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Effect of Blanching Duration and Drying Methods on the Proximate Composition of Green Chilies (*Capsicum annuum* L.)

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Abstract

Farmers in Bhutan practice hot water blanching and sun drying of green chillies as one of the preservation measures. The blanched dried chilli is known as *ema shukam* locally and is used in preparing various traditional cuisines. Blanching is done for 2-3 minutes by immersing in boiling water and drying in open sun. However, blanching and drying process lead to quality changes such as texture, colour, flavour, and nutritional value. Therefore, this study aimed to determine the proximate compositions of sun dried and oven dried green-blanched chillies. An experiment with two drying methods and two levels of blanching durations with three replications for each treatment were conducted to examine the proximate compositions of the dried and blanched chillies. Blanching duration of two minutes retained higher carbohydrates ($\tilde{x}$ = 31.78) than three minutes ($\tilde{x}$ = 26.08). However, the Mann -Whitney *U* test showed no significant effect of blanching duration on carbohydrate (U = 7.5, z = -.690, p > .05). Drying methods had significant effect only on fat content with oven drying retaining higher fat content ($\tilde{x}$ = 4) compared to sun drying method ($\tilde{x}$ = 2); (U = 2, z = -2.713, p < .01). Blanching for three minutes resulted in higher loss of Vitamin C content. The colour of oven dried chilli was dark brownish green even at lower temperature of 37 °C. Hot water blanching of green chillies for two minutes followed by sun drying produced desired colour of dried chillies.

Keywords: Blanch, chilli, oven drying, nutrient, sun drying

Introduction

Chilli (*Capsicum* spp.) is widely grown across several continents and is used as a vegetable, spice, and flavoring and colouring agent. It occupies an important position in food and culture of many countries. It is the only plant species known to produce capsaicinoid, which gives the sensation of hotness when it is consumed by humans. It is also one of the first crops domesticated in the Western Hemisphere about 10,000 BC (Perry *et al.*, 2007) and the most probable reason for early adoption is that traditionally it is used as a medicinal plant to relieve pain (Cichewicz and Thorpe, 1996). It is also a good source of vitamin A, B, and C. It has antioxidant, anticarcinogenic and anti-inflammatory properties; promotes energy metabolism and suppresses fat accumulation (Reyes-Escogido *et al.*, 2011). It is also used as insect repellent and pesticides (Khan *et al.*,

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2014). Therefore, demand for chilli is increasing in the world due to its diverse uses.

In Bhutan, chilli (*Capsicum annuum* L.) is one of the most important vegetables and is a major source of cash income for farmers. Chilli is sold fresh, sun dried when red, blanched and sundried in green stage, and in powdered form. Since cold storage facilities are lacking in Bhutan, drying is one of the most important practices that farmers carry out to prevent the postharvest losses and to make it available during off seasons. Green chillies are blanched and dried especially when there is glut in the market and the price is low. The blanched dried chillies are called *ema shukam* and are used to make traditional *ema shukam datshi* and are also used in other curry preparations. Blanching is an essential thermal treatment done prior to many preservation processes such as drying, canning, freezing and it determines the quality of food (Xiao *et al.*, 2014).

The main objectives of blanching are mainly to inactivate the enzymes such as polyphenol oxidase (PPO) and peroxidase (POD) to prevent deterioration such as undesirable changes in colour and off-flavours and to reduce microbial load. There are many methods of blanching such as hot water blanching, steam blanching, microwave blanching, and infrared blanching among others. However, hot water blanching is the most common as it is the simplest method (Mukherjee and Chattopadhyay, 2007). In hot water blanching, products are immersed in hot water (from 70–100 ^{o}C) for several minutes. Chemical reagents such as sodium sulfite and sodium metabisulfite are often added to blanching water to preserve colour of products. However in Bhutan, farmers usually blanch green chillies for 2-3 minutes by immersing in boiling water without any chemical reagent. Then it is dried in sun, however sun drying has drawback of contamination and it takes 7-15 days depending upon weather conditions (Hossain, 2003). Therefore, greenhouse type solar drying, solar cabinet drying, freeze drying, and hot air oven drying methods are practiced for many crops.

According to Wang *et al.* (2016), blanching temperature and time have significant effect on activity of PPO and POD. During pretreatment and drying processes, the product undergoes physical, chemical, nutritional and structural changes which can affect quality attributes such as texture, colour, flavour, and nutritional value (Di Scala and Crapiste, 2008). In the past, drying was focused on increasing the shelf life of food materials. However, now the focus is changing as consumers become more health conscious and demand quality dried products in terms of colour, texture, and nutrition. Therefore, such studies on postharvest treatments are becoming important. Therefore, the objective of this research is to determine the effect of blanching duration and drying methods on the proximate composition of green-blanched chillies.

Materials and Methods

Sample collection

Fresh green chillies were bought from Centenary Farmers Market, Thimphu and were stored in refrigerator at 4 ^{o}C. The variety was Khasadraphcu ema, which is long and has wrinkled surface when dried. This variety fetches higher price as red dried due to its wrinkled surface, which provides good texture when cooked with cheese to make *ema datshi*, a popular Bhutanese curry.

Experimental design

A 2 x 2 experimental design with two drying methods (open-sun and hot air oven) and two levels of blanching (blanched for two minutes and blanched for three minutes) were conducted. Proximate analysis of fresh green chillies was also done for comparison, however not used in statistical analysis. Two hundred fifty grammes of chilli samples were selected for each treatment with three replications on the basis of maturity and size to have uniform physical characteristics of the material.

Blanching and drying

Blanching technique was done as practiced by Bhutanese farmers. Whole chilli pod samples were poured in boiling water and mixed by stirring and blanched in batches of two and three minutes. There were three replications of 250 g for each blanching duration sample. The samples were kept on a strainer to drain out the water and left to cool. All samples treated with two blanching durations were dried in open sun and in a hot air oven. For sun drying, the samples were dried for eight hours a day and took approximately 9 days to dry with good weather conditions of continuous sunshine and the oven drying was done at 37 ^{o}C until a constant loss of moisture were maintained which took 56 hours. Chillies are dried at temperature ranging from 50–70 ^{o}C (Wiriya *et al.*, 2009), therefore the samples were first dried at 55 ^{o}C. However in oven drying, the colour of chillies turned dark brown and became unattractive. As per Ergunes and Tarhan (2006), an increase in temperature lead to formation of brown products, therefore it was dried at lower temperature of 37 ^{o}C aiming to maintain light-desirable colour as colour is an important component of *ema shukam*. All the dried samples were packed in sterile polythene bag and stored in desiccator for proximate analyses.

Proximate analyses

Association of Official Analytical Chemists (AOAC) method (1995) was used to estimate the moisture, dry matter, fat, protein, ash and crude fibre contents in chilli. Carbohydrate content was determined by difference: 100 - (% moisture + % ash + % protein + % fat + % crude fibre). The moisture content was estimated by hot air oven method at 105 ^{o}C. The macro Kjeldahl method was used for the determination of protein content. The total crude protein was calculated by assuming that the average amino acid in a protein contains 16% amino acid. Thus, the total crude protein was calculated as follows:

$$\% \text{ Crude Protein} = \text{Total nitrogen} \times 6.25$$

The total fat content was determined by extracting 2 g of sample with petroleum ether (boiling point 60–70 ^{o}C) using the Soxhlet extraction method. To estimate the ash content, 2 g of sample each was taken in tarred porcelain crucible and incinerated at 550 ^{o}C in a muffle furnace until ash was obtained.

The crude fibre was determined by Wendee's method using fibra plus instrument. Two grammes of sample were taken in porcelain crucible and extracted using 1.25% H_2SO_4 and 1.25% NaOH solution and after that the residues were ashed, and the loss in the weight was determined as crude fibre.

Determination of ascorbic acid

Ascorbic acid (vitamin C) content in the chilli was determined by redox iodometric titration method (Igwemmar *et al.*, 2013). Chilli sample (100 g) was blended in a food blender together with about 50 ml distilled water. After blending, the pulp was strained through cheesecloth, washed with 10 ml distilled water, and the extracted solution was adjusted to 100 ml in a volumetric flask. Twenty millilitre of each of the extract was pipetted into a pre-

Table 1: Proximate compositions of chilli with different treatments, values expressed in % ± *SD*

Treatment	Moisture	Dry Matter	Protein	Fat	Fibre	Ash	Carbohydrate
FC	87.12±0.85	12.88±0.85	4.79±0.25	1.40±0.53	2.98±0.43	0.93±0.06	2.78±0.70
B2SD	11.53±2.37	88.47±2.37	13.93±1.87	1.67±0.58	31.06±1.07	7.67±0.58	34.14±1.13
B2OD	9.73±1.61	90.27±1.61	16.58±1.55	4.67±1.15	32.14±5.06	8.33±1.53	28.56±3.05
B3SD	10.67±1.63	89.33±1.63	14.54±1.35	2.67±1.15	37.89±0.10	8.33±1.53	25.91±0.44
B3OD	8.73±0.99	91.27±0.99	19.60±0.48	4.33±1.53	34.67±2.31	7.00±1.00	25.67±1.61

Fresh green (FC), blanched for two minutes and sundried (B2SD), balanced for two minutes and oven dried B2OD, blanched for three minutes and sun dried (B3SD) and blanched three minutes and oven dried (B3OD). Data represent mean ± *SD*; *n*=3.

washed conical flask and 5 ml of 10% potassium iodide (KI) with 2 ml of 0.3 M sulphuric acid (H_2SO_4) were added into the flask. One ml of 0.5% starch indicator was added to the solution containing the samples. The excess iodine was titrated against 0.01 M Potassium Iodate ($KI0_3$) till the end point when black-blue colour was formed. The titre value was recorded and the vitamin C was calculated by following the equation:

$$IO_3^-{}_{(aq)} + 5I^-_{(aq)} + 6H^+_{(aq)} \text{ à } 3I_{2(aq)} + 3H_2O_{(aq)}$$

$$C_6H_8O_{6(aq)} + I_{2(aq)} \text{ à } C_6H_6O_{6(aq)} + 2I^-_{(aq)} + 2H^+$$

Statistical analyses

The data are presented as the means of three replications. A Mann-Whitney *U* test was conducted to analyse the data using SPSS software. Difference at $p < .05$ was considered statistically significant.

Results and Discussion

The proximate composition

Results of the proximate analyses of fresh green chilli, fresh green chilli blanched for two minutes and three minutes in boiling water, and sundried and oven dried chillies are shown in Table 1. The moisture content in fresh green chillies was 87.12 ± 0.85 *SD* and is similar to that of other studies (e.g., 86.31 g/100 g by Kamal *et al.*, 2019). Wall and Bosland (1993) reported that the ideal final moisture content for dried chilli is 8% and if it is above 11% mould grows and moisture content below 4% leads to an excessive colour degradation. However, according to Pitt and Hocking (1997) chilli generally needs to be dried to a moisture content of below 13% in order to prevent potential aflatoxin production. Therefore, even the sun-dried sample had moisture less than 13% in this study which shows that if stored properly can be free of the aflatoxin hazards which is anyway not common.

All the other proximate compositions were lower in fresh chillies than that of the blanched dried samples as shown in Table 1. Blanching duration of two minutes retained higher ($\tilde{x}$ = 31.78) carbohydrates than three minutes ($\tilde{x}$ = 26.08). However, Mann-Whitney *U* test (Table 2) showed that there is no significant effect of blanching duration on carbohydrate ($U = 7.5$, $z = -.690$, $p > .05$). Similarly, there was no significant effect of two minutes ($\tilde{x}$ = 89.59) and three minutes blanching ($\tilde{x}$ = 89.64) on dry matter ($U = 15$, $z = -.484$, $p > .05$). Also, the two and three minutes durations had no effect on protein ([$\tilde{x}$ = 15.68, 15.61] $U = 17.5$, $z = -.0.080$, $p > .05$), fat ([$\tilde{x}$ = 3.00, 4.00] $U = 14.5$, $z = -.594$, $p > .05$), fibre ([$\tilde{x}$ = 31.50, 36.91] $U = 7.5$, $z = -1.693$, $p > .05$), ash ([$\tilde{x}$ =8, 8] $U = 16$, $z = -.341$, $p > .05$), and moisture ([$\tilde{x}$ = 10.41, 10.34] $U = 15$, $z = -.484$, $p > .05$) contents. According to Owusu-Kwarteng *et al.* (2017) crude ash content significantly reduced following blanching for four minutes in boiling water and blanching by use of 2% NaCl solution. It could be stated that farmers in Bhutan have learnt this technique of blanching and sun drying through many years of experiences and found the most appropriate blanching duration of 2-3 minutes. Moreover, farmers cool blanched materials naturally in ambient condition rather than in running water. It is a good practice as the cooling of soyabean in running water after hot water blanching lead to leaching of carbohydrates (Min *et al.*, 2010).

Drying methods had significant effect on fat content with oven drying retaining higher fat ($\tilde{x}$ = 4) compared to sun drying ($\tilde{x}$ = 2), ($U = 2$, $z = -2.713$, $p < .01$) (Table 3) irrespective of blanching duration. The higher retention of fat could be because of faster drying in hot air oven (53 hours) as compared to sun drying (72 hours). There was no significant effect of sun and oven drying in all the other proximate compositions; carbohydrate ([$\tilde{x}$ = 29.63, 29.89] $U = 12$, $z = -.966$, $p > .05$), dry matter ([$\tilde{x}$ = 88.40, 90.68] $U = 10$, $z = -1.290$, $p > .05$), protein ([$\tilde{x}$ = 14.40, 15.75] $U = 6$, $z = -1.932$, $p > .05$), fiber ([$\tilde{x}$ = 35.04, 34.0] $U = 12$, $z = -.968$, $p > .05$), ash ([$\tilde{x}$ = 8, 8] $U = 16$, $z = -.341$, $p > .05$) and moisture ([$\tilde{x}$ = 11.60, 9.3] $U = 10$, $z = -1.290$, p > .05). The product qualities par-

Table 2: Mann -Whitney *U* test on effect of blanching duration on proximate compositions

Variable	Blanching duration			
	2 Minutes	3 minutes		
	Mean rank	Mean rank	U-Value	Z-value
Moisture	7	6	15	-0.484
Dry matter	6	7	15	-0.484
Protein	6.58	6.42	17.5	-0.08
Fat	5.92	7.08	14.5	-0.594
Fibre	4.75	8.25	7.5	-1.693
Ash	6.17	6.83	16	-0.341
Carbohydrate	8.25	4.75	7.5	-1.69

ticularly colour, texture, flavour, ascorbic acid, b-carotene, phenolics and other nutrients are often deteriorated by thermal drying due to the development of browning pigment and direct contact with air and light (Wiriya *et al*., 2009). Therefore, the non-significant difference in drying methods on almost all the proximate compositions could be because of the lower temperature even on oven drying.

Ascorbic acid content

Ascorbic acid (vitamin C) is considered as one of the indicators of the quality of food processing due to its low stability during thermal processes (Podsedek, 2007). The result of the ascorbic acid degradation due to blanching duration and drying methods are shown in Figure 1. The ascorbic acid content in fresh unblanched green chilli was 396.22 g/100 g (fw) which is higher compared to 188.2 ± 4.5 mg /100 g fw (Toontom *et al.*, 2005) and 75–277 mg/100 g fw (Castro *et al.*, 2008) in red pepper. Comparable ascorbic acid content of 315.3 mg/100 g was found in Bhut Jolokia (Kenneao *et al*., 2020). Higher ascorbic acid (184.90 mg/100g) was retained by blanching for two minutes and sun drying than by blanching for three minutes (158.49 mg/g) and sun or oven drying. Similarly in case of broccoli, longer blanching time in boiling water causes higher loss in ascorbic acid, which could be attributed to the leaching of nutrients (Severini *et al*., 2016). Drying temperatures of hot air oven have strong detrimental effect on the retention of ascorbic acid in chilli (Vega-Gálvez *et al*., 2009). Increasing drying temperature from 50 °C to 70 °C increased the degradation rate constants of ascorbic acid. In this case, the sun and oven drying did not show difference and it could be because even the hot air oven drying temperature was kept lower at 37 ^{o}C. The loss of ascorbic acid using the sun drying method results due to oxidation as the dried chilli is exposed directly to sun light (Gregory, 1996). Howard *et al.* (1994) also reported that 75% of ascorbic acid in red chilli was lost during drying. Likewise, a maximum loss of 98.2% in vitamin C was observed in samples dried at 90 °C (Vega-Gálvez, 2009). In this study, 66.67% of ascorbic acid was lost during three minutes of blanching irrespective of

Table 3: Mann-Whitney *U* test on effect of drying on proximate composition of chilli

Variable	Drying methods			
	Open sun drying	Hot air oven drying		
	Mean rank	Mean rank	U-Value	Z-value
Moisture	7.83	5.17	10	-1.29
Dry matter	5.17	7.83	10	-1.29
Protein	4.5	8.5	15.75	-1.932
Fat	3.83	9.17	2	-2.713**
Fiber	7.5	5.5	12	-0.968
Ash	6.17	6.83	16	-0.341
Carbohydrate	7.5	5.5	12	-0.966

Note: ** Significant at $p < .01$ probability level

the drying methods compared to 53.34% and 60% loss in two minutes blanching and sun drying and two minutes blanching and oven drying respectively. Steam blanching is reported to maintain vitamin C content and colour of chilli (Anoraga *et al*., 2018). Freeze drying has higher ascorbic acid retention than hot air oven and sun drying (Toontom *et al*., 2005). Therefore, these techniques could be tried to make *ema shukam.*

Colour

One of the most important criteria of food quality is colour. The market value and consumer's acceptance decrease with the undesirable change in colour. Figure 2 shows the colour retention of the sun and oven dried blanched chillies. The market preference for the *ema shukam* is creamy white and is obtained from sun drying. However, the oven dried *ema shukam* had dark brown colour. At first, the samples were dried at 55 ^{o}C which gave unattractive colour therefore, it was dried at 37 ^{o}C to test if the colour could be maintained as Ergunes and Tarhan (2006) had observed that an increase in temperature lead to formation of brown products due to non-enzymatic browning. However, the colour still remained dark brown. Wiriya *et al*. (2009) also mentioned that the dried product qualities particularly colour, texture, flavour, ascorbic acid, b-carotene, phenolics and other nutrients often deteriorate by thermal drying due to the development of browning pigment and direct contact with air and light. Colour preservation could also be attempted through the two-stage temperature regime, using 70 ^{o}C for four hours followed by 50 ^{o}C until the required moisture content is attained, as it gives the highest values of lightness, chroma and hue angle indicating better colour retention (Wiriya *et al*., 2009). Therefore, further research on this two-stage temperature regime could be done to maintain the colour.

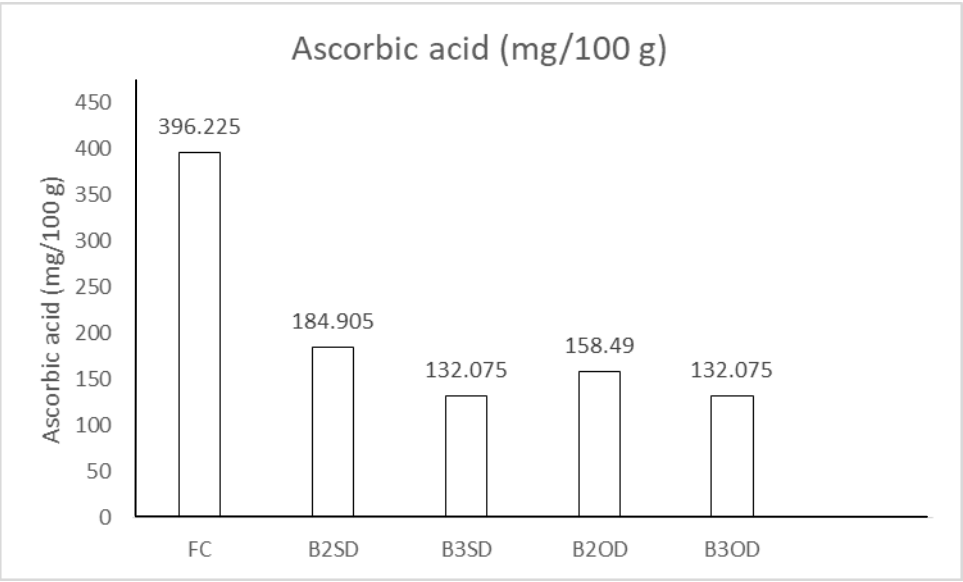

Figure 1: Ascorbic acid content in fresh green (FC), blanched for two minutes and sundried (B2SD), balanced for two minutes and oven dried (B2OD), blanched for three minutes and sun dried (B3SD) and blanched three minutes and oven dried (B3OD).

Conclusions

This study showed that hot water blanching of green chillies for two and three minutes and cooling in ambient conditions did not have significant effect on the proximate composition of chilli. However, ascorbic acid retention was higher (184.905 and 158.49 mg/100g) in 2 minutes of blanching and sun drying and oven drying as compared to 132.075mg/100 g each in three minutes of blanching and drying in two methods. Fat retention was higher (4.67 and 4.33 mg/100 g) in oven drying method as compared to (1.67 and 2.67 mg/100 g) in sun drying irrespective of the blanching duration. Desirable colour typi-

Figure 2: Colour attributes due to blanching and drying methods: (A) blanched for two minutes and oven dried, (B) blanched for 3 minutes and oven dried, (C) blanched for two minutes and sun dried and (D) blanched three minutes and sun dried

cal of the blanched sun dried *ema shukam* could not be preserved by hot air oven drying method even at low temperature of 37 ^{o}C. Therefore, two minutes blanching is recommended however alternative drying methods which are efficient in terms of colour and nutrient retention other than sun drying needs to be explored.

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