Effect of Processing on Nutritional Quality of Spinach (*Spinacia oleracea*)

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Abstract- Fruits and vegetables contain significant levels of biologically active components that result health benefits beyond basic nutrition. Spinach is considered as one of the most nutritious vegetables. It is the excellent source of phytochemicals. Investigations were carried out to study the effect of drying on total phenol content, antioxidant property of dehydrated spinach. The dehydration of spinach was done at 50^0C, 60^0C, 70^0C for 4 hours using tray drier. For tray drying the drying rate increased with increased temperature but decreased with increase in time. Pretreatment showed insignificant effect on quality of dehydrated spinach. In addition, Freeze drying resulted in products with better quality characteristic of dehydrated spinach. The experimental drying data of spinach was applied to Newton model.

Keywords -Tray drying, Freeze drying, Total phenol content, Antioxidant capacity, Moisture content etc.

I. INTRODUCTION

Epidermiological studies have revealed that intake of vegetables reduces the risk of cancer and cardiovascular diseases[1].This beneficial effect on human health is attributed due to the presence of different antioxidant components such as vitamins, polyphenols and phytochemicals in vegetables[2].

Spinach (*Spinacia oleracea),* the cool annual leafy vegetable is considered to have a high nutritional value[3]. It is a rich source of vitamins, minerals and dietary fibers[4,5], Carotenoids, Flavonoids and polyphenols[6,7].

Drying is the one of the widespread methods of preservation of agricultural products[8.]
The reduction in moisture content not only helps in increasing the shelf life of the commodity but reduces the weight and volume. Therefore minimizing packing and also storage and transportation cost[9]. However thermal processing can affect nutritional quality and also acceptability of the processed spinach. Retention of the nutritive features plays a considerable role in overall acceptability of thermally processed vegetables[10]. Therefore the present investigation was made to study the drying characteristics of spinach at various temperatures along with changes in polyphenol and antioxidant capacity of pretreated spinach during processing.

There are different ways to model drying processes, which is a necessary part for the development energy efficient drying techniques. Mathematical modeling is important to improve the performance of drying system[11]. An attempt was made to apply the experimental drying data on Newton model[12] to describe the behavior of spinach and develop a drying equation.

II. MATERIALS AND METHODS

Fresh spinach leaves were procured from local market. The leaves were washed thoroughly with tap water to remove adhering dust. The surface moisture on the wet sample was removed with a muslin cloth. The samples were then subjected to following parameters:

1) Spinach leaves without any blanching were considered as control
2) Water blanching (1:5 w/v) prior drying
3) Salt blanching (1:5 w/v) with saline solution (2% NaCl) prior drying

Spinach leaves were dipped in boiling water and salt solution (2% NaCl) respectively for 2-3 minutes followed by cooling with cold water. Each pretreatment sample was divided into two parts. One part was dried in tray drier at different temperatures. The other part was dried at freeze drier. Drying experiments were performed by tray drier at 50^0C, 60^0C, 70^0C for 4 hours. Samples were taken at 1hr interval and analyzed for moisture content, total phenol content and FRAP analysis.

Analytical parameters:
Moisture content was determined according to method described by Ranganna[13] (1986).
Total phenolic content was determined by Folin-Ciocalteu method[14] at a wavelength of 765 nm and expressed as mg of Gallic acid/mg of spinach.
Antioxidant capacity of spinach sample was estimated according to the procedure described by Benzie and Strain[15] as modified by Pulido, Bravo, and Saura-Calixto[16] at a wavelength of 593 nm using a spectrophotometer (Hitachi U-2000).
The value of MR moisture ratio is calculated by the method developed by Henderson[17] and Perry (1976)

$$MR = \frac{M - M_e}{M_i - M_e} \quad (1)$$

Where, M_i and M are the moisture content (% db) at initial and final time respectively.
Since during drying, the samples were not exposed to uniform relative humidity and temperature continuously. Therefore, moisture ratio was simplified according to Doymez[18] and Goyal[19] and expressed as

$$MR = \frac{M}{M_i} \quad (2)$$

From Newton equation,

$$MR = e^{-kt}$$

Therefore,

$$\ln MR = -kt$$

Then the graph was plotted ln MR vs time (in hr).

III. RESULTS AND DISCUSSION

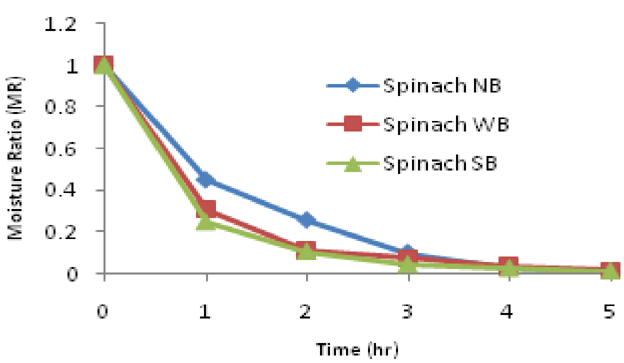

Fig 1a.Effect of thermal treatment of spinach on tray drying at 50^0C

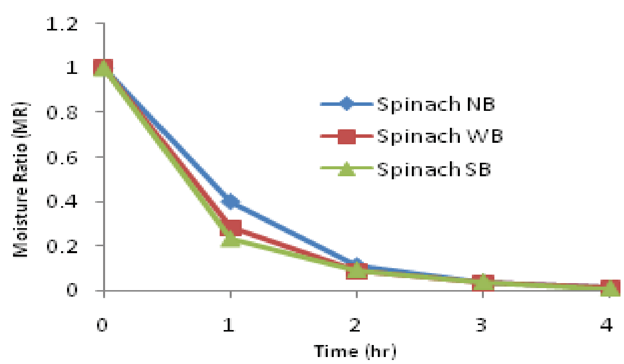

Fig1b.Effect of thermal treatment of spinach on tray drying at 60^0C

Moisture ratio vs Time curves for tray drying at 50^0C, 60^0C, 70^0C are shown in Fig1a, Fig 1b and Fig 1c respectively. At 50^0C curves shows the decreasing trend of drying process. After completion of drying maximum moisture ratio was observed with Non-blanching control sample (NB)(0.0119) than water blanching sample (WB) (0.0113) than that of salt blanching sample(SB)(0.00984). Similar result was observed at 60^0C and 70^0C. At 60^0C maximum moisture ratio was observed with control (0.0118) than water blanching sample (0.00893) than that of salt blanching sample (0.00809). At 70^0C maximum moisture ratio was observed with control (0.0102) than water blanching sample (0.00773) than that of salt blanching sample (0.00748).

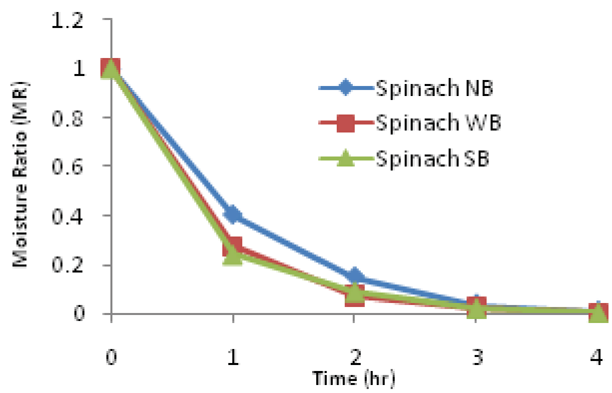

Fig 1c.Effect of thermal treatment of spinach on tray drying at 70^{0}C

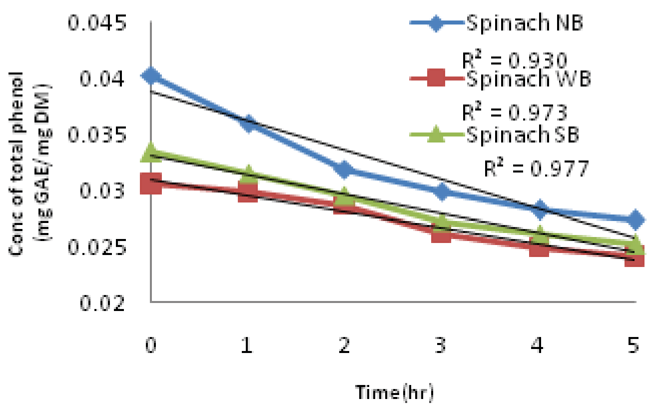

Fig 2a.Effect of thermal treatment of spinach on total phenol content at 50^{0}C

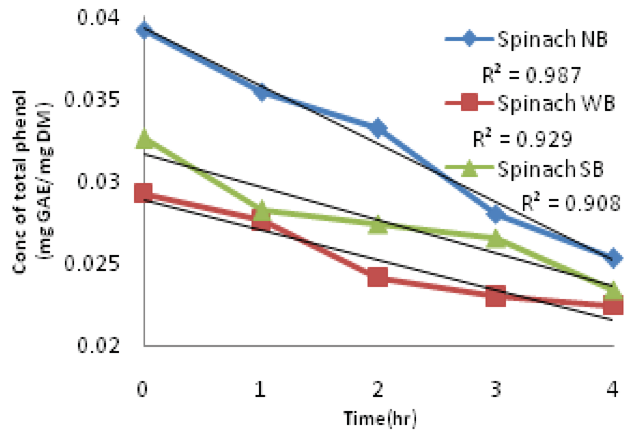

Fig 2b.Effect of thermal treatment of spinach on total phenol content at 60^{0}C

Fig2a,2b,2c represents of effect of thermal treatment on total phenol content of control (non-blanching),water blanching and blanching with salt solution(2%Nacl) spinach sample at 50^{0}C, 60^{0}C, 70^{0}C respectively. At 50^{0}C control (non-blanching) spinach sample (NB) has highest total phenol content [0.0273] (mg GAE/mg DM) than water blanching (WB) [0.0241] (mg GAE/mg DM) and blanching with salt solution (2%Nacl) spinach sample (SB) [0.0252] (mg GAE/mg DM) after completion of drying. Similar result was observed at 60^{0}C and 70^{0}C. At 60^{0}C highest total phenol content was observed in control sample [0.0253] (mg GAE/mg DM) than water blanching sample [0.0224] (mg GAE/mg DM) than that of salt blanching sample [0.0234] (mg GAE/mg DM). At 70^{0}C maximum total phenol content was observed with control sample [0.0245] (mg GAE/mg DM) than water blanching sample [0.0220] (mg GAE/mg DM) than that of salt blanching sample [0.0228] (mg GAE/mg DM).

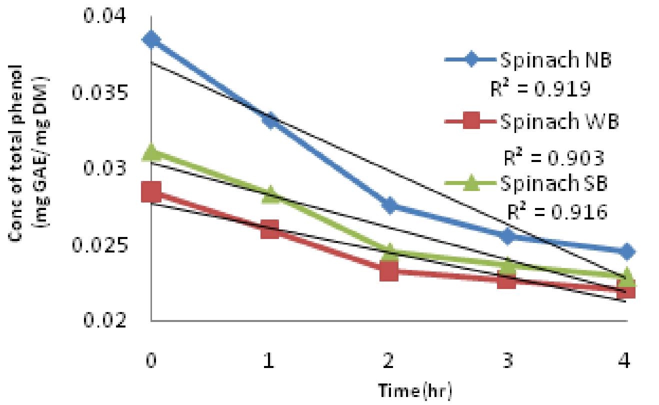

Fig 2c.Effect of thermal treatment of spinach on total phenol content at 70^{0}C

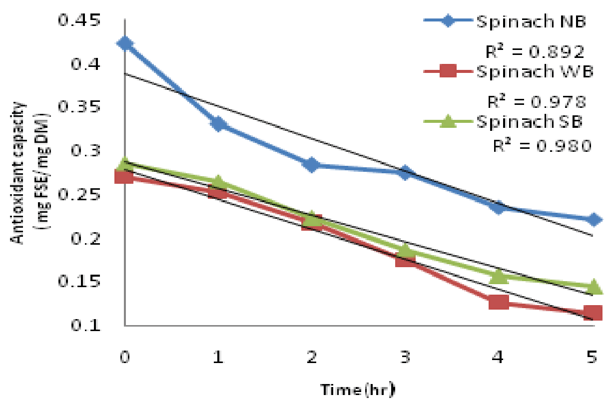

Fig 3a.Effect of thermal treatment of spinach on antioxidant activity at 50^{0}C

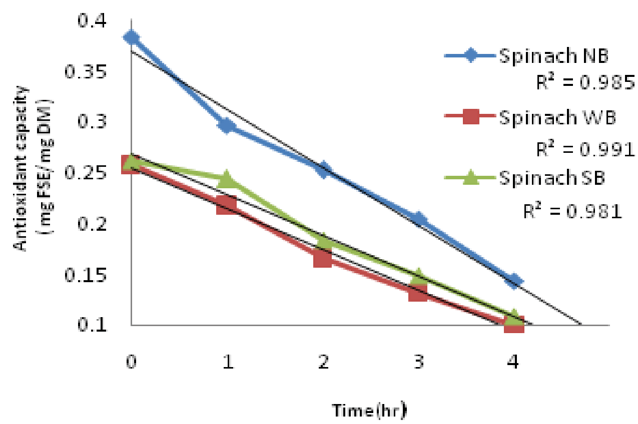

Fig3b.Effect of thermal treatment of spinach on antioxidant activity at 60^{0}C

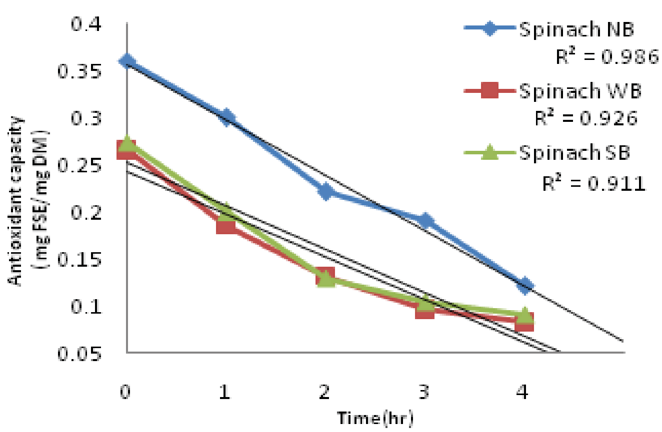

Fig 3c.Effect of thermal treatment of spinach on antioxidant activity at 70^{0}C

Fig3a,3b,3c represents of effect of thermal treatment on antioxidant capacity of control (non-blanching),water blanching and blanching with salt solution(2%Nacl) spinach sample at 50^{0}C, 60^{0}C, 70^{0}C respectively. At 50^{0}C control (non-blanching) spinach sample(NB) has highest antioxidant capacity [0.221] (mg FSE/mg DM) than water blanching(WB) [0.113] (mg FSE/mg DM) and blanching with salt solution (2%Nacl) spinach sample(SB) [0.144] (mg FSE/mg DM) after completion of drying. Similar result was observed at 60^0C and 70^0C. At 60^0C highest antioxidant capacity was observed in control sample [0.143] (mg FSE/mg DM) than water blanching sample [0.100] (mg FSE/mg DM) than that of salt blanching sample [0.108] (mg FSE/mg DM). At 70^0C maximum antioxidant capacity was observed with control sample [0.121] (mg FSE/mg DM) than water blanching sample [0.0826] (mg FSE/mg DM) than that of salt blanching sample [0.0913] (mg FSE/mg DM).

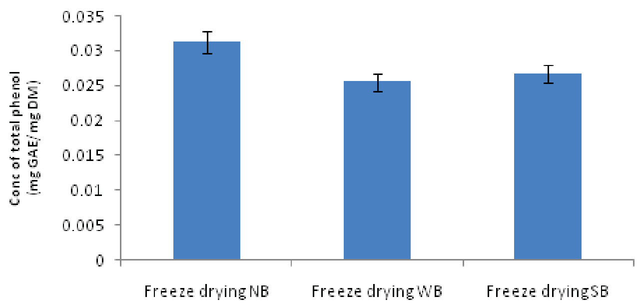

Fig4a. Total Phenol content of pretreated freeze dried spinach samples (NB-Control, WB-Water blanched and SB-blanching with salt solution)

Total phenol content of freeze dried control (non-blanching) spinach sample [0.0313] (mg GAE/mg DM) was highest than that of water-blanching [0.0255] (mg GAE/mg DM) and blanching with salt solution (2%Nacl) spinach sample [0.0267] (mg GAE/mg DM).

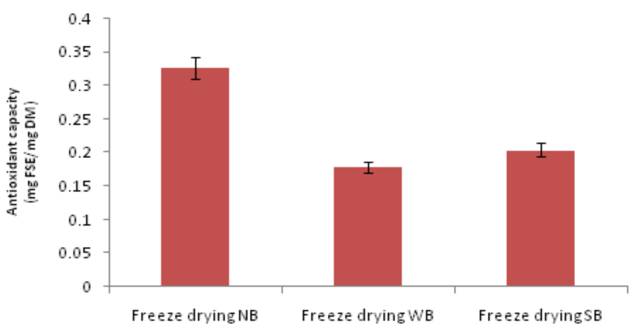

Fig4b. Antioxidant capacity of pretreated freeze dried spinach samples (NB-Control, WB-Water blanched and SB-blanching with salt solution)

Total Antioxidant capacity of freeze dried control (non-blanching) spinach sample [0.326] (mg FSE/mg DM) was highest than that of water-blanching [0.178] (mg FSE/mg DM) and blanching with salt solution (2%Nacl) spinach sample [0.204] (mg FSE/mg DM).

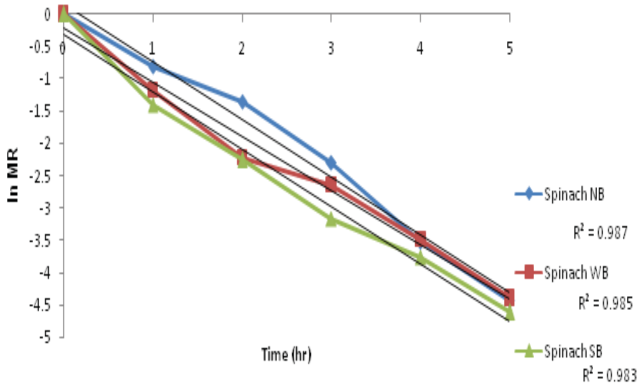

Fig 14. Newton model equation of all spinach sample [Non-blanched (Control), Water-blanching and blanching with salt solution (2%Nacl)] at temperature 50^{0}C

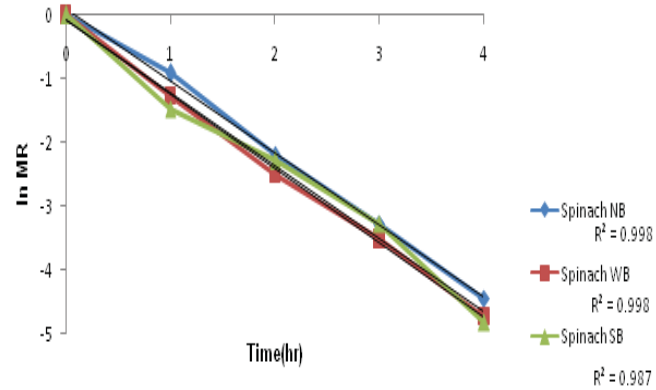

Fig 15. Newton model equation of all spinach sample [Non-blanched (Control), Water-blanching and blanching with salt solution (2%Nacl)] at temperature 60^{0}C

Drying characteristic of spinach leaves at different temperature was studied in this work .The drying curve showed a clear exponential tendency and the formula used to simulate the experimental reading is given in table.

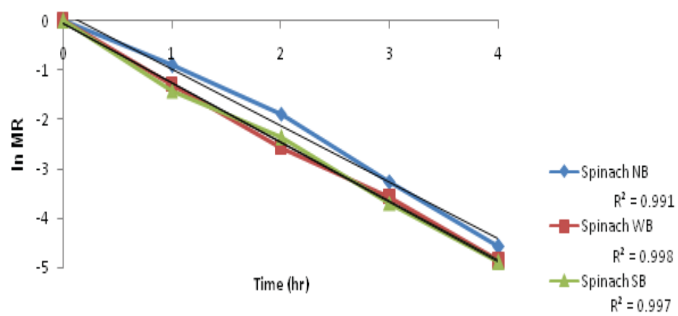

Fig 16. Newton model equation of all spinach sample [Non-blanched (Control), Water-blanching and blanching with salt solution (2%Nacl)] at temperature 70^{0}C

Table 1: Newton Model Equation at different temperature

Sample	NME at 50^{0}C	NME at 60^{0}C	NME at 70^{0}C
Control	$MR=e^{-0.893t}$	$MR=e^{-1.122t}$	$MR=e^{-1.152t}$
Water blanching	$MR=e^{-0.837t}$	$MR=e^{-1.167t}$	$MR=e^{-1.200t}$
Blanching with salt solution	$MR=e^{-0.868t}$	$MR=e^{-1.142t}$	$MR=e^{-1.207t}$

IV.CONCLUSION

Dehydration process is economically beneficial for preservation of food materials. It is one of the well known methods. Drying characteristics of spinach leaves at different temperature were studied in this work. The whole drying took place in falling rate period only. We used the freeze drying technique also and observed better retention of nutritional quality than that of tray drying but it is very costly.

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