THE ROLE OF FATS IN POTATO CHIPS

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If we neglect the small amount of moisture present, potato chips are typically about 60% potato solids and 40% fat. United States Department of Agriculture potato research has been reported to chippers over a number of years. A great volume of this work has originated with the staff members at Beltsville, Maryland. Other potato studies associated with chip manufacture have emanated from the Western Regional Research Laboratory. The potato research of the Eastern Regional Research Laboratory related to chips was previously reported before the Eastern Regional group of Potato Chip Institute, International[1]. The United States Department of Agriculture, while conducting more research on the potato than on the fat fraction of chips, has not neglected fat research. The purpose of this paper is to summarize what is known concerning fats in potato chips.

The paper "The Relative Value of Various Lards and Other Fats for the Deep-Fat Frying f Potato Chips"[2] by Florance B. King, Rosemary Loughlin, R. W. Riemenschneider and . R. Ellis appeared in 1936, while the chip industry was making its early strides leading to the impressive stature it has now attained. These U.S.D.A. authors used different types of unhydrogenated lards, hydrogenated lard, hydrogenated cottonseed oil, and refined corn, cottonseed and peanut oils for frying chips. They made several observations that have since become common knowledge. Among these are that, in fat deterioration, the free fatty acid content does not increase as rapidly on continuous frying as does the peroxide value (measure of oxidation), and that peanut oil is unusually desirable for chip frying.

The Eastern Regional Research Laboratory has conducted a comprehensive research program on animal fats on a continuous basis since the building was first occupied in 1940. Researches on corn and soybean oils are conducted at the Northern Regional Research Laboratory at Peoria, Illinois and on cottonseed and peanut oils at the Southern Regional Research Laboratory at New Orleans, Louisiana. Much of the attention in the animal fats research at the Eastern Laboratory has been directed toward non-food, industrial uses, leading to a series of accomplishments that have been widely recognized. Attention has also been given to the meat food fats: lard and beef tallow. Mr. R. W. Riemenschneider and associates have conducted studies regarding food fats and factors determining their quality and preservation of quality. Mr. Riemenschneider addressed the PCI meeting in Chicago in 1952 on "Meat Fats for Frying Potato Chips"[3]. In this, he pointed out that meat fats should be given serious consideration in chip frying.

NATURE OF FATS AND THEIR DETERIORATION

is difficult to tell chippers something that is really new to them concerning the nature of fats. By means of talks presented at national meetings, through PCI technical reports, and through columns of the Potato Chipper, the fundamentals have been well stated. However, in this age of accelerated developments, complexities,

and business pressures, one can keep abreast only of the subjects in which he specializes. With this thought in mind, we will take some time to review the basic facts concerning fats.

Fats, whether they be of animal or vegetable origin, in liquid or solid state, are principally compounds of glycerol (glycerine) and fatty acids. When heated in the presence of water, fats eventually split to some extent to give free fatty acids. Extensive splitting action causes the fat to become rancid and lowers its smoke point. In the presence of oxygen and accelerated by heat and the presence of traces of metals, fats undergo oxidation. This type of deterioration gives rise to an off-odor and off-flavor. Unsaturated fats, that is, those that can add certain elements such as hydrogen and iodine, undergo oxidative deterioration more readily than those that are nearly saturated.

SUMMARY OF FAT USAGE IN CHIP FRYING

Mr. Olen C. Turner reported in 1955[4] that of 102 chippers surveyed, 46 used vegetable oil, 26 hydrogenated vegetable shortening, and 22 used mixtures of these two, with 8 failing to disclose the fat employed. Of the 46 chippers using vegetable oil, 27 used cottonseed oil, 11 corn oil, 2 peanut oil and 6 did not specify the oil used. No information was given regarding the total amount of each kind of fat used in the plants surveyed. Hence, the total quantity of each fat involved may not have been, by any means, proportional to the number of chip plants using the respective fat. Apparently little or no meat food fats are used in chipmaking, as far as we are aware. While 20-25 years ago meat food fats were deficient in stability relative to hydrogenated vegetable shortening, the quality of meat fats has been so improved that they are now probably equal to any product of vegetable origin. The popularity of meat food fats in pastry shortening is of long standing. Lard is used by many of the best bakeries and in hotel and restaurant kitchens because it is recognized that it gives baked products of fine flavor and a crisp, flaky crust. Lard also finds favor in baking due to the fact that it is comparatively economical as a rule. Practically all of the pre-mixing baking formulations use animal food fat as the shortening.

INDUSTRIAL AND PCI COOPERATION IN FATS RESEARCH

Companies engaged in the extraction and refining of vegetable oils and meat fats and in the hydrogenation of fats have contributed immensely in the accumulation and dissemination of information regarding their products. Industrial firms engaged in packaging materials and machinery and those manufacturing and selling antioxidants have cooperated with the chip industry in conducting needed research and making available their findings. The American Meat Institute Foundation also has been responsible for advancing the state of knowledge concerning the use of fats and oils, with and without antioxidants, in chip frying.

The importance of research was fully recognized by PCI in 1948, with appointment of a Research Committee which met regularly. Some of their meetings were held with U.S.D.A. personnel. Mr. Frederick J. Meyer was the first chairman of this PCI Research Committee and his interests in this direction have never diminished. Mr. Meyer also served on the U.S.D.A. Potato Research and Marketing Advisory Committee for 8 years. Another early chairman of the PCI Research committee was Mr. E. L. Nicolay. Under his leadership the Production and Technical Committee was established. Cooperation

through this "F and T" Committee, of companies supplying chippers with their fats and packaging materials has been an outstanding example of industries working together to solve research problems.

Research was conducted in 1948 at the Southern Research Institute on the summer storage of potato chips, under contract for PCI. Results from this research[5] pointed to the advisability of using high quality fat, adding an antioxidant to the fat, and exclusion of light in the packaging.

The consensus seems to be that peanut oil is without peer among the vegetable oils for chip frying, but it is used less than cottonseed or corn oil because of its slightly higher price. The stability of cottonseed and peanut oils toward oxidative deterioration has been well reviewed by Dollear[6]. Soybean oil early came into disfavor for frying because of its tendency to take on an objectionable off-flavor, probably due to oxidation. This flavor deterioration is called "reversion".

Unquestionably, soybean oil is one of the principal oils hydrogenated. Although liquid soybean oil is not usually used for frying chips, mixtures of the hydrogenated oil are accepted for this use in some parts of the country as a result of technical improvements in processing.[7] It has been demonstrated by the American Meat Institute Foundation[8] and by members of the industry[9] interested in both meat food fats and vegetable oils that meat fats properly rendered and processed, containing an antioxidant, present an excellent frying medium for producing chips of fine flavor and good keeping quality.

PROTECTION OF FAT QUALITY

Every chipper's attention has been drawn a number of times to the various important factors to be observed in preserving the flavor, color, and general quality of frying oil or shortening. Frying temperature should be kept no higher than necessary consistent with high production of chips that do not contain excessive fat. Localized heating should be avoided by some system of rapid transfer of heat to the fat bath, and heat should be turned off when chips are not being fried. The fat should be filtered continuously or as often as necessary to remove charred particles. Stack "drip back" should be prevented as this condensate is high in free fatty acids. Air should be excluded as much as possible from the fat at all times. Riemenschneider recently reviewed comprehensively the oxidation of fats and their stabilization by antioxidants.[10] The fast fat turnover in chip frying relative to other types of frying helps keep the fat in good condition, but still it should be discarded when necessary. Many feel that the fat should be discarded when the free fatty acid content reaches about 0.5%. Contamination with metals, particularly copper, should be avoided. A suitable antioxidant mixture should be used when necessary. Furthermore, the chipper using straight limpid oil in cool weather may be forced to use a blend with solid fat in hot weather in order to obtain "dry" chips of pleasing appearance and "feel" in the mouth.

LARD IN CHIP FRYING AND ITS PRESERVATION BY USE OF ANTIOXIDANTS AND SYNERGISTS

Vegetable oils contain natural antioxidants called tocopherols. Admixture of as little as 5 to 6% of vegetable oil or shortening with lard increases the stability of the lard 2 to 3 fold.[3] Addition of more vegetable fat gives a mixture of even

greater stability. Magoffin and Bentz[9] found that chips fried in a mixture of equal amounts of lard and peanut oil kept better than those fried in either fat alone. Chips fried in equal amounts of vegetable shortening and lard kept nearly as well as those fried in vegetable shortening alone and much better than chips fried in lard alone.

Olen C. Turner reported from a 1955 survey of the practices of 102 chippers, referred to previously, that 41% used an antioxidant in some form, i.e., in the frying medium, salt, or both. A popular type of antioxidant mixture contains butyl hydroxyanisole ("BHA") (and perhaps some butyl hydroxytoluene ("BHT")), propyl gallate, and citric acid all dissolved in propylene glycol to give a solution containing about 30% total solids. While BHA, BHT, and propyl gallate are regarded as antioxidants proper, citric acid is regarded as a "synergist" and deactivates traces of metals found in the oil bath. The antioxidants mixture is sometimes added in quantity sufficient to make up about 0.1% of the fat medium, but it is effective in much lower concentration for stabilizing chips.

Morris and others at the Eastern Regional Research Laboratory[11] found that the presence of copper, iron, nickel, or tin salts in only a few parts per million greatly diminished the stability of lard, even in the presence of antioxidants. They also evaluated various acid and acid salts as synergists, finding ascorbic acid to be more effective than the commonly used citric acid.

ard used in chip frying should be a good grade of prime steam lard, preferably deodorized, and processed to give a "neutral" flavor. It should be stabilized with an antioxidant to extend the shelf life of the chips. If one desires maximum shelf life from this type of shortening, the use of hydrogenated lard containing an antioxidant is essential.

THERMAL POLYMERS

The possibility of development of thermal polymers in chip frying fat was discussed by Melnick,[12] following a survey made on samples submitted by 89 chippers to the P & T Committee in 1957. If such insoluble material were formed in any considerable quantity, the nutritive value of the fat would be reduced. The results of this survey, fortunately, indicated that there is little polymer formation in vegetable oils and shortenings under conditions of chip production. While under good operating conditions, the amount of polymer accumulation in the kettle does not appear to be alarming, studies on the physiological effects of these polymers strongly suggest that continued attention should be given to the question of how often the kettle fat should be discarded. The magnitude of the decrease in iodine value (measure of the degree of unsaturation), following use of the fat in frying, was taken as an indication of the amount of polymer formation. Although the drop in iodine value was small in all instances, it was less in partially hydrogenated vegetable shortenings (relatively high in saturated fats) than in limpid oils. In lard, we have a shortening containing a fair amount of natural saturated fatty acids.

SUMMARY AND CONCLUSIONS

The use of oils and shortenings in chip frying has received considerable attention of research workers in government and industry. Much progress has been made in developing improved methods of handling and stabilizing frying fats. Cottonseed oil,

corn oil, peanut oil, and hydrogenated vegetable shortening are the principal fats employed in chipmaking. While little or no meat food fats are used at present by chippers, to the best of our knowledge, there seems to be no doubt that high quality, stabilized lard would be quite suitable from all considerations. Lard is somewhat cheaper than vegetable oil or shortening, at least during some periods. Apparently, then, chippers should consider meat food fats for some of their frying since this type of fat has been shown to give adequate performance and is a product of American agriculture chemically similar to vegetable oils and shortenings.

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