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OPTIMIZATION OF SOME MINERAL CONTENTS OF DRIED OSMO-PRETREATED GREEN BELL PEPPER (*Capsicum annuum*) USING RESPONSE SURFACE METHODOLOGY

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Abstract
A study to optimize three mineral contents (magnesium, potassium and manganese) of dried osmo-pretreated green bell pepper was done using Response Surface Methodology (RSM). Five levels of osmotic solution concentration (A) (5% (w/w), 10% (w/w), 15% (w/w), 20% (w/w) and 25% (w/w)) of common salt and osmotic process durations (B) (60 min, 90 min, 120 min, 150 min and 180 min) were considered. After osmotic dehydration, all pre-treated and some control (unpre-treated) samples were dried at a constant temperature of 50˚C in a fabricated cabinet dryer. RSM under central composite design in Design Expert 8.0.3 computer software package was used to design the experiment, analyse data, optimize the process and present all results with 2-dimesional and 3-dimensional plots. From results obtained, optimized combinations were selected on the basis of their desirability values which were 0.931, 0.432 and 1.00 for magnesium, potassium and manganese respectively. From the desirability values on the response surface plots, the optimum (maximum) value of magnesium was found to be 29.18 mg/100g at osmotic process duration of 180 min and osmotic solution concentration of 25% (w/w); for potassium, the optimized value was 46.13 mg/100g at osmotic process duration of 60 min and osmotic solution concentration of 5% (w/w); while the optimized value for manganese was 10.96 mg/100g at osmotic process duration of 150 min and osmotic solution concentration of 15% (w/w). Dried pre-treated products had values closer to fresh samples than control (dried unpre-treated) samples for all the three mineral contents considered.

Keywords: Green bell pepper, optimization, Response Surface Methodology (RSM), osmotic dehydration, drying.

1. Introduction

Bell peppers (*Capsicum annuum)*, also known as sweet peppers are plump, bell-shaped vegetables featuring either three or four lobes. They come in various colours such as green, red, yellow, purple, white and even rainbow between stages of ripening (Steve, 2009). According to GMF (2010), bell peppers are not 'hot' because the primary substance that controls "hotness" in peppers called capsaicin is found in very small amount in them. Green bell pepper contains vitamin A and vitamin C which are rich in lycopene and has been proven to prevent cancer (Vengaiah and Pandey, 2006). Some of the other nutritional contents of green bell pepper are: vitamin B (B1, B2, B3 and B5), vitamin K, vitamin E, fiber, calories (lowest nutrient) and others. Green pepper assists in digestion and has been proven to cure cold, cataracts, rheumatism and diabetes (GMF, 2010 and Vengaiah and Pandey, 2006). Some minerals like magnesium, manganese and potassium are very beneficial to human health and are also present in green bell pepper. Magnesium contains enzymes that aid metabolism of calcium by converting sugar to energy and protein synthesis in the body, and according to FAO (2002), deficiency of magnesium could cause nervousness, heart spasm and calcium depletion to human health. Potassium helps to regulate body waste balance system and normalises heart rhythms thereby stimulating the kidney functions and reducing the risk of high blood pressure (Salmonson, 2013). Manganese is an antioxidant and also helps in the stabilization of human blood sugar (GMF, 2010).

Pre-treating vegetables helps it keep its natural colour and kills off enzymes that can cause food spoilage (PresvervingVegetables, 2001). Osmotic dehydration is a pre-treatment method for partial dehydration of water-rich foods, such as fruits and vegetables, by immersing them in hypertonic solution of sugar and/or salt. Heat may not be applied during osmotic dehydration hence it offers higher retention of initial food characteristics, such as colour, aroma, nutritional constituents, and flavour compounds (Sunjka and Raghava, 2004). Some factors that influence osmotic dehydration include osmotic solution concentration, osmotic process duration, osmotic solution temperature, type of osmotic agent, ratio of product to osmotic solution, agitation of solution during osmotic dehydration (Chavan and Amarowicz, 2012) and physiology of the food material to be pre-treated.

Drying is an old method of preserving food. It is a simultaneous heat and mass transfer process that involves the transfer of heat to provide the necessary latent heat of vaporization and movement of water or water vapour through the food material and then away from it to effect separation of water from it. Drying removes water from foods for two reasons; to prevent (or inhibit) micro-organisms and hence preserve the food, and to reduce the weight and bulkiness of food for cheaper transport and storage. Dried foods can be stored for long periods without deterioration and according to Earle and Earle (2004), the principal reason for this is that the microorganisms which cause food spoilage and decay are unable to grow and multiply in the absence of sufficient water.

Optimization is simply the process of finding input variables (process conditions) that would give the maximum or minimum values of desired output. Linear programming and sequential technique, differential calculus, and simultaneous technique are some of the methods of optimization. The need to execute research tasks easily within the shortest possible time with greater accuracy and precision is required in recent times. For this reason, optimization tools with various methods in form of software packages for computer systems are now available; example of such method is RSM which is available in Design Expert software package. RSM was used to optimize osmotic dehydration process and drying of carrot by (Singh *et al.*, 2006) in sodium chloride solution and drying temeperature of 65˚C. The optimum conditions obtained were 11% salt concentration, 30˚C osmotic solution temperature and process duration of 120 min.

Green bell pepper contains some minerals like magnesium, potassium and manganese that are highly beneficial to human health. This important fruit crop is usually faced with the problem of short shelf life when freshly harvested. In Odewole and Olaniyan (2016), ten (10) days was reported as the maximum period in which the crop can retain its maximum nutritional contents in refrigerated storage. The implication of this is that, the availability of the crop in areas where refrigerated storage of the freshly harvested crop can not be easily achieved may be imposibble. Osmotic dehydration coupled with hot air drying in a specialized mechanical dryer is one of the promising ways of curtailing the aforementioned problems. Therefore, the objective of the study was to establish osmotic dehydration conditions that will optimize some mineral contents (magnesium, potassium and manganese) of dried osmo-pretreated green bell pepper with with the use of RSM in Design Expert (version 8.0.3) computer software package.

2. Materials and Methods

2.1. Experimental Equipment and Materials

The following equipment and materials were used for the study: laboratory oven (GENLAB, Model N53 CF, England), a fabricated cabinet dryer, electronic weighing balance (OHAUS CL Series, Model CL 201, China), stop watch (Nokia X2-01), desiccator, containers for osmotic dehydration pre-treatment, stainless steel tray and knife, foil paper, spatula and hand gloves. Common salt, distil water, fresh green bell pepper.

2.2. Experimental Design

Five levels of osmotic solution concentrations (A) of common salt (5% (w/w), 10% (w/w), 15% (w/w), 20% (w/w) and 25% (w/w)) and five levels of osmotic process duration (B) (60 min, 90 min, 120 min, 150 min and 180 min) were substituted into the experimental design interface of Design Expert 8.0.3 version under RSM of Central Composite Design. The result gave an experimental table with various combinations of A and B that were used for conducting the osmotic dehydration pre-treatment process.

2.3. Experimental Procedure

Fresh green bell peppers (Figure 1) mostly of bell boy variety were procured from a food stuff market in Ilorin, Kwara state, Nigeria. They were deseeded (Figure 2) and sliced to 3 mm longitudinally and 100 g of sliced pepper was introduced into the osmotic solution concentrations for each pre-treatment combination at average ambient temperature of 28 ˚C. At the end of the pre-treatment, a non-uniform mass of not greater than 82 g was achieved. For the drying operation, 75 g of pre-treated product was introduced into the dryer for each pre-treatment combination. The temperature of 50 ˚C was maintained throughout the period of drying. The drying temperature of 50˚C was chosen based on what Odewole and Olaniyan (2016) reported that the best temperature range for drying fruits and vegetables is 35˚C to 75˚C. After drying (that is, when samples in the dryer attained almost constant weight and the texture properly turned crispy, and at approximately four hours of drying), all the dried samples were arranged inside the desiccator and were later taken for nutritional analysis. The experiment was carried out in the Laboratory of Food and Bioprocess Engineering Department, University of Ilorin, Ilorin, Nigeria.

Figure 1: Fresh samples of whole green bell pepper

Figure 2: Green bell pepper after deseeding

2.4. Output Parameters

Magnesium, potassium and manganese of dried osmo-pretreated products were determined according to AOAC (2002) procedures.

2.5. Data Analysis

All the output data obtained for magnesium, potassium and manganese were introduced back into the experimental table earlier designed with Design Expert computer software package. The data were analysed following the stipulated procedures of the software for RSM in order to get the 3-dimensional (3-D) plots and 2 dimensional (2-D) contour plots that relate the two process conditions (A and B) with each of the output parameter (mineral contents) and desirability values for optimum process conditions.

3. Results and Discussion

3.1 Optimized Mineral Contents

This section presents the results and discussion of the optimization process. For the three outputs considered (magnesium, potassium and manganese), the higher their values in the dried product, the better the product; because of their excellent importance in human body as earlier mentioned. Hence, the goal of the optimization process for the three outputs was to maximize them in the dried osmo-pretreated product.

3.1.1 Magnesium (mg/100g)

Figures 2a and 2b show the desirability value (always between 0 and 1) of optimum process conditions for magnesium in form of 2-D and 3-D plots respectively. Also, Figure 2c shows the optimum value of magnesium with respect to process conditions A and B. The desirability value is 0.931 for optimized (maximized) value of magnesium. This desirability value shown in small rectangular and square boxes on figures 2a and 2b is the closest to 1 and is the best combinations that enabled the goal of the optimization of getting maximum value of magnesium to be achieved. The location of desirability value of 0.931 from figures 2a and 2b on figure 2c indicate that the optimum value of magnesium of the dried osmo-pretreated green bell pepper is about 29.18 mg/100g with osmotic process duration of 180 min and osmotic solution concentration of 25% (w/w). The control sample of green bell pepper that was not pre-treated contained 19.63mg/100g of magnesium after drying, and fresh sample of green bell pepper contained 30.03mg/100g magnesium which is almost the same as the amount present in dried osmo-dehydrated green bell pepper. Hence, this is a confirmation that osmotic dehydration helps to retain nutrients in food. This is in agreement with results obtained by Odewole *et al*., (2015), Sunjka and Raghava (2004) and Odewole and Olaniyan (2015) for osmotic dehydration and drying of different food materials.

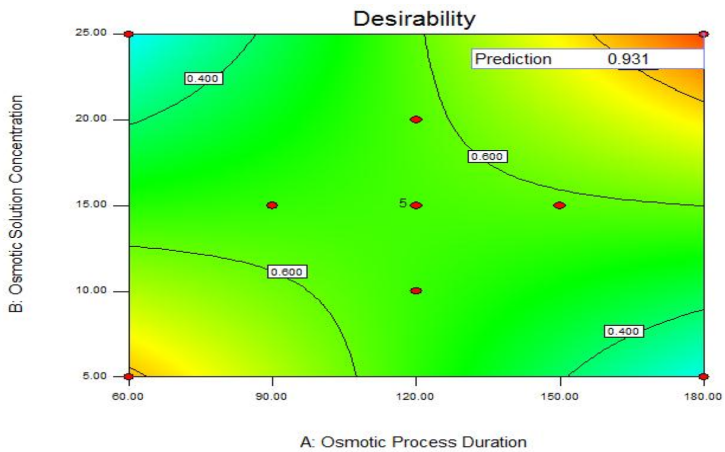

Figure 2a: 2-D Plot showing desirabilty value of optimum process conditions for magnesium

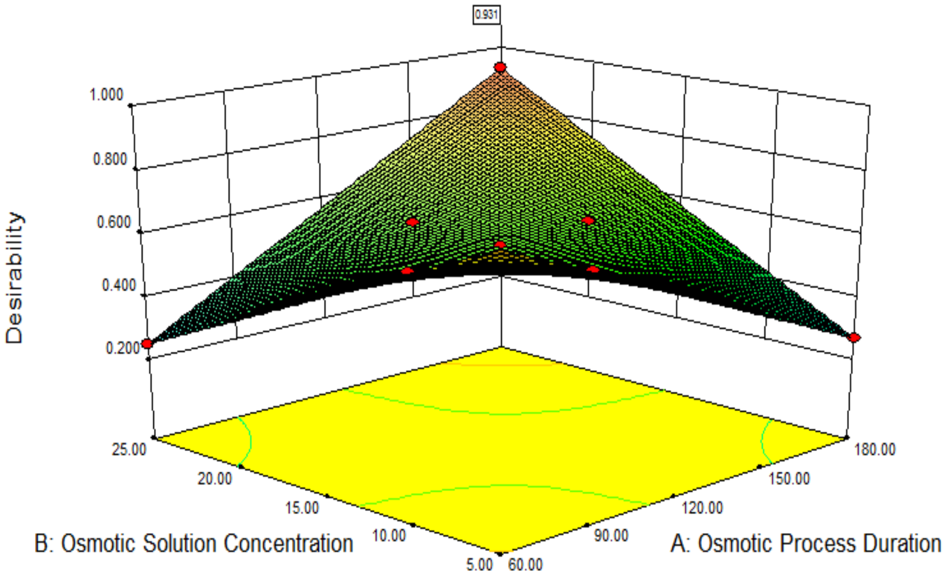

Figure 2b: 3-D plot showing desirabilty value of optimum process conditions for magnesium

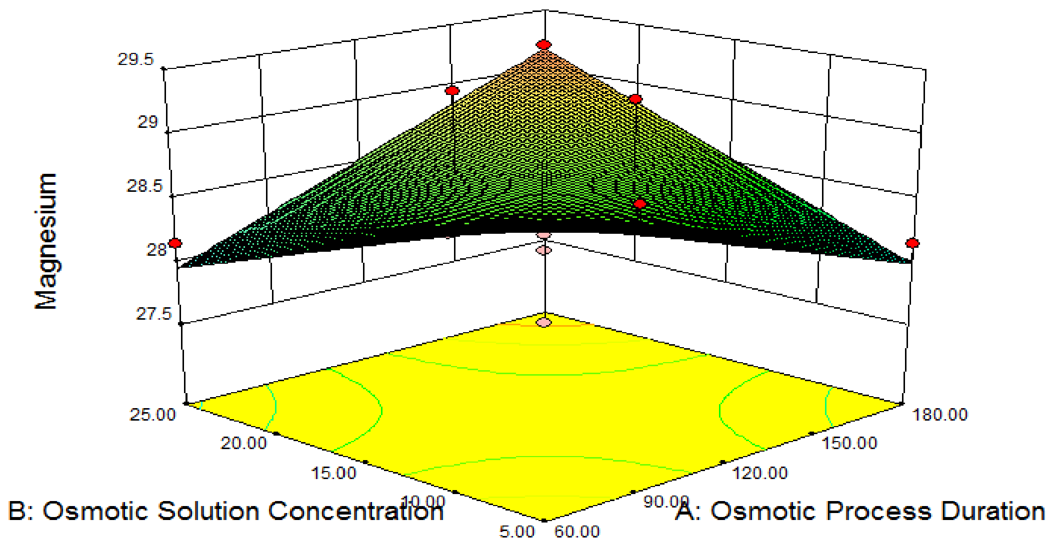

Figure 2c: 3-D plot for optimum value of magnesium (mg/100g)

3.1.2 Potassium (mg/100g)

Figures 3a and 3b show the desirability value of optimum process conditions for potassium. Also, Figure 3c shows the optimum value of potassium with respect to process conditions A and B. The desirability value is 0.432 for optimized (maximized) value of potassium. From figure 3c, the optimum value of potassium is 46.13mg/100g with 60 min osmotic process duration and 5% (w/w) osmotic solution concentration. Fresh sample of green bell pepper used for this study contained 47.40mg/100g of potassium while the control sample that was just dried without osmotic dehydration pre-treatment had 36.18mg/100g of potassium. The amount of potassium present after osmotic dehydration (46 mg/100g) is very close to the amount in the fresh sample and considerably higher than the amount present in the dried unpre-treated control sample. This means, osmotic dehydration led to quality retention of green bell pepper after drying.

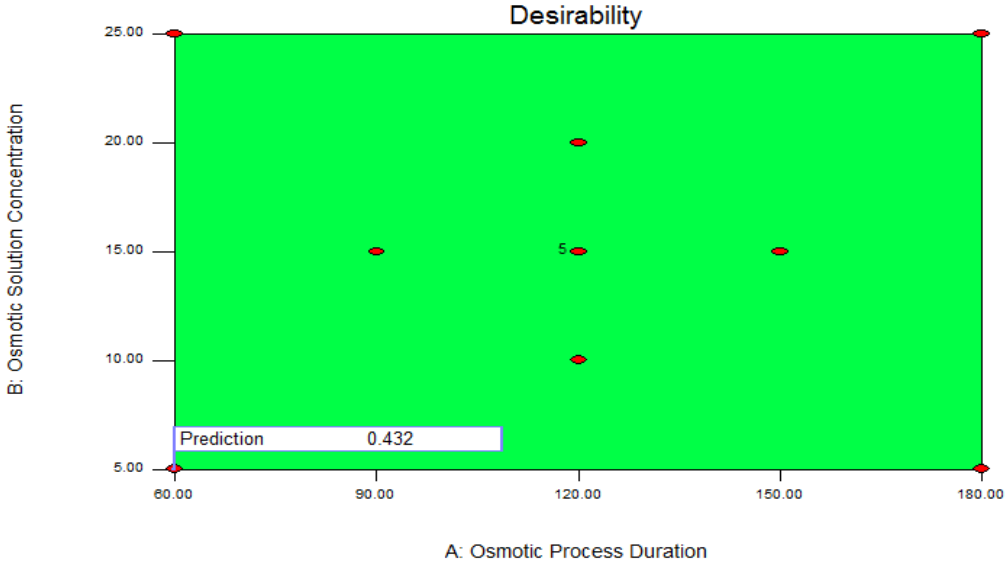

Figure 3a: 2-D plot showing desirabilty value of optimum process conditions for potassium

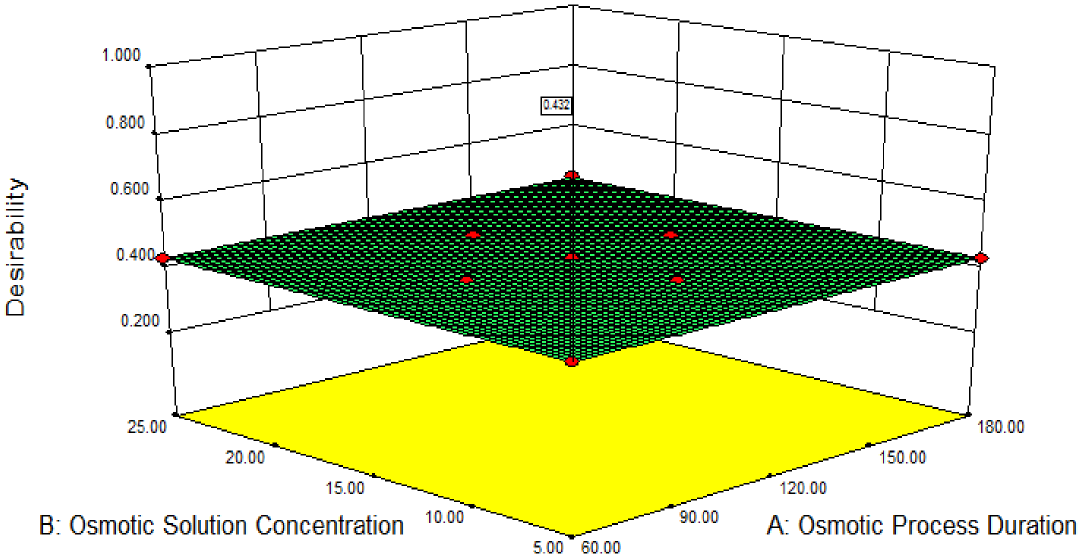

Figure 3b: 3-D plot showing desirabilty value of optimum process conditions for potassium

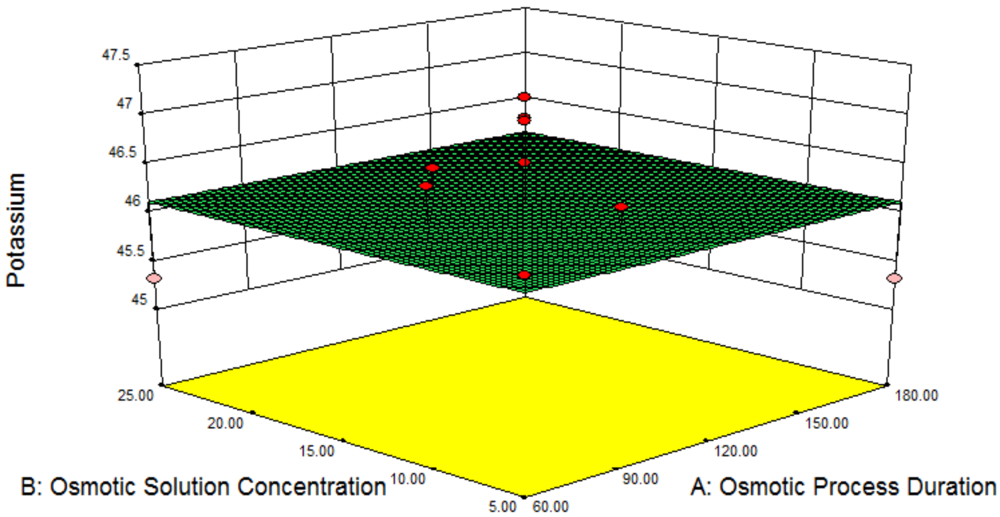

Figure 3c: 3-D plot for optimum value of potassium (mg/100g)

3.1.3 Manganese (mg/100g)

The desirability value of optimum process conditions for manganese is shown in Figures 4a and 4b. Also, Figure 4c shows the optimum value of manganese with respect to process conditions A and B. The desirability value is 1.00 for optimized (maximized) value of manganese. From figure 4c, the optimum value of manganese is 10.96 mg/100g with 150 min osmotic process duration and 15% (w/w) osmotic solution concentration. The amount of manganese present in dried untreated (control) sample of green bell pepper (7.23 mg/100g) is low compared to the amount present in fresh samples of green bell pepper (11.40 mg/100g). This result further confirmed the report of Singh *et al*., (2006) and Pokharkar and Prasad, (1998) that osmotic dehydration used to improve quality of products.

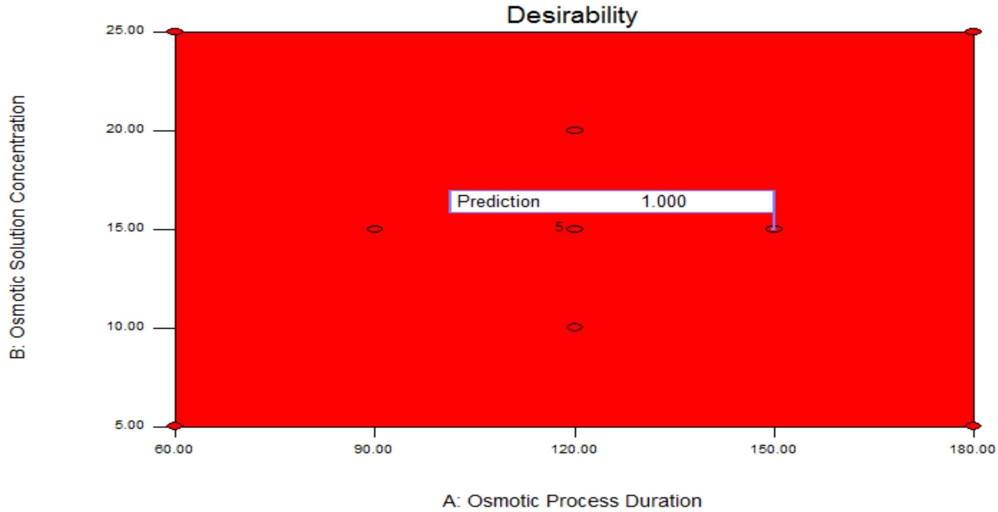

Figure 4a: 2-D plot showing desirabilty value of optimum process conditions for manganese

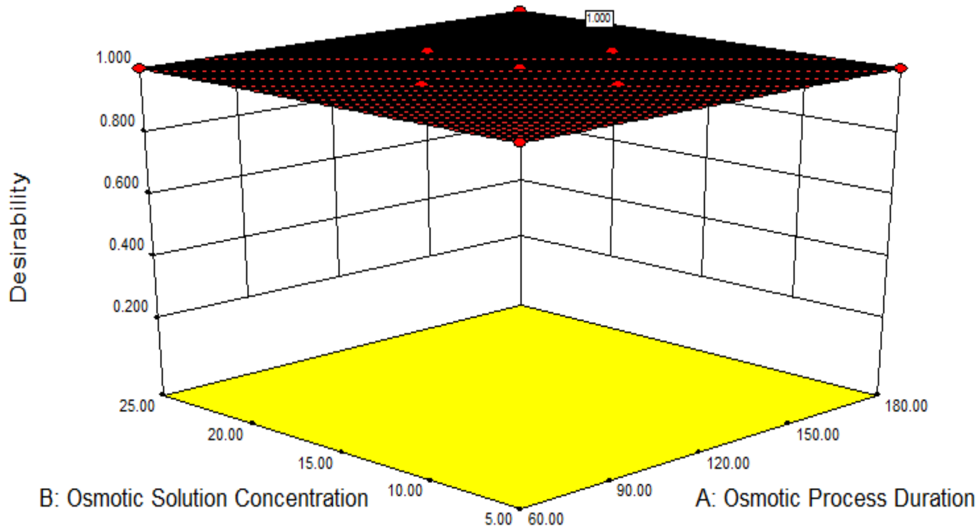

Figure 4b: 2-D plot showing desirabilty value of optimum process conditions for manganese

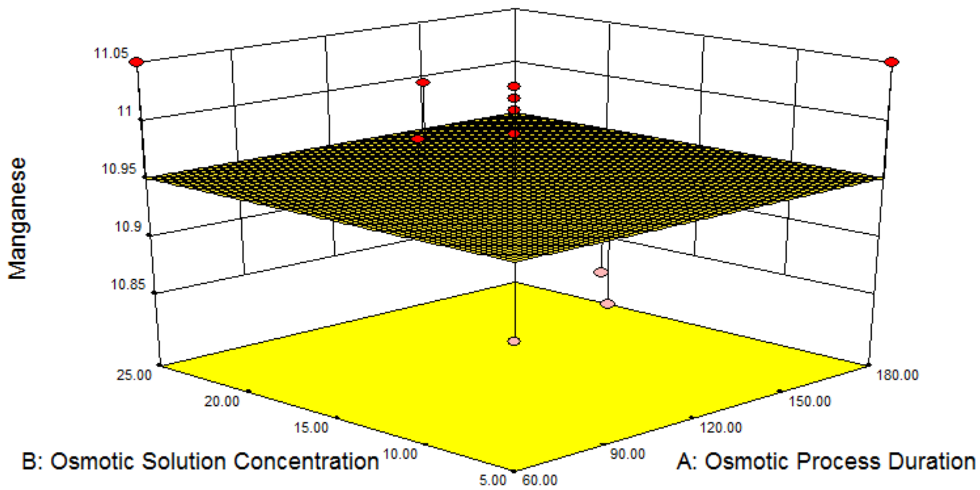

Figure 4c: 3-D plot for optimum value of manganese

4. Conclusion

In conclusion, different combinations of osmotic solution concentration and osmotic process duration gave the optimum values of magnesium, potassium and manganese of dried osmo-pretreated green bell pepper *(Capsicum annuum).*The optimized combinations were selected on the basis of their desirability values which were 0.931, 0.432 and 1.00 for magnesium, potassium and manganese respectively. From the desirability values on the response surface plots, the optimum value of magnesium was found to be 29.18 mg/100g at osmotic process duration of 180 min and osmotic solution concentration of 25% (w/w); for potassium, the optimum value was 46.13 mg/100g at osmotic process duration of 60 min and osmotic solution concentration of 5% (w/w); while for manganese it was 10.96 mg/100g at osmotic process duration of 150 min and osmotic solution concentration of 15% (w/w). Dried pre-treated products had nutrients values closer to fresh samples than control (dried unpre-treated) samples for all the three nutrients considered. This further confirmed osmotic dehydration as a quality improving pretreatment method for food materials after drying.

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