlorine bleach applied.

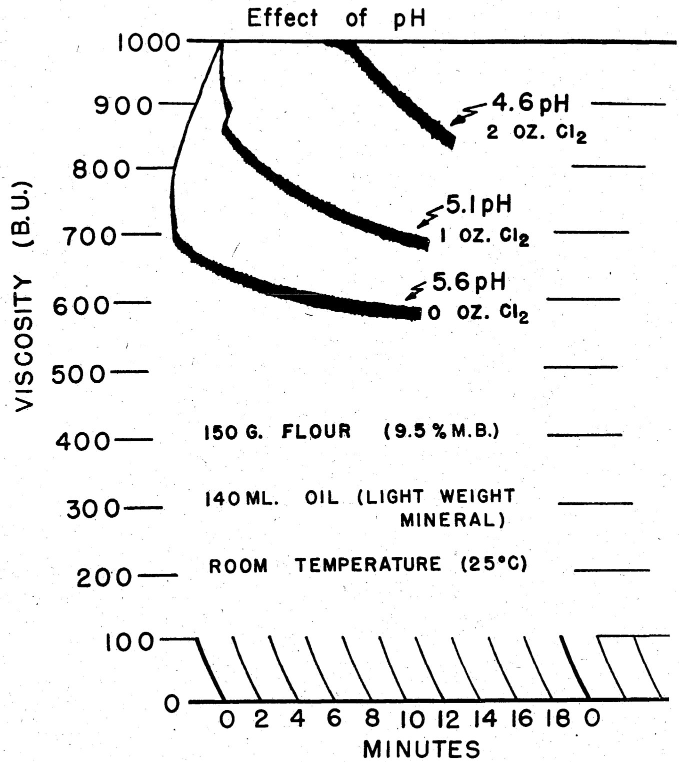

Fig. 6. Amylograms of oil-flour slurries with different increments of chlorine bleach applied to the flour.

From these two studies it might be concluded that protein and/or the effect of chlorine bleach on the protein was the only factor affecting the oil-binding capacity of the flour. However, as is shown in the table below, wheat starch also exhibits the property of absorbing oil.

Effect of Chlorine Bleach on Oil-Binding Characteristics of Wheat Starch

Sample	*pH*	*Weight of Oil Absorbed per g. of Flour*
		g.
Regular	5.71	0.130
Bleached	5.35	0.262

The sample of wheat starch used contained 0.25% of protein. The data showed an increase in oil absorption when the wheat starch was bleached with chlorine. This would indicate that chlorine bleach, in itself, is an important factor in influencing the oil absorption characteristics as shown by the data given in Figs. 5 and 6, and that this influence can be independent of the protein content, which was shown in Fig. 3.

If this binding of oil was selective and/or chemical, the type of oil used should affect the amount of oil bound by a given flour. However, the data shown in the following table indicate that the oil-binding

Amount of Different Types of Oils Absorbed by a Given Flour

Oil Type	*Iodine Number*	*Weight of Oil Absorbed per g. of Flour*
		g.
Mineral	. . .	0.512
Coconut	9	0.517
Corn	111	0.506
Linseed	185	0.496

property of a flour is independent of the type of oil used. In this particular series approximately 0.5 g. of oil was absorbed per g. of flour. This would indicate that the amount of oil absorbed is independent of the type of oil used, and the oil is bound physically rather than chemically.

The preceding data show that flours have different oil-binding capacities. The two techniques described are comparable in that they both demonstrate the same effects.

The use of oil-binding measurements may be a useful tool for characterizing flours. Preliminary studies have indicated that aged or bleached soft wheat flours bind enough oil to form a gel-like protein-oil-water complex which has a low specific gravity. This gel-like complex is the sludge layer formed in the centrifuge method and is not formed when freshly milled and unbleached flour is used. This oil-binding characteristic may be a very useful index for measuring bleaching and/or aging effects.

Literature Cited

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