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Effect of Mild Heat Treatments Prior to Air Dehydration of Dried Onions Quality

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Abstract

The effects of immersion temperature (20, 40 and 60°C) and immersion times (6, 12 and 18 min) in a distilled water prior to air dehydration upon the browning reaction and pyruvic acid content of air dried onions to a 4.0% moisture content (wet basis) were analyzed by a response surface methodology (RSM). Those values were also predicted by using a second degree polynomial regression model. Immersion temperature had more influence to browning reaction and pyruvic acid content than immerision time in these experimental ranges. The processing conditions to minimize the browning reaction of dried onions at 50°C of air temperature (O.D. = 0.071) were 60°C of immersion temperature and 18 min of immersion time compared to control (O.D. = 0.168) of air dehydration at 50°C. Pyruvic acid contents of dried onions at 50°C of air temperature were maximized (39.85 μmole/g onion solid) at 60°C of immersion temperature and 12 min of immersion time compared to control (24.08 μmole/g onion solid) of air dehydration at 50°C.

Key words: onions, browning reaction, pyruvic acid content, response surface methodology (RSM)

Introduction

Dehydrated onions and powders are widely used in many processed foods or seasoning blends. Blanching treatments prior to conventional dehydration to minimize physico-chemical changes during dehydration have not been used in onion processing owing to flavor loss.[1] The total pyruvic acid content, flavor quality index, of blanched onions in a boiling water for 12 min was only 8.01% of that of fresh onions.[2,3] Therefore, many process conditions using solvent treatments before dehydration and dehydration conditions have been developed to obtain high qualities of dried onions. L-cystein (0.05-0.3%, w/w) was added before dehydration to prevent pink discoloration in onions during dehydration.[4] High qualities of dried onions were obtained in such dehydration conditions; 4-6 in. loading depth and 1/8 in. slice thickness, and cut right angles to the vertical axis of onions.[5] Also, the air temperature during dehydration of onions should preferably be reduced from about 180°F until 6% moisture content (wet basis) and then 110°F to 4% moisture content (wet basis).[6]

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The objectives of this study were to determine the optimum processing conditions and to develop predictive models based on minimizing browning reaction and maximizing pyruvic acid content during air dehydration, which attribute quality indices dehydrated onions.[1]

Materials and Methods

Materials

Onions (*Allium cepa*) used in this study were obtained from the 1990 harvest. The moisture content of onions was 91.07% on a wet basis. The onios were manually peeled and sliced to a 3 mm thickness using a food processor (Sunbeam, Oskar).

Experimental design

In this study, three levels and two factors (3^2 factorial design) were adopted. Response surface methodology (RSM) designs were undertaken with immersion temperature (°C) and immersion time (min). Each of 9 observations were made on browning reaction and pyruvic acid content, respectively.

The regression coefficients (A_i) represented an interaction effects of the independent variables were estimated with a second degree polynomial regression model using statistical analysis system (SAS).[7]

$$Y = A_0 + A_1X_1 + A_2X_2 + A_3X_1^2 + A_4X_1X_2 + A_5X_2^2 \qquad \text{(Equ. 1)}$$

, where, independent variables, X_1 and X_2 were immersion temperature (°C) and immersion time (min), respectively for browning reaction (O.D. units) and pyruvic acid content (μmole/g onion solid).

Heat treatments

Approximately 100g onion slices (wet basis) was added to a 400 ml distilled water at different immersion temperatures (20, 40 and 60 °C). Also, varying lengths of immersion times (6, 12 and 18 min) were added to the constant factors according to a statistical response surface design.

Dehydration

Onions on a 0.5g/cm^2 tray load were dried in a cabinent drier at 50 °C with a 3m/s air velocity directly to a 4.0% moisture content (wet basis).

Determination of moisture content

Moisture content was determined after drying onions using a vacuum oven (Yamato vacuum oven, DP-41) at 70 °C and 27 in Hg. for 24 hr.

Determination of browning degree

Browning degree was determined by modified method of Henedl et al.[8], which putting a 1g dehydrated onion powder in a 250 m*l* flask containing 40 m*l* of 10% trichloroacetic acid solution. The flask covered with parafilm was allowed to remain at room temperature for 2 hr with occasional shaking. After the solution was filtered through tyro No. 2 filter paper, the O.D. of the filtrate was read at 420 nm using a spectrophotometer (Shimaduzu double beam spectrophotometer, UV-200S).

Determination of pyruvic acid content

Total pyruvic acid content was determined according to the method of Schwimmer and Weston.[9]

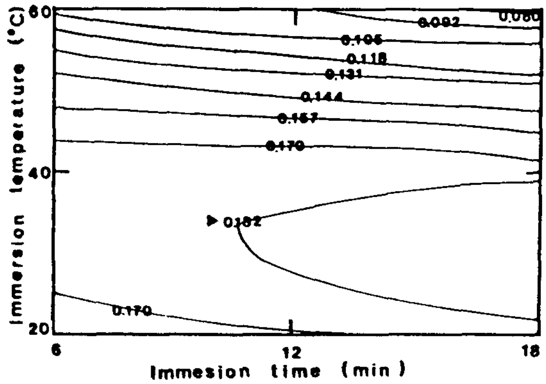

Fig. 1. Browning reaction as a function of immersion temperature and immersion time
▶ O.D. at 420 nm
O.D. unit for broning degree of control dried to a 4.0% moisture content (wet basis) at 50 °C of air temperature was 0.168.

Results and Discussion

Effect of immersion temperature and immersion time on browning reaction

Figure 1 shows the effects of immersion temperatures (20-60 °C) and immersion times (6-18 min) on browning reaction. The degree of browning reaction of dried onions at 50 °C of air temperature was decreased rapidly with increasing temperatures between 50 and 60 °C, and maximized in between 25 and 35 °C. This was likely due to polyphenoloxidase activity. At higher temperature ranges (50-60 °C). Polyphenoloxidase activity was reduced gradually as increasing the temperature. Whereas, favorite temperature ranges of polyphenoloxidase (25-35 °C) enhanced its activity.[10] However, browning reaction was not significantly influenced by immesion time.

According to this study, minimum browning reaction of dried onions (O.D. = 0.071) at 50 °C of air temperature could be carried out using pretreatments such as 60 °C of immersion temperature and 18 min of immersion time compared to control (O.D. = 0.168) dried at 50 °C of air temperature. The mean O.D. value of response surface for browning reaction of dried onions in these experimental ranges was 0.143. Immersion temperature had more influence to browning reaction than immersion time as shown in Table 1.

Effect of immersion temperature and immersion time on pyruvic acid content

Puruvic acid values in dehydrated onions would be of considerable pratical importance in that total pyruvic acid may be of value in assessing at least

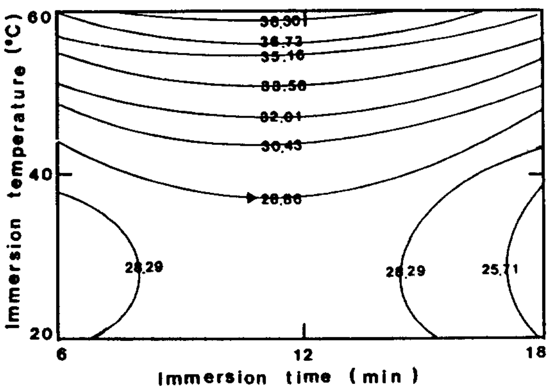

Fig. 2. Pyruvic acid content as a function of immersion temperature and immersion time
▶μmole/g onion solid
Pyruvic acid content of control dried to a 4.0% moisture content (wet basis) at 50 °C of air temperature was 24.08 μmole/g onion solid.

Table 1. Analysis of variance for the effect of two process variables on the two responses

Process variables	Browning reaction		Pyruvic acid content	
	F-ratio	Prob.	F-ratio	Prob.
Immersion temperature	107.91	0.0015	94.83	0.0018
Immersion time	3.71	0.1552	7.08	0.0712

certain aspects of the flavor quality of dehydrated onions.[2]

As the immersion temperatures were increased from 40 °C to 60 °C, the pyruvic acid contents were increased rapidly as shown in Fig. 2. However, lower immersion temperatures (20-40 °C) did not cause any significant changes in pyruvic acid contents. Optimum immersion time for pyruvic acid content was 12 min at all different temperature ranges (20, 40 and 60 °C).

A maximum retention of pyruvic acid content (39.85 μmole/g oning solid) during 50 °C of air dehydration could be achieved by 60 °C of immersion temperature and 12 min of immersion time compared to control (24.08 μmole/g onion solid) dried at 50 °C of air temperature. The reduction of pyruvic acid content during processing in onions was owing to destruction of structure during slicing, inactivation of allinase and loss of substrate during air dehydration.[1] The mean value of response surface for pyruvic acid content of dried onions in these experimental ranges was 30.77 μmole/g onion solid. Likewise in browning reaction, immersion temperature had more influence to pyruvic acid content than immersion time as shown in Table 1.

Table 2. Regression coefficients of the second degree polynomials for two response variables

Coefficient[a)]	Browning reaction[b)]	Pyruvic acid content[b)]
A_0	0.02578	26.99667
A_1	0.16983	-11.16667
A_2	0.02100	9.26667
A_3	-0.04717	4.20000
A_4	-0.01150	-0.20000
A_5	0.00033	-2.40000

a) These are coefficients of eq. 1 and each independent variables, X_1 and X_2, is transformed to 1, 2 and 3 as increasing the level.
b) Each independent variables, X_1 and X_2, represents immersion temperature and immersion time, respectively.

Table 3. Determination coefficients of the second degree polynomials for two response vairables

Regression	Browning reaction	Pyruvic acid content
Linear	0.7735	0.6722
Quadratic	0.2160	0.2848
Cross product	0.0007	0.0339
Total regress	0.9903	0.9908

Fitting the models

Second degree polynomial model (equation 1) contains seperate linear and quadratic components for each of the independent variables by immersion temperature (°C) and immersion time (min) and a cross product term. Equation 1 in two independent variables were adapted to situations where the response function was unknown and a suitable model was to be developed empirically. Therefore, equation 1 was fitted to the experimental data. Two models (Table 2) were obtained and tested to fittness by coefficients of determination, R^2, as shown in table 3. Based on the coefficients of determination, browning reaction ($R^2 = 0.9903$) and pyruvic acid content ($R^2 = 0.9908$) were highly fitted to the experimental data.

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열풍건조 전 순한 열처리가 건조 양파의 품질에 미치는 영향

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열풍건조전 증류수에 침지온도(20, 40 및 60℃)와 침지시간(6, 12 및 18분)에 따른 열풍건조양파(4% 수분도: 습량기준)의 갈색화 반응과 pyruvic acid 함량에 미치는 영향을 반응 표면 분석법으로 조사하였다. 나타난 수치들을 또한 이차 다항 회귀 모델로써 예측하였다. 이 실험범위에서 침지 시간보다 침지 온도가 갈색화 반응과 pyruvic acid 함량에 큰 영향을 미쳤다. 갈색화 반응은 50℃로 열풍건조시킨 대조구(O. D. =0.168)와 비교하여 50℃의 열풍건조 중 최소화시키는 공정(O. D. =0.071)으로 60℃의 침지온도에서 18분간의 침지 공정이었다. 또한, pyruvic acid 함량은 50℃로 열풍건조시킨 대조구(24.08 μmole/g onion solid)와 비교하여 50℃의 열풍건조 중 최대화시키는 공정(39.85 μmole/g onion solid)으로는 60℃ 침지 온도에서 12분간의 침지 공정이었다.