The Importance of Peroxide Value in Assessing Food Quality and Food Safety

Sir:

Fats and oils in foods are oxidized during processing, circulation, and preservation. This reaction causes deterioration in taste, flavor, odor, color, texture, and appearance, and a decrease in the nutritional value of the foods (1). Furthermore, the reaction can induce food poisoning. Therefore, from a food quality and food safety perspective, this oxidation reaction must be suppressed. Instant noodles are a fried food, and therefore instant noodles contain a lot of fat and oil. In 1964 and 1965, Japan had a food poisoning epidemic caused by the degradation of the fat and oil in instant noodles (2). Many people who ate the degraded instant noodles developed acute symptoms such as diarrhea, nausea, emesis, abdominal pain, fatigue, and headache, but fortunately, no one died. After the incidents, the Ministry of Health and Welfare, currently the Ministry of Health, Labor and Welfare, in Japan set standards for instant noodles in the Food Sanitation Law to protect against food poisoning and to control the quality of instant noodles. In that law, peroxide value (PV) and acid value (AV) were chosen as useful indices to control food safety and quality, and the standard values of PV and AV were set at no more than 30 mequiv/kg and 3, respectively. These values were chosen because they indicate the initial stage of fat and oil deterioration. After setting these values, there have been no reported cases food poisoning caused by instant noodles in Japan.

At the initial stage of fat and oil deterioration, the reasons for measuring PV and AV are very different because of the different mechanisms underlying the formation of hydroperoxide and FFA from fat and oil. Hydroperoxide is formed by the oxidation of fat and oil, whereas FFA are formed by the hydrolysis of fat and oil. PV is an index to quantify the amount of hydroperoxide in fat and oil. Several studies have reported that secondary oxidized oil products are generally toxic (3). Also, weakly oxidized fat and oil at levels of only 100 mequiv/kg of PV are neurotoxic (4). Therefore, the formation of hydroperoxide, the primary oxidized product of fat and oil, must be suppressed to protect against the oxidation of fat and oil and the formation of secondary oxidized products from both food quality and food safety perspectives. Meanwhile, AV is an index to measure the amount of FFA. The FFA themselves are not toxic; however, the presence of FFA affects food quality. Consequently, measuring both indices is indispensable to control food quality and safety.

There is currently a movement worldwide to use only AV to control food quality and safety. For example, the 36th session of the Codex Committee on Food Additives and Contaminants held at Rotterdam, The Netherlands, in 2004 expressed the opinion that PV is not a safety factor (5,6). As a result, the 28th session of the Codex Committee on Methods of Analysis and Sampling held at Budapest, Hungary, in 2005 determined that only AV is useful as an index of fat and oil deterioration to control the quality and safety of instant noodles. PV was not recommended as an index in this standard (7). This is very dangerous, because there is evidence that the oxidized products of fat and oil formed from deteriorated fat and oil are the real cause of food toxicity (3,4). Furthermore, it is impossible to predict the magnitude of the PV from the AV because the underlying mechanisms of formation are completely different.

As an illustration, 218 kinds of fried-type instant noodles of package and cup-type were collected from commercial sources all over the world (including Brazil, China, England, Germany, India, Indonesia, Japan, Korea, The Netherlands, The Philippines, Singapore, Thailand, USA, and Vietnam), and PV and AV were measured to determine the levels of deterioration of instant noodles sold in the market and the relationship between PV and AV.

Figure 1 shows the relationship between PV and AV in instant noodles. The results demonstrate that both values range widely and sometimes exceed the criteria (PV: ≤30 mequiv/kg and AV: ≤3) established in the Food Sanitation Law in Japan. Because almost all samples were sold in cool conditions, samples exceeding 30 mequiv/kg in PV might have been exposed to strong light for a long period. On the other hand, the samples exceeding 3 in AV might have been stored under high humidity. Light and humidity strongly affect the degradation of fat and oil. If both AV and PV increase simultaneously during storage, then a plot of the two indices would produce a plot with a positive slope and there would be a significant correlation between them. This, however, is not the case (Fig. 1). The correlation coefficient for PV and AV was −0.1083 (calculated using Pearson's product-moment coefficient of correlation), indicating that the plot had a negative slope. In addition, the correlation between PV and AV was low, indicating that PV and AV do not form simultaneously in instant noodles during the initial stage of deterioration. Furthermore, the P value was 0.1106, indicating that the relation between PV and AV was not significant. These results strongly support that PV cannot be estimated from AV.

During food storage, many kinds of reactions, such as oxidation, hydrolysis, polymerization, cyclization, and β-scission can occur in the fats and oils. It is very difficult to determine how the individual reactions interact to form toxic compounds. Almost all of these reactions, however, relate to oxidation and

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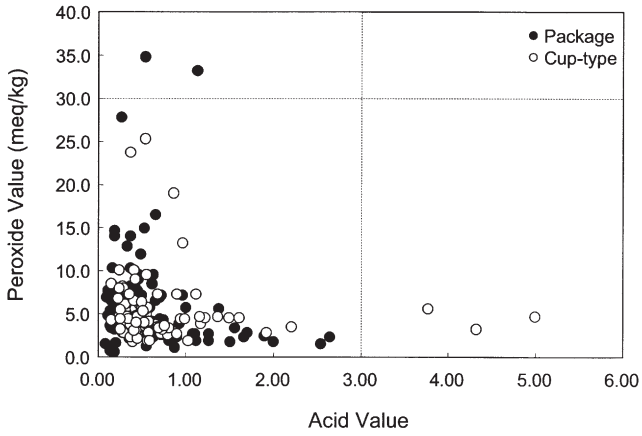

FIG. 1. Plot of acid value vs. peroxide value (PV) in instant noodles collected from around the world (n = 218).

proceed *via* the formation of lipid hydroperoxides. Consequently, protecting against the formation of lipid hydroperoxides is the best way to maintain food safety and quality. In the Food Sanitation Law of Japan, PV is set to no more than 30 mequiv/kg because deteriorated instant noodles with a PV as low as 100 mequiv/kg have caused food poisoning in Japan (2). A PV value of 100 mequiv/kg might not be very high, but animal studies reveal that this level of deteriorated fat and oil is neurotoxic (4). During the oxidation of fat and oil, sudden oxidation, i.e., the propagation period, occurs after the induction period once the antioxidants in food have been consumed during the induction period. Although 30 mequiv/kg is much less than 100 mequiv/kg, once the sudden oxidation starts during the propagation period the 100 mequiv/kg level would be reached soon after the 30 mequiv/kg level. Furthermore, this initial stage of PV alteration cannot be estimated by changes in AV because the two indices do not increase simultaneously (Fig. 1). Consequently, setting a criterion of 30 mequiv/kg for PV in instant noodles is important to control food safety.

It is not sufficient to monitor food deterioration with AV alone to maintain food quality and food safety. We conclude that PV must be adapted as an index in the Codex standard for instant noodles.

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