Mayonnaise Spoilage and Rancidity of Oil

Many Factors Exert Influence Upon Keeping Qualities of Mayonnaise, Thousand Island Dressing and Sandwich Spreads

By A. S. Richardson, E. W. Eckey and J. T. R. Andrews
The Procter & Gamble Company, Ivorydale, Ohio

IN ITS broadest sense, the term "rancid" is applied to almost any material which has developed an offensive smell or taste. We hear of rancid nuts, rancid cheese, rancid butter, rancid bread, rancid candy and we oil chemists hear most of all about rancid oil.

We are inclined to appropriate the word rancidity and think of it as applying primarily to fatty materials. We have even begun to influence popular dictionaries, one of which gives as the preferred definition of rancid: "Having the peculiar smell of oily substances which have begun to spoil." Certainly among ourselves, we oil chemists must think of the word rancidity as applying principally to a certain disagreeable odor and flavor which no one can exactly describe, but which we recognize as one of the results of oxidation of fatty material. In the world at large rancidity is quite another matter; it has long been used and will long continue in use as a general term for offensive taste and smell, regardless of any effort to restrict its meaning.

Even as a technical term in oil chemistry, rancidity must not be too narrowly defined. Each oil presents a separate set of complications. The free fatty acids of butter have a foul odor and may be the sole cause of rancidity in butter fat, whereas cottonseed and most other free fatty acids are odorless and almost tasteless, and have no direct connection with the practical problems of rancidity. The peculiar odor resulting from the oxidation of fish oils is qualitatively different from the odor of oxidized drying oil of vegetable origin, which in turn is different from the odor of oxidized semi-drying or non-drying fatty oils or animal fat. Aside from differences in the nature of the true fatty matter which may be oxidized, each oil has its own peculiar set of non-fatty constituents, small in amount, but sometimes having a powerful effect on the odor of the oxidized oil.

Rancidity Problems of Interest to the Mayonnaise Manufacturer

WHAT aspects of this broad and complicated problem of rancidity of oil are of special interest to the mayonnaise manufacturer? Obviously the mayonnaise manufacturer is directly interested in the rancidity of salad oils only, consisting chiefly of corn oil and winterized cottonseed oil in the United States up to the present time. The interest of the mayonnaise manufacturer is, or should be, confined to the type of oil rancidity which results from oxidation. However, rancidity is by no means synonymous with oxidation, or related to it in any simple manner.

Above everything, the mayonnaise manufacturer should know to what extent rancidity of oil contributes to deterioration and spoilage of mayonnaise. In this connection, a useful point of view will be to consider separately (1) rancidity of salad oil resulting from oxidation up to the time of mixing and packing mayonnaise and (2) history of the oil thereafter.

Development of Rancidity in Oil Before Incorporation in Mayonnaise

OXIDATION of oil doubtlessly occurs to some extent even in oil-bearing seed before crushing. Unpublished data available to the authors suggest that, within practical limits, this is of negligible importance in the case of cottonseed salad oil. Oils believed to be from seed exposed to varying degrees of oxidation were refined and deodorized, and found to show no significant difference in rate of development of rancidity. Further study of this difficult problem may some day yield interesting results.

Oil is next exposed to oxidation as crude oil. Both corn oil and cottonseed oil, in their crude state, show wide variations in their susceptibility, over the same general range, as shown in figure 1. Each curve here gives the result of an experiment in which one gram of oil was exposed to air in a 50 cc. Erlenmeyer flask at 120° F and the course of oxidation followed by means of a mercury manometer. The majority of samples of both these crude oils should be classed as showing relatively high resistance to oxidation. After alkali refining, susceptibility to oxidation is greatly increased and becomes of more practical interest to the mayonnaise manufacturer. At least from this point, all oxidation is injurious to flavors, even if the oil does not become distinctly rancid.

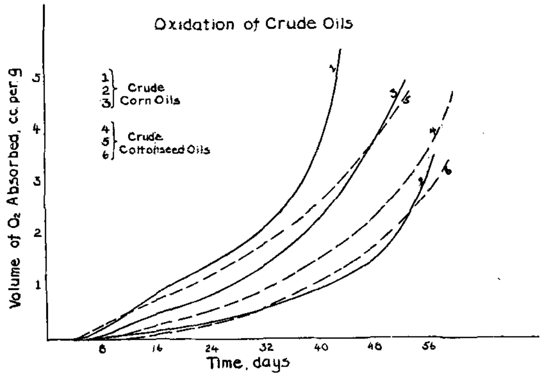

Fig. 1

Winterizing involves very little possibility of oxidation, because of the low temperature at which it is carried out. Steam deodorization, the final essential step in the processing of the edible oil, partially compensates for any previous oxidation, but cannot give neutral flavor to a rancid oil. Neither of these processing steps has any very great effect on susceptibility of oil to oxidation, but careful handling naturally involves less oxidation and gives a better flavor than careless handling.

Different samples of both cottonseed and corn oils, after complete processing as salad oils, will vary in susceptibility to oxidation, again over the same general range. Oxidation curves on the finished oils are similar to those shown in figure 1, except that differences are somewhat less and the average rate of oxidation about five times as fast. Our observations in this respect contradict the statement of Harris and Epstein (The Canner, Dec. 6, 1930, p. 28) that "corn oil is markedly more resistant to attack by oxygen than an oil like cottonseed." We find no consistent drift in favor of either oil as measured by oxygen absorption tests, but do note a less rapid development of objectionable flavor in cottonseed oil under similar conditions of exposure to air. Possibly the conclusion of Harris and Epstein was based on too limited a number of experiments. We have on record individual sets of experiments which would prove (?) *either oil* the more susceptible to oxygen absorption.

Thus up to the point of complete processing of a salad oil, the mayonnaise manufacturer is vitally interested in the problem of oil rancidity. The manufacturer of the salad oil can offer no satisfactory alibi for either a rancid oil or one which is off in flavor as a result of oxidation. The ideal salad oil is an unoxidized oil.

Behavior of the Oil After Incorporation in Mayonnaise

IS there not further great danger from this thing called incipient rancidity? Even though oil of good flavor is put into mayonnaise, does it not later turn rancid and become a major factor in mayonnaise spoilage? The proper answer to this question is an emphatic "no". Incipient rancidity is bad enough from the standpoint of its effect on flavor of oil as incorporated in mayonnaise; to saddle upon it the burden of blame as a major source of mayonnaise spoilage thereafter is without justification in theory or fact. In plain language, the mayonnaise trade has been the victim of mistaken emphasis on the subject, emanating from so many sources that none need be named.

As already mentioned, development of rancidity in salad oil requires oxidation, or, in other words, requires air. Mayonnaise is packed in an almost tight container. Even if the mayonnaise jar contained 20% air, the amount of oxygen furnished thereby (less than 0.01% of the weight of the oil) would be insufficient to make a critical difference in the flavor of the oil. To be sure, further exposure occurs when the jar is opened, but the mayonnaise is usually consumed rapidly or afforded the protection of an ice box or other cool place. There is another factor which, practically speaking, keeps rancidity of oil in mayonnaise from becoming a major factor in spoilage. Even assuming free exposure to air at ordinary atmosphereic temperature, evaporation of water will spoil the appearance of the mayonnaise surface before the oil turns rancid. Of course, oil may get the blame, especially since free oil will probably separate, but oil would still be likely to get the blame even if it were inherently and absolutely unoxidizable.

We have been assuming above that, if mayonnaise is oxidized the oil will take up the oxygen. Even this assumption will not stand critical examination. Egg is rich in material which takes up oxygen more readily than oil. At least two of these substances are known to act specifically as antioxygens, giving a substantial protection against oil rancidity. Harris and Epstein have presented observations on this subject, mentioning cholesterol as the probable inhibitor of oxidation. The full facts have not been developed, but lecithin is in general a still more powerful antioxygen, and is present in egg yolk in still larger amount (about 9%!) than cholesterol.

We do not question the possibility of oxidation of oil in mayonnaise to the extent that might be recognized by some deterioration in oil flavor, if the other ingredients of the mayonnaise were not present to obscure the effect. We merely assert that the condition of oil after incorporation in mayonnaise is such that it is extremely unlikely to go rancid, and that rancidity of present day salad oils is not a major factor in mayonnaise spoilage. We have at various times examined hundreds of samples of mayonnaise in various stages of deterioration, including many dozens of samples which had to be regarded as inedible. In a negligible number of such samples was there ever any suggestion of oil rancidity.

Why, then, does mayonnaise go rancid? In the special sense of oil rancidity, it rarely does. In the broader sense, it does go rancid, and for the explanation we should look to the organic constituents other than oil. The egg is the most perishable material; vinegar and sugar not above suspicion; and even the spices are subject to decomposition when wet.

In view of its composition, spoilage of mayonnaise is remarkably slow. A tight container, sufficient in itself to protect the oil, is no insurance at all against decomposition of egg. The latter, unmixed with other materials, would undergo bacterial decomposition and spoil within a few days, whereas a typical good mayonnaise is likely to remain quite fresh for weeks and edible for months. As is well recognized, some of the other ingredients in the mayonnaise must protect the egg from its usual rapid spoilage.

We have investigated the usual ingredients separately and in all possible combinations, and find the triple combination of salt, vinegar, and a little mustard oil a remarkably effective, but not perfect, egg preservative. Probably the oil has considerable additional preservative effect, although alone it would be ineffective. Thanks to the combined preservative effect of these ingredients, the bacteria normally present in egg are killed or suppressed to the point that commercial mayonnaise ordinarily spoils very slowly. However, mayonnaise has been known to spoil rapidly, becoming practically inedible within as short a time as two or three weeks. This is not the normal behavior, but has occurred not infrequently in the past. This rapid spoilage used to be very mysterious. We have fairly well emerged from darkness to light, with remarkably little frank and open discussion of the important factors involved.

Let us go back about six years. A number of people were making good mayonnaise, including several large producers. In one way or another they knew the secret of avoiding rapid spoilage, but naturally enough they were not telling all they knew. There were learned (?) dissertations and speeches on mayonnaise spoilage. Troubles were classified, for instance, as physical and chemical, and these further classified into subdivisions. The result was usually a catalogue of the causes of mayonnaise spoilage, more or less truthful, but not very useful on the particular subject of rapid development of rank flavor.

About five years ago we started out in our laboratories to find which ingredients in mayonnaise were chiefly responsible for rapid development of bad flavor. The results were striking; mustard alone presented a serious problem. The other ingredients from almost any source made mayonnaise that kept well, but of commercial brands of mustard flour tested at that time only two appeared safe, as compared with a much larger number which introduced a fatal contamination, presumably bacterial in nature. We have not reinvestigated the matter, but understand that the situation is now greatly improved. The matter of contamination through the spices has been gradually dragged into the open, with rather less emphasis than it deserves. Possibly we put undue emphasis on the mustard; if so, let others offer their evidence.

Mariam S. Iszard was one of the first to focus attention on the spices. (Canning Age, *8*, 434 [1927]). Dr. Iszard isolated specific bacteria associated with spoilage of salad dressing, and attributed the contamination to "a heavily spiced foundation paste." She did not study the spices separately. Gray, discussing bacterial spoilage in mayonnaise relishes and spreads, suggested the sterilization of the separate ingredients, and called particular attention to a bacterial spore in pimentos, resistant to heat. (The Canner, Aug. 6, 1927, p. 31.) Pederson, studying bacterial spoilage of thousand island dressing, found contaminating organisms in pepper and paprika. (The Spice Mill, *54*, 405 [1931].) Doubtlessly this list of references could be extended further.

When mayonnaise is diluted or mixed with other ingredients to make sandwich spreads, thousand island dressing, and other specialties, the chances of bacterial spoilage are greatly increased. In such preparations, mustard contamination is only one possibility to be emphasized. But when mayonnaise proper deteriorates so rapidly as to become inedible within a few weeks, it is time to examine the mustard very critically. Mustard oil is free of this contamination and may serve as a useful check against suspected mustard flour, even though the latter may be preferred for regular use.

Summary

SUMMING up, we believe that the mayonnaise manufacturer is vitally concerned with oil rancidity, but that the whole of his real interest relates to the problem of getting an oil of good flavor into the mayonnaise. Thereafter, development of rancidity in present day salad oils is so slow that it is practically never a critical cause of mayonnaise spoilage.

The oil in mayonnaise is normally well protected against appreciable oxidation by antioxygens in the egg and by a closed container. If it is freely exposed, the mayonnaise is spoiled by surface evaporation of water before the oil has time to become rancid.

The important cause of mayonnaise spoilage, other than mechanical separation, is bacterial decomposition. Decomposition due to organisms from the egg is fairly well checked by the preservative action of salt, acetic acid, and mustard oil. Resistant organisms capable of causing rapid spoilage of mayonnaise are most likely to be introduced through mustard flour. Some mustard flours are suitable and some unsuitable for mayonnaise.

■

Glycerin Analysis Committee Report

The Glycerin Analysis Committee will continue the investigation begun last year of the discrepancy between the acetin and other methods of glycerin analysis. We propose to determine first the cause of the low results by the acetin method and, once the cause is known, we hope to find a remedy for it, if possible.

The membership of the Committee will remain essentially the same as last year.

J. T. R. ANDREWS, *Chairman*

■

Comparative determination of free fatty acids in fats showed that as accurate results are obtained by use of a solution of alkali in alcohol as by the use of a mixture of alcohol-ether or alcohol-benzene, provided the titration is carried out at high temperature when ether or benzene is not used. Moreover, the use of ether has the disadvantages that the dissolved neutral fat is very easily saponified (this makes the endpoint more difficult to detect) and that commercial ether frequently contains esters which are saponified at low temperature and are, therefore, counted as acidity of the fat, (this necessitates preliminary distillation of the ether over sodium). No difference was noted when aqueous or alcoholic potassium hydroxide solution was used. *Chimie et Industrie,* Special No. 637 (March, 1931).

■

A hydroxy-polybasic aliphatic acid compound such as a tartrate may be added to compositions such as those containing castor oil and nitrocellulose in order to retard rancidification. U. S. Pat. No. 1,805,458.

■

The rate of expansion of fats on heating, starting with solid fat at 20° C., has been investigated with the aid of a specially designed dilatometer. A myristo-laurin mixture expands during melting at 35°, 8,500 cubic millimeters per 100 grams; fully hardened linseed oil (almost pure stearin) expands up to 39°, then contracts from 39 to 47° to even below its original volume, then expands again and at 64-69° the volume increase is 16,900 cu. mm. per 100 g. Oleic acid shows a fairly uniform expansion rate without sudden increase at any one temperature, but slight irregularities appear when the rate of freezing is varied. More or less irregular curves are shown for tallow, butter fat, compound lard, hardened soybean oil and hardened peanut and fish oils. *Chem. Umschau Fette, Oele, Wachse Harze* 38, 17-22 (1931).

■

Mrs. M. F. Lauro, wife of Michael F. Lauro, Assistant Chemist, Bureau of Chemistry, New York Produce Exchange, passed away at Liberty, New York, on November 10th. She was survived by her husband and two children. Mr. Lauro has been a frequent contributor to the scientific literature of the American Oil Chemists' Society and has been *Chairman* of the Olive Oil Committee for the past two years. The sympathy of his many friends in the Society is extended him in his loss.

■