



Short communication

Utilization of mixed adsorbents to extend frying oil life cycle in poultry processing

Patchimaporn Udomkun^{a,*}, Bhundit Innawong^b, Chatchalai Siasakul^b, Christopher Okafor^c^a International Institute of Tropical Agriculture (IITA), Bujumbura, Burundi^b Silpakorn University, Faculty of Engineering and Industrial Technology, Department of Food Technology, Thailand^c IITA, Bukavu, The Democratic Republic of the Congo

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ABSTRACT

The effects were studied of two different adsorbent combinations (com I; bentonite: activated carbon: celite = 3:4:1 and com II; bentonite: activated clay: celite = 3:4:1 + 1% citric acid) on the physico-chemical changes of oil used continuously for deep-fat frying of chicken drumsticks. The results showed that the % FFA was reduced by 44.3, PV by 50.2, and FOS reading by 40.1% in com I whereas reductions of 41.6, 44.9, and 32.8%, respectively, were found in com II. The oil treated with com II exhibited a lighter color than with com I. The changes of oil color in com I were L* 30.7, a* 1.7, and b* 31.9%; in com II they were 53.2, 19.1, and 39.5% respectively. The higher the L* observed, the better the oil quality obtained because of the bleaching ability of adsorbents. Therefore, the use of such adsorbents is recommended for poultry processing.

1. Introduction

Deep-fat frying is a complex and important dehydration process, widely used at home and on a commercial scale where numerous physical and chemical changes occur in the frying medium and fried products. The quality of oil used in deep fat frying directly contributes to the quality of the fried food. It is crucial to maintain the quality of oil in a frying system as high as possible because the undesirable constituents produced from degraded oils can pose a health hazard. In general, approximately 50% (or more) of frying fat and oil used in food service operations is discarded after frying (Hunter & Applewhite, 1993). This means some quantity of used oils is still retained in the fryer and adsorbed by every single fried product. To reduce the detrimental effects and prolong the life cycle of frying oil, several scientific studies have addressed the safety of the used oils and claimed that the regular cleaning and maintenance of equipment, use of good quality frying fat, and proper frying conditions are required (Stevenson, Vaisey-Jenser, & Eskin, 1984).

Currently, active filtration such as the use of commercial natural and synthetic adsorbents for maintaining the quality of frying oil is intensively interested. Active filtration responds by removing surfactant materials carbonized on the surface as well as precursors of polymers formed from the frying oil. The active filtrations are generally called adsorbent powders, such as activated carbon, magnesium oxide, diatomaceous earth, bleaching earth, calcium silicate, and various forms of

silica. Many reports are available on the effect of adsorbents in the bleaching step. For example, Jacobson (1976) reported that synthetic calcium silicate and synthetic magnesium silicate were able to reduce free fatty acid (FFA) and color in frying oil. Mancini-Filho, Smith, Creveling, and Al-Shaikh (1986) showed that the dielectric constant changes (DCC) obviously improved with the use of bleaching clay and charcoal. The removal of FFA in frying oil by diatomaceous earth was reported by Zhang and Addis (1992).

McNeill, Kakuda, and Kamel (1986) also examined the feasibility of various mixtures between activated carbon and silica for improving the quality of used canola oil and reported that the oil treated with mixed adsorbents showed more effective reductions in acid values (AV), peroxide value (PV), saturated and unsaturated carbonyl contents, total polar components (TPC), and photometric color than the control (without treatment). Activated carbon seemed to decrease the saturated and unsaturated carbonyl content in oil samples more than silica. Bhattacharya, Sajilata, Tiwari, and Singhal (2008) also reported that the binary and quaternary adsorbent treatments were better than a single adsorbent in improving the quality of palm oils used continuously for 30 and 36 h in the deep-fat frying of legume-based snacks. These results might be caused by a greater capability and higher adsorption power of mixed adsorbents to react with the chemical compounds in the used oils.

In addition, researchers have shown interest in applying commercial synthetic adsorbents such as Britesorb, Hubersorb600, Frypowder, and

* Corresponding author.

E-mail address: P.Udomkun@cgiar.org (P. Udomkun).

Magnesol to prolong the quality as well as the shelf life of used oils. Lin, Akoh, and Reynolds (2001) reported that a mixture of 3% Hubbersorb600, 2% Frypowder, and 3% Magnesol reduced the final values of FFA by 64%, TPC by 19.1, Foodoil Sensor (FOS) reading by 32.6%, and color difference by 4.4% in used oil after daily treatment for 4 days compared to the untreated control.

Although several studies have been reported the potential of adsorbents in retarding oil deterioration, these do not provide insight into their performance under practical conditions on a commercial scale (Boki, Shinoda, & Ohno, 1989; Yates & Caldwell, 1992; Zhu, Yates, & Caldwell, 1994). Therefore, the objective of this study was to investigate the performance of adsorbent combinations for improving quality and prolonging life of frying oil at the scale of commercial practice. Based on different properties of adsorbents in removing impurities, five different types of adsorbent available in the market were selected to use.

2. Materials and methods

2.1. Sample preparation

Fresh and clean chicken drumsticks, nearly uniform in shape and size (about $10 \times 13 \times 3$ cm) and weighing approximately 140 g/piece, were soaked in 15% seasoning solution containing salt, pepper, monosodium glutamate (MSG), and sodium triphosphate (STPP). Subsequently, samples were pre-dusted, steamed, battered, and then individually powdered with 140 g of mixed seasoning (wheat flour, modified corn starch, water, salt, spices, sugar, artificial flavor, paprika powder, and extracts of paprika in soybean oil). The initial moisture of the breaded drumsticks was 62.5%, fat content was 45.1%, and the temperature was kept at 45 °C before frying.

In addition, partial hydrogenated soybean oil was obtained from a local processor (Argkun, Cheer Co., Ltd., Thailand) and supplied in metal cans of 13.75 L. The quality of fresh oil was batch measured.

2.2. Adsorbents preparation

Five different adsorbents, celite (Celite® coarse 545, Flukachemical, Buchs, Switzerland), activated clay (Power Dry Co., Ltd., Thailand), activated charcoal (Flukachemical, Buchs, Switzerland), bentonite (Sigma Aldrich Chemica, GmbH, Germany), and citric acids were used to examine their adsorption capability for the degradative polar constituents in the used oils. Celite was a white, odorless powder of silicon dioxide (SiO₂). Activated clay, composed of calcium aluminosilicate, was odorless gray granules, insoluble in water. Activated charcoal was an odorless black powder, and bentonite was a light brown odorless powder composed of silicon dioxide and aluminum dioxide (Al₂O₃).

Two different mixtures of adsorbent combinations were prepared as follows: com I (bentonite, activated charcoal, and celite at a ratio of 3:4:1), and com II (bentonite, activated clay, and celite at a ratio of 3:4:1 + 1% of citric acid). The selection of the adsorbent type and their appropriate ratio were based on our preliminary study.

2.3. Frying experiments

The frying treatments were composed of three different treatments and labeled 'control', 'com I', and 'com II'. The frying treatment labeled 'control' was oil without addition of adsorbents but with regular filtering with a commercial filter paper pore size 30 μm that only removed the food crumbs and particulates at the end of each frying day. The treatments labeled as 'com I' and 'com II' were oils with the addition of the different mixed adsorbents and use of a filtration system. The frying process was continuously performed for 6 h/day for 6 days. Thirty-six batches/day of powdered chicken drumsticks were continuously fried to imitate the same amount of frying load/oil used in manufacturing. Each batch, consisting of four powdered chicken drumsticks, was fried

at 10 min intervals.

In the frying process, a commercial dual-unit electric batch fryer Model H 114-2 CSC (Fry-master, Shreveport, LA, USA) with a capacity of 21 L of frying oil was used. Before frying, fresh oil was preheated at 175 °C for 30 min to simulate normal frying conditions. The frying oil was maintained at ± 5 °C of the set temperature (175 °C) using a programmable temperature controller. No fresh oil was added during frying. However, at the beginning of the next frying date a small amount of fresh oil (about 200 ml/day) might be added in the fryer to keep the initial oil level constant.

Four powdered chicken drumsticks of about 560 g were randomly fried in 13 kg of heated oil. Each batch of the chicken drumsticks was fried at a temperature setting of 175 °C. For each frying cycle, the chicken samples were placed in a stainless basket to keep them submerged and fried for 150 s; the frying oil was kept at a temperature of 175 °C for the rest of the frying cycle even if food materials were being unloaded. The gap between each frying cycle provided time for preparing the next batch and making up any loss in temperature in the fryer. The fried samples were immediately withdrawn from oil and cooled to the ambient temperature.

2.4. Oil filtration

At the end of each day, after the last batch of frying, a gravity filtration method was used to filter the used oil from the fryer pot to remove food crumbs and sediments of batter. The hot oil was collected into an oil container and then recirculated and filtered under vacuum conditions with filter paper obtained from Noonsfeer Co., Ltd., Thailand and recognized as the control. Similarly, oils in com I and com II treatments were gravity filtered, treated with 1% (by weight) of mixed adsorbents, and then recirculated to pass through the filter paper. After the recirculated oil had been poured and stirred continuously for 5 min, the adsorbent particles were ultimately recovered and separated from the used oil for 20 min via the vacuum filtration system.

2.5. Sample collection

The frying oil was randomly collected every 3 h, twice daily. The oil samples were individually kept in closed containers, sealed off with caps to prevent oxidation, then air cooled in a dark room (approximately 7 °C) for 1 h. Thereafter, samples were kept at room temperature until the further physico-chemical analyses. The FFA, PV, FOS reading, and color parameters were measured with regard to the deterioration rate of the oil.

2.6. Quality analyses

2.6.1. Free fatty acid (FFA)

Free fatty acid content was analyzed using AOCS procedure Ca 5a-40 (AOCS, 1990). The test was repeated three times.

2.6.2. Peroxide value (PV)

Peroxide value was determined by AOCS procedure Cd 8-53 (AOCS 1990). The test was repeated three times.

2.6.3. Dielectric constant

Changes in the dielectric properties of frying oil were measured using the FOS (model NI-2C, Northern Instrument Co., Lino Lakes, MN). In general, the test consisted of two steps. In the first, the instrument was equilibrium balanced to zero with the fresh oil used in the frying process. A few drops of the fresh oil or test oil were placed into an open test cell containing a heater and temperature controller. The dielectric properties of oil normally varied owing to differences in source and temperature, it is essential to take all readings at the same temperature. After calibration with fresh oil to zero, the fresh oil was then removed from the instrument cup with soft tissue paper; the tested oil samples

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