which the shortening functions properly is called the quality period and may be correlated with the increase in free fatty acid, but there is no particular percentage of free fatty acid which indicates this point for all shortenings. We have established by frying tests that the greater the degree of saturation, the longer the pre-quality period. In the case of the fully hydrogenated cottonseed shortening, a free fatty acid of 0.35% was reached before quality doughnuts resulted. The partially hydrogenated cottonseed shortening developed a free fatty acid of 0.25% before it functioned normally. The corn oil and oil and stearin mixtures were satisfactory at 0.1% free fatty acid. These relationships hold in all cases of machine made doughnuts.

Fatty Acid Added to Accelerate Quality Period

In order to accelerate appearance of the quality period, fatty acids prepared from partially hydrogenated cottonseed shortening were added to the same type shortening in amount calculated to produce a fatty acid content of 0.5%. Doughnuts were fried in this shortening and the length of the pre-quality period noted as well as the rate of fatty acid increase. As was expected, the smoke point decreased, but there was no acceleration of the free fatty acid development. Due to the addition of the free fatty acid there was practically no pre-quality period, as the doughnuts began to develop normally almost immediately and were of the same quality as those fried in a shortening that had reached its quality stage. This subject is still under investigation. It should be noted at this point that although the absorption of the shortening by the frying doughnut is for all purposes constant, we do not advocate the use of oil in the frying of doughnuts because of organoleptic reasons. The desired characteristics of frying shortenings for doughnuts will be found to lie between the oil and all hydrogenated shortening.

Conclusions

1. Neither the peroxide value nor active oxygen hour rating are indicative for quality of frying shortenings used in preparing doughnuts.
2. Fat absorption is not a function of the degree of saturation of frying shortenings.
3. Fat absorption is not a function of the free fatty acid below 0.6%.
4. Added fatty acids decrease the pre-quality period of frying shortenings.
5. The active oxygen hour rating of a frying shortening before and during frying is not indicative of incipient rancidity in absorbed doughnut shortening.

REFERENCES

1. King, Roschen and Irwin. Oil and Soap *9*, 89 (1932).
2. Lowe, B. Research Bulletin 279, Iowa State College.
3. Thiessen, E. J. Food Research *4*, 135-143 (1939).
4. Lea, C. H. Rancidity in Edible Fat. The Chemical Publishing Co., Inc., New York (1939).
5. Hilditch, T. P. Chemical Constitution of Natural Fats, London, Chapman and Hall, Ltd. (1940).

The Phosphatides and Fats in Brewers' and Vinegar Yeast

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There are a large number of investigations (1) and publications about the fat contents of the most common yeast, bakers' yeast, especially the work of F. Salisbury and R. J. Anderson and M. S. Newman (2). These authors also mention that this yeast contains a considerable quantity of lecithin as well as of kephalin, and that the phosphatides of bakers' yeast consist of about 80% of lecithin and 20% of kephalin.

Hitherto there have been no statements about the composition of the fatty matter, especially of the phosphatides in other yeast species. In recent times, however, brewers' yeast has been increasingly important. In a dried form it is used in ever increasing quantities as a medicine because of its extraordinary high contents of vitamins of the B_1 group and as an autolysed extract it is used in the kitchen as a valuable condiment.

Vinegar yeast occupies a singular position because it is an organism living in a strongly acid medium. It was therefore important to discover whether phosphatides could be developed under such extreme conditions and to what extent.

The behavior of fats and phosphatides of brewers' yeast, which was allowed to undergo autolysis at 58° C., was also included in these investigations, whether they would remain in the non-autolysed remnant of yeast to be stored there, or, whether they would be destroyed by the enzymes of the living yeast.

The effect of the "debittering" on the phosphatides was also investigated. All the brewers' yeast, intended for food purposes, must undergo such a process to remove the bitter taste of the hops. For this purpose the yeast is washed with a weakly alkaline medium.

It has frequently been noticed previously that the fats and the phosphatides could only be removed from the raw material to a small degree if they are extracted, after careful drying under a high vacuum, in the usual way, with petrol ether. Even an extensively protected extraction with this solvent only yields relatively small amounts of extract. A second extraction was therefore added to the first. It was carried out with a mixture of 80 parts benzine and 20 parts alcohol—accompanied by heat—and was continued as long as traces of fatty matter would go into solution. To separate out unwanted by-products, especially sugars, the extract was dried under vacuum and treated with pure ether. The clear etherical solution was used for further investigations; but even now all fatty substances had not been removed from the yeast. It is known that 1% HCl solution in alcohol will dissolve out further small quantities of fatty matter. This method was, therefore, used as third extraction. It was naturally expected that this treat-

TABLE 1

Petrolether Extract

	Dried Brewers' Yeast	Dried Vinegar Yeast	Dried Debittered Yeast	Dried Autolysed Yeast Residue
Amt. of Extract	0.28%	3.39%	1.62%	1.65%
Amt. of Oil	0.23%	3.33%	0.87%	1.07%
Amt. of Phosphatides	0.047%	0.06%	0.75%	0.47%
% P.	4.86%	6.48%	3.90%	6.06%

Alcohol soluble in Dried Brewers' Yeast—64.2% Lecithin.
Alcohol insoluble in Dried Brewers' Yeast—35.8% Kephalin.

TABLE 2

Alcohol and Benzol Extract

	Dried Brewers' Yeast	Dried Vinegar Yeast	Dried Debittered Yeast	Dried Autolysed Yeast Residue
Amt. of Extract	1.71%	4.26%	2.49%	3.98%
Amt. of Oil	0.93%	4.07%	1.02%	2.49%
Amt. of Phosphatides	0.78%	0.19%	1.47%	1.32%
% P.	2.96%	3.03%	3.93%	3.39%

Ratio: Alcohol soluble phosphatide to insoluble 69:31.

ment would yield little true phosphatides since the acid could cause hydrolysis. The third extract was also dried carefully in a high vacuum and extracted with ether. It was surprising to find that in some of the cases the phosphatides were not totally destroyed and that small quantities could even be extracted by this method. The amount of fats, or fatty acids, which were extracted by this acid medium was quite considerable, between 0.5-1.0% in most of the raw materials—only vinegar yeast gave a very low yield.

The method used for separating the fatty matter of the phosphatide was the usual one. In each case 700 gr. of carefully dried raw material was used. The extracts obtained, after removal of non-fatty matter, were repeatedly washed with cold acetone. The phosphatides were dried under vacuum and then analyzed —in some cases they were split into components—lecithin and kephalin—with alcohol, in the well-known manner.

The results of all these experiments are summarized in the four tables.

Conclusion

These investigations give the somewhat surprising result that the vinegar yeast has a relatively very high content of total fats but that the amount of phosphatides is extremely low. Brewers' yeast contains less than half the total amount of fat but its phosphatide content is more than three times as great. The washing process with a weak alkali considerably increases the fat content and especially that of the phosphatides. It is furthermore surprising that the autolysis hardly affects the phosphatides at all. It is very well known that the proteins of the yeast are split, during the autolysis, into amino acids; it is further well known that other ferments attack the

TABLE 3

Alcohol and 1% HCl Extract

	Dried Brewers' Yeast	Dried Vinegar Yeast	Dried Debittered Yeast	Dried Autolysed Yeast Residue
Amt. of Extract	0.93%	0.07%	0.68%	1.51%
Amt. of Oil	.....	.....	.....	1.27%
Amt. of Phosphatides	none	.....	none	0.205%
% P.	.....	1.39%	.....	5.66%

TABLE 4

Total Quantities in the Different Types of Yeast

	Bitter Yeast	Vinegar Yeast	Debittered Yeast	Autolysed Yeast
% of Total Extract	2.97%	7.73%	4.79%	7.00%
% of Oil	1.16%	7.40%	1.89%	4.83%
% of Phosphatides	0.82%	0.26%	2.22%	2.00%

P containing components during this process—but the phosphatides are not—or apparently not in a high degree—decomposed during the long time of the autolysis. The autolysed yeast extract has a high amount of phosphoric acid salts. The fat is hardly affected by the autolysis, although there is a considerable increase in f.f.a.

It is not quite clear what is the cause of the very high P content of some of the phosphatides in the petrolether extract. It is possible that, in spite of frequently repeated re-precipitation, small amounts of other P containing products—in which the yeast is especially rich—are still present. But it seems also possible that some of the phosphatides, especially in a strong acid medium, may be decomposed during the process and glycerophosphates may be formed which still remain in the phosphatides—in such a case the P content would be higher than usual.

The ratio of lecithin:kephalin in those cases where it could be checked was approximately 70:30, which is in accordance with the results obtained by Newman and Anderson, who also found that bakers' yeast has more lecithin than kephalin. (Seed phosphatides usually have more kephalin.) The total fat content also stands in fairly close relation to results obtained by the same authors with the single exception of bitter brewers' yeast. These authors used also a third extraction with 1% HCl in alcohol; our results in this case are also close to those found for bakers' yeast.

REFERENCES

1. Hoppe Seyler Zeitsch, f. physiol. Chemie *2*, 427, (1879); *3*, 374, (1879).
Sedlemayer: Zeitsch. f. gesamte. Brauereiwesers *26*, 381, 397 (1903).
Koch Zeitsch. f. physiol, Chemie, *37*, 181 (1903).
Austin, Jour. Biol. Chem., *52*, 59 (1921).

2. Journal of Biological Chemistry *112*, 541-550 (1936).
Journal of Biological Chemistry *102*, 219-228 (1933).
Journal of Biological Chemistry *102*, 229-235 (1933).
See also: Thierfelder & Klenk Chemie der Cerebroisde and Phosphatide, 1930, page 173-174.
Macleans: Lecithin and allied substances, 1927, 164-165.
Rewald: Bioch. Zeitsch, *218*, 481 (1930).