KOREAN J. FOOD SCI. TECHNOL.
Vol. 4, No. 4 (1972)

Relative Effectiveness of BHA and Ascorbic Acid in Retarding the Rancidity Development of Potato Chips Stored in Various Conditions

by

Hong-Lyour Kim and Dong-Hoon Kim

Department of Food Technology, College of Agriculture, Korea University

(Received September 6, 1972)

여러 條件下에서 貯藏된 감자튀김의 酸敗에 있어서 BHA 와 Ascorbic Acid 의 相對的 抑制效果에 對하여

金 弘 烈 · 金 東 勳

고려대학교 농과대학 식품공학과

(1972년 9월 6일 수리)

Abstract

In the present study, the relative effectiveness of BHA, ascorbic acid, and BHA+ascorbic acid on the rancidity development of potato chips in various conditions were examined. BHA, ascorbic acid, and their mixture (BHA 0.05%, As. A 0.1%, and BHA 0.05%+As. A 0.1% relative to the weight of the potato chips) were dissolved respectively in 95% ethyl alcohol and incorporated to potato chips in the form of atomized mist.

When the potato chips were stored in a dark place at 33.0±0.5°C, BHA was very effective in retarding the rancidity development of the potato chips. Ascorbic acid showed some antioxidant activity, but it was less effective than BHA. When BHA and ascorbic acid were used together, the antioxidant activity of the mixture appeared to be primarily due to BHA. Irradiation of direct sunlight to the potato chips, which were covered with coloress transparent polypropylene films, reduced the antioxidant activity of BHA incorporated to them. Ascorbic acid appeared to lose its antioxidant activity completely under the same condition. BHA retained a considerable degree of antioxidant activity when yellow transparent polypropylene films were used to cover the potato chips. Ascorbic acid, however, kept little antioxidant activity even in this condition.

Introduction

Prevention of rancidity development is one of the most important factors in extending shelf-life of potato chips.

Smith[1] has reported that BHA and BHT either

alone or with PG delayed the rancidity development of hydrogenated vegetable shortening which had been used for potato chips production. NDGA, PG, BHA, BHT, and tocopherols[2,3] have been used as antioxidants in the potato chips industry. Dowdle[4] has found that levels of antioxidants in frying oils decreased rapidly as frying started, but the levels were stabilized within 4 to 8 hours. It has been reported that the rancidity development was delayed effectively by atomizing Tenox II on potato chips immediately after potato chips were removed from frying oils, or by incorporating Suron PB into the salts which were added to potato chips[5]. Incorporation of antioxidants into cellophane films or paper board had been found to be effective in retarding the rancidity development of potato chips[6,7]. Kimura,[8] and Honda[9] have shown that ascorbic acid had effective antioxidant activity in β-carotene and in dehydrated oat flour. Similarly, Evans et al[10] has reported that ascorbic acid showed antioxidant activity in some vegetable oils. However, Anderson et al[11] has shown that ascorbic acid in cereals acted as a proxidant at higher levels and had no discernible effect as an antioxidant at lower levels.

Ascorbic acid, widely used as an antioxidant[12~15] as well as an anti-browning agent, may be appropriate for extending shelf-life of potato chips which are susceptible for both rancidity development and browning. But there seems little information on the effectiveness of ascorbic acid which is incorporated in fatty food such as potato chips and subjected to intermittent irradiation of direct sunlight.

In the present study, ascorbic acid and BHA, which is one of the most widely used antioxidants for potato chips, had been selected for use as antioxidants. Their relative effectiveness in retarding the rancidity development of potato chips, stored under various conditions, was compared with one another.

Experiments

The potato chips used in this study were prepared from Irish Cobbler, the most important commerical potato variety in Korea. Potato slices were soaked in hot water for 5 minutes, drained, and fried in cotton seed oil at 190°C. for 4 to 5 minutes (Smith[16]).

Buthylated hydroxyanisole (Eastman Company, U.S.A.), ascorbic acid (Merck AG., West Germany), and their mixture were employed as antioxidants for the potato chips. These antioxidants were dissolved respectively in 95% ethyl alcohol, and the alcoholic solutions were applied to the potato chips in the form of atomized mist(BHA 0.05%, As. A 0.1%, and BHA 0.05%+As.A 0.1% relative to the weight of the potato chips).

The first experiment was conducted to study the relative effectiveness of the antioxidants in retarding the rancidity development of the potato chips stored in a dark place. The potato chips were covered with 0.01mm transparent polypropylene film and stored in a dark place at 33±0.5°C. Fresh potato chips, which were not treated with the antioxidants, were used as control.

The second experiment was conducted to examine the relative effectiveness of the antioxidants in the potato chips which were covered with coloress transparent and yellow transparent polypropylene films and exposed to direct sunlight for 6 hours daily.

After the direct sunlight exposure, all samples were stored in a cold (2°C), dark storage room.

Rancidity development was estimated by determining the peroxide values and the free fatty acid values of the potato chips at appropriate intervals. Ten of ground potato chips was extracted with diethyl ether in Soxhlet apparatus for 4 hrs. The extracted oil was used for determination of the peroxide values and the free fatty acid values. The peroxide values were derermined by using a modified method which was based on the method described by Wheeler, D.H.[17]. The free fatty acid values were determined by the method described by Tribold[18].

Results and Discussion

Table 1 shows the effects of BHA and ascorbic acid on the peroxide value development of the potato chips stored in a dark place at 33.0±0.5°C. In the control group, the peroxide values of the potato chips increa-

Table 1. Effects of BHA, As. A, and BHA+As. A on the peroxide value development of the potato chips stored in a dark place at 33.0±0.5°C

Treatment \ Time in days	0	3	6	12	15	21
Control	9.2±1.0	10.7±0.9	12.7±1.1	17.6±2.1	23.9	42.0
BHA	9.2±1.0	10.1±0.4	11.5±1.1	13.5±1.4	16.3	21.7
As.A	9.2±1.0	10.0±1.1	12.1±0.3	15.6±2.5	19.0±1.9	32.0
BHA+As.A	9.2±1.0	9.8±0.9	11.0±0.9	14.5±0.7	17.0±1.4	25.9

(1) Peroxide values are expressed in meq./kg
(2) Figures without S.D. are the mean values

Table 2. Effects of BHA, As.A, and BHA+As.A on the acid value development of the potato chips stored in a dark place at 33.0±0.5°C

Treatment \ Time in days	0	6	12	18	21
Control	1.6±0.05	1.6±0.1	1.7	1.8	1.8
BHA	1.6±0.05	1.6±0.05	1.6±0.05	1.7	1.7
As.A	1.6±0.05	1.6±0.05	1.7±0.05	1.8	1.9
BHA+As.A	1.6±0.05	1.6±0.1	1.7±0.05	1.7	1.8

(1) Acid values are expressed as free fatty acid value calculated as % oleic
(2) Figures without S.D. are the mean values

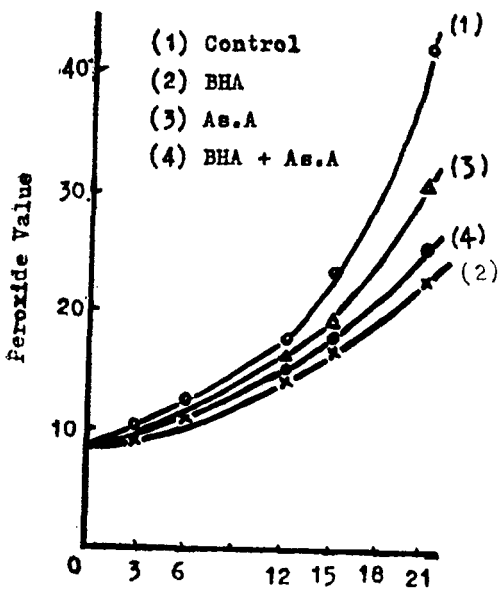

Fig. 1. Effects of BHA, As.A, and BHA+As. A on the P.V. development of potato chips stored in a dark place at 33.0±0.5°C

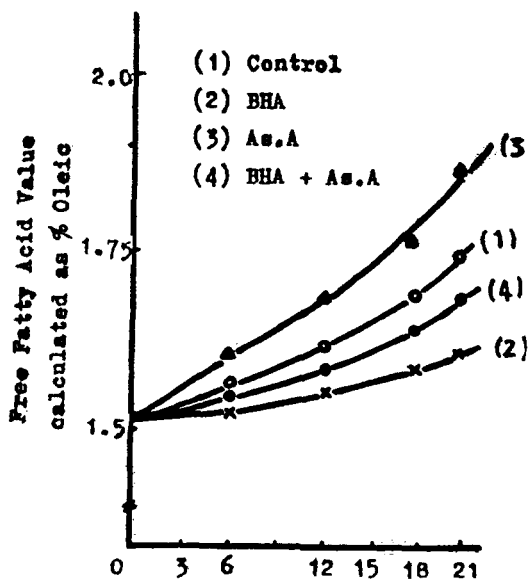

Fig. 2. Effects of BHA, As.A, and BHA+As.A on the acid value development of potato chips stored in a dark place at 33.0±0.5°C

sed very slightly during the first 6 days, and then increased rapidly. The Peroxide values at the end of the experiment were slightly less than 50 meq/Kg. However, the BHA-treated potato chips showed remarkably slow increase of peroxide values throughout the storge period. The peroxide values of this group, i.e., the BHA-treated potato chips, at the end of the experiment were only half of those of the control group. The ascorbic acid treated potato chips showed consistently higher peroxide values than those of the BHA-treated potato chips throughout the storage period. A group of potato chips which contained both BHA and ascorbic acid exhibited slightly higher peroxide values than BHA-treated group. However, the peroxide values of the BHA+ascorbic acid-treated group were lower than those of the ascorbic acid-treated group. As a whole, it appeared that the differences among the peroxide values of the 4 groups became more pronounced as the length of the storage period increased.

Jankowski[7] has reported that potato chips without any antioxidant treatment, packaged with duplex glassine bags, became rancid in around 20 days when they were kept in a hot (48°C), dry, and dark room, but BHA treatment delayed rancidity by about 15 days. The present results indicate that the untreated potato chips would have reached a rancid stage in a similar period to the one reported by Jankowski, even though the untreated potato chips in this experiment were kept at lower storage temperature.

It is evident from this experiment that BHA, ascorbic acid, and the mixture of BHA and ascorbic acid retarded effectively the rancidity development of the potato chips stored in a dark place. BHA was particularly effective in preventing the rancidity development of the potato chips. Ascorbic acid was, however, less effective than BHA. The potato chips became rancid more rapidly when both BHA and ascorbic acid were treated in combination than when BHA was treated alone (Table 1 and Fig. 1).

Table 2 and Figure 2 show that the free fatty acid values of the potato chips used in the experiment increased slightly during the storage period. But the increase in the free fatty acid values was most pronounced in the control group, then the ascorbic acid-treated group. Both BHA treatment and BHA+ascorbic acid treatment retarded the development of the free fatty acid values to some extent. These retarding effects appear to be due to the presence of BHA and not to the presence of ascorbic acid.

The effects of BHA and ascorbic acid on the peroxide value development of the potato chips, covered with colorless transparent polypropylene films and exposed to sunlight, are shown in Table 3 and Figure 3. The peroxide values of the untreated potato chips increased rapidly, and the potato chips became rancid in 2 days. BHA-treated potato chips exhibited consistently lower peroxide values than the control group throughout the storage period. The peroxide values of the ascorbic acid-treated potato chips were slightly higher than those of the control group. BHA+ascorbic acid showed similar strong antioxidant activity to BHA.

Table 3. Effects of BHA, As.A, and BHA+As. A on the peroxide value development of potato chips irradiated with direct sunlight

Treatment \ Time in days	0	2	4	5	10
Control	12.0±1.3	52.8	95.4	109.3	169.4
BHA	12.0±1.3	39.4	68.2	87.4	154.4
As.A	12.0±1.3	55.2	—	115.8	176.7
BHA+As. A	12.0±1.3	41.8	70.9	90.7	154.2

(1) Peroxide values are expressed as meq./kg.

(2) All samples were covered with colorless transparent polypropylene films (thickness : 0.01 mm) and irradiated with direct sunlight daily. Irradiation time : 6 hrs/day. Average temperature at the time of irradiation : 29.0±3.7°C.

(3) All figures except those at the beginning of the experiment are the mean values.

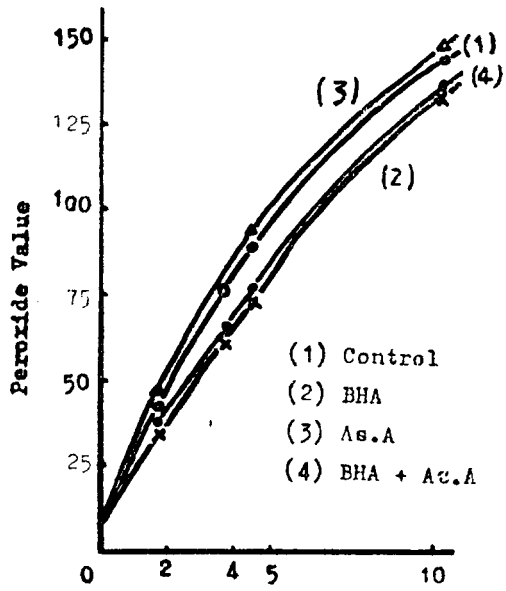

Fig. 3. Effects of BHA, As.A, and BHA+As. A on the P.V. development of potato chips covered with colorless transparent polypropylene films and irradiated with direct sunlight

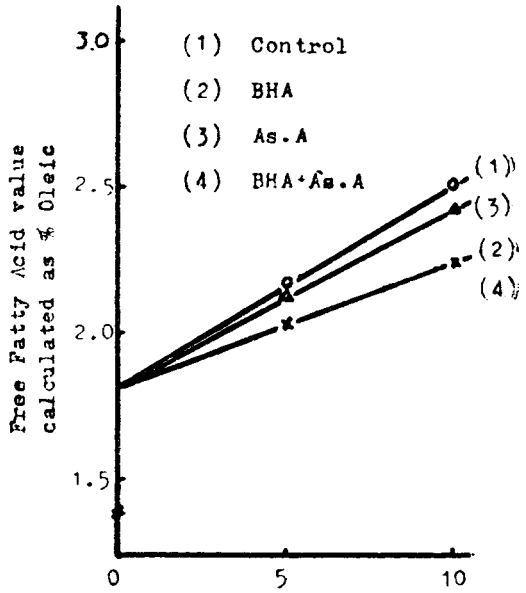

Fig. 4. Effect of BHA, As.A, and BHA+As. A on the acid value development of potato chips covered with colorless transparent polypropylene films and irradiated with direct sunlight

Table 4. Effects of BHA, As. A, and BHA+As. A on the acid value development of potato chips irradiated with direct sunlight

Treatment \ Time in days	0	5	10
Control	1.7±0.2	2.4	2.7
BHA	1.7±0.2	2.1	2.4
As.A	1.7±0.2	2.3	2.6
BHA+As.A	1.7±0.2	2.1	2.4

(1) Acid values are expressed as free fatty acid value calculated as % oleic.
(2) All samples were covered with coloreless transparent polypropylene films and irradiated with direct sunlight daily. Irradiation time: 6 hrs/day. Average temperature at the time of irradiation: 29.0±3.7°C.
(3) All figures except those at the beginning of the experiment are the mean values.

alone. But it is evident that the activity is mostly due to BHA and not to ascorbic acid. In the present study, it has been found that ascorbic acid exhibited considerable antioxidant activity when ascorbic acid treated potato chips were stored in a dark place, but it did not show any antioxidant activity when the potato chips were exposed to sunlight 6 hours daily. The free fatty acid values of both control and antioxidant-treated groups incresed during the storage period (Table 4 and Figure 4). The control and ascorbic

acid-treated groups showed slightly higher free fatty acid values than BHA or BHA+ascorbic acid-treated grouos.

Yellow transparent polypropylene films delayed markedly the rancidity development of the potato chips which were subjected to direct sunlight. The BHA-treated group had remarkably lower peroxide values than the control group throughout the experimental period (Table 5 and Figure 5).

It appears that the yellow color of the films prevented considerably the loss of antioxidant activity of BHA when the potato chips were exposed to direct sunlight. Ascorbic acid showed little antioxidant activity in the potato chips in this condition. The free fatty values of the potato chips which were covered with the yellow transparent polyporpylene films increased

Tabl 5. Effects of BHA, As. A, and BHA+As. A on the peroxide value development of potato chips Irradiated with direct sunlight

Treatment \ Time in days	0	2	4	5	10
Control	12.0±1.3	27.7	52.7	61.5	94.2
BHA	12.0±1.3	18.4	31.4	38.6	62.0
As.A	12.0±1.3	—	49.6	59.1	91.8
BHA+As.A	12.0±1.3	—	42.1	52.2	78.8

(1) Peroxide values are expressed in meq./kg.
(2) All samples were covered with yellow transparent polypropylene films (thickness 0.01 mm), nd irradiated with direct sunlight. Irradiation time : 6 hrs/day. Average temperature at the time of irradiation: 29.0±3.7°C.
(3) All figures except those at the beginning of the experiment are the mean values.

Table 6. Effects of BHA, As.A, and BHA+As.A on the acid value development of potato chips irradiated with direct sunlight

Treatment \ Time in days	0	5	10
Control	1.7±0.2	1.9	2.1
BHA	1.7±0.2	1.8	1.9
As.A	1.7±0.2	1.9	2.0
BHA+As.A	1.7±0.2	1.9	1.9

(1) Acid values are expressed as free fatty acid value calculated as % oleic.
(2) All samples were covered with yellow transparent polypropylene films, and irradiated with direct sunlight. Irradiation time : 6 hrs/day. Average temperature at the time of irradiation : 29.0±3.7°C.
(3) All figures except those at the beginning of the experiment are the mean values

gradually throughout the storage period (Table 6 and Fig.6). The free fatty acid values were generally lower than those of the potato chips covered with the transparent films.

요 약

BHA (0.05%), ascorbic acid (0.1%) 그리고 BHA (0.05%)+ascorbic acid (0.1%)를 각각 첨가시킨 감자튀김을 여러 조건하에서 저장할 때 이들 BHA, As.A 및 BHA+As. A의 상대적인 산패억제 효과를 비교 관찰하였다. 즉 감자튀김을 암소(暗所)에서 33±0.5°C로 저장하였을 때는 감자튀김의 산패억제에 대한 BHA의 효과는 매우 컸다. Ascorbic acid도 상당한 항산화 효과를 보였으나 BHA 보다는 약하였으며, 한편 BHA와 ascorbic acid를 동시에 처리하였을 때에는 그 효과는 BHA 단독의 경우와 거의 같았다. 투명, 무색 polypropylene film으로 덮은 감자튀김을 하루 6시간씩 일사광선에 조사(照射)시키면서 저장하였을 때는 BHA의 항산화력은 상당히 감소되었으며, 한편 ascorbic acid의 항산화력은 거의 완전히 상실되었다. 그러나 황색

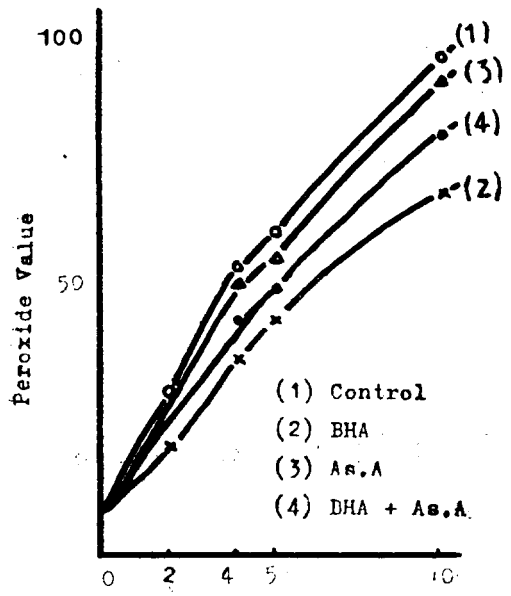

Fig. 5. Effects of BHA, As.A, and BHA+As.A on the P.V. development potato chips covered with yellow transparent polypropylene films and irradiated with direct sunlight

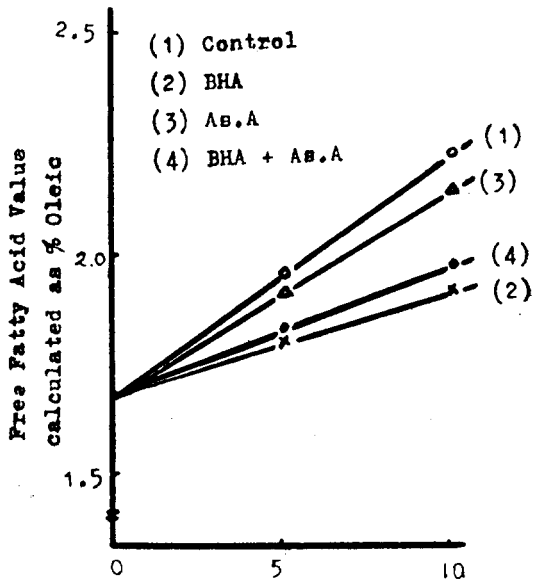

Fig. 6. Effects of BHA, As.A, and BHA+As.A on the acid value development of potato chips covered with yellow transparent polypropylene films and irradiated with direct sunlight

으로 착색된 투명 polypropylene film을 대신 사용하였을 경우에는 BHA는 그 항산화력을 상당히 잘 유지하였다. 한편, ascorbic acid는 이와 같은 조건하에서도 그 항산화력을 거의 상실하였다.

References

1) Smith, O.: *Natl. Potato Chip Inst.*, 1, (1953).
2) Talburt, W. F. and Smith, O.: *Potato Processing*, Avi Publishing Co., Inc., Westport, Connecticut, p. 306 (1962).
3) Dugan, L. R., Jr. and Kraybill, H. R.: *J. Am. Oil Chemists' Soc.*, 33, 527 (1956).
4) Dowdle, R. L.: *Proc. Prod. and Tech. Division Meetings. Potato Chips. Inst. Intern.*, 20, (1962).
5) Smith, O.: *Natl. Potato Chips Inst.*, 1, (1950).
6) Woodford, R. T. and Smith, O.: *Proc. Prod. and Technol. Division Meetings. Potato Chips Inst. Intern.*, 18, (1959).
7) Jankowski, B. O.: *Proc. Prod. and Tech. Division Meetings. Potato Chip Inst. Intern.*, 7, (1960).
8) Kimura, S.: *J. Food Sci. Technol. (Japan)*, 13, 3 (1966).
9) Honda, K., Kabashima, H., and Kawasaki, S.: *Food Industry (Japan)*, 10, 45 (1967).
10) Evans, C. D., Moser, H. A., Cooney, P. M., and Hodge, J. E.: *J. Am. Oil Chemists' Soc.*, 35, 84 (1958).
11) Anderson, R. H., Moran, D. H., Huntley, T. E., and Hikahan, J.L.: *Food Technol.*, 17, 1587 (1963).
12) Privett, O. S. and Quackenbush, W.: *J. Am. Oil Chemists' Soc.*, 13, 321 (1954).
13) Moustafa Lotfy, Hussein Aref, and Abdel Aziz Hussein.: *J. Am. Oil Chemists' Soc.*, 34, 96 (1957).
14) Smith, G. J. and Dunkley, W. L.: *J. Food Sci.*, 27, 127 (1962).
15) Deobald, H. J. and Mclemore, T. A.: *Food Technol.*, 18, 145 (1964).
16) Smith, O.: *Natl. Potato Chip Inst.*, 1 (1951).
17) Wheeler, D. H.: *Oil and Soap*, 9, 89 (1932),
18) Tribold, H. O. and Aurand, L. W. *Food Composition and Analysis*, D. Van Nostrand Co., New York, p. 164 (1963).