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Effect of drying time and temperature on biochemical composition of *Moringa oleifera* leaf powder

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Abstract

The research was conducted to determine the effect of drying time and temperature on proximate composition of moringa leaf powder. The experiment conducted in late 2018, followed Completely Randomized Design involving six treatments (50^0C for 4 hours, 50^0C for 5 hours, 50^0C for 6 hours, 60^0C for 4 hours, 60^0C for 5 hours and 60^0C for 6 hours) and three replications per treatment. Parameters evaluated were weight, moisture, fat, fiber, protein, ash and carbohydrate content. Significance ($p \leq .05$) effect of treatments on the proximate composition was determined using a statistical test Two-way Analysis of Variance (ANOVA). Drying time had significant effect on moisture, protein and carbohydrate contents while, all the parameters were significantly affected by drying temperature. Moisture content ranged from 2.40% to 5.40% and protein from 27.65g/100g to 34.12g/100g. Moisture and protein contents decreased significantly with increase in time and temperature. Carbohydrate content ranged from 25.81g/100g to 35.36g/100g; Carbohydrate increased significantly with the increase in drying time and temperature. Ash content increased significantly from 11.24g/100g to 11.54g/100g with increase in drying temperature. The present study concludes that higher time and temperature effect protein content which is the most lacking nutrients in Bhutanese vegetarian diet. The use of lower temperature and time (50^0C for 4 hours) is the best method to dry moringa leaf.

Keywords: Moringa leaf powder, proximate composition, temperature, time.

Introduction

Moringa belongs to Moringaceae family of perennial angiosperm plants. It has 13 species including *Moringa oleifera* Lam. It is found in the wild and is also cultivated[1]. It is a deciduous perennial shrub or tree, drought tolerant with approximate height of 12m at maturity. It is found at elevation of 1,400m and below[2]. The moringa tree is native to the sub-Himalayan region.

Moringa leaves have been studied extensively for its medicinal value[3]. *M. oleifera* with its numerous medicinal properties could be a promising solution in combating Non Communicable Diseases (NCDs), food insecurity and malnutrition in Bhutan. Moringa is rich in nutrients such as vitamin A, calcium, potassium, iron and protein[4].

Moringa is also valued for its agricultural, industrial and economic purpose[5]. Bhutanese farmers use moringa mainly as a fodder for cattle and for fences. It is also consumed for its therapeutic value in treating diabetes. Moringa pods and flowers are used as vegetables while its leaf is used for medicinal purpose.

Moringa powder is easy to handle, store and can be used any time; addition of moringa leaf powder to any food can enrich its nutrient contents. Cookies, drinks, cereals and other food items can be fortified and enriched using moringa powder[6,7]. Addition of a small amount of moringa powder does not produce any disagreeable and significant effect on the taste of the food[8].

To make moringa available in various forms throughout the year, it can be processed. Processing destroys pathogens and is also good way to add value. However, depending on the methods used, processing could affect the concentrations and availability of nutrients and essential compounds in food due to sensitivity to light, heat and oxygen[9].

Processing of food includes at least one drying step[10]. Drying is a process of simultaneous heat and mass transfer resulting in moisture removal from the product[11]. It is commonly used for preservation of perishable agricultural goods since olden days[12].

Different drying methods used to dry *M. oleifera* leaves are freeze drying, hot air drying, shade and sunlight drying. Freeze drying is the most preferred method to preserve vitamins, minerals and color quality of the product. However, it is one of the most expensive methods[13]. Hot air drying method affects the biochemical composition of moringa leaves[14]. Shade and sunlight drying are economical and most commonly used but it includes the risk of contamination, difficulty in achieving constant quality standard, inability to produce in large quantities to meet large market demand and longer drying time required[15-17]. The tray drying method is economical and readily

available in Bhutan, but the higher temperature could harm the heat liable nutrients[13]. Various mathematical models are developed and used to determine drying time but the effect of drying time (i.e. duration) and temperature on proximate composition of moringa leaf powder using tray drying method has not been explored[18,19].

Thus, this research was designed to determine the effect of different drying time and temperature on proximate composition of moringa leaf powder in tray dryer.

Materials and Methods

Study site: The study was done from December 2018 to March 2019. The raw material (*M. oleifera* leaf) was collected from Samteling Geog (26.9ºN and 90.5ºE) Sarbang Dzongkhag, which lies in a wet subtropical zone with an altitude of 300 masl. Processing and analysis were done at the College of Natural Resources (CNR) food science laboratory and soil laboratory Lobesa, Punakha.

Processing and analysis of biochemical composition: Experimental design and layout: Processing of fresh moringa leaf into dried moringa leaf powder was done at CNR Food Science laboratory using tray dryer. Completely Randomized Design (CRD) was used for the experiment, six treatments with three replications each were employed. Each experimental unit comprises of 100g of fresh moringa leaves spread thinly on the tray (1,800g of moringa leaves in total).

The treatments included combination of both drying time and drying temperature. Treatments were Treatment 1 (T1) - 50^0C at 4 hours; Treatment 2 (T2) - 50^0C at 5 hours; Treatment 3 (T3) - 50^0C at 6 hours; Treatment 4 (T4) - 60^0C at 4 hours; Treatment 5 (T5) - 60^0C at 5 hours; and Treatment 6 (T6) - 60^0C at 6 hours.

Raw material collection: The matured leaves were harvested from the tree manually. Approximately equal amount of leaves was harvested along with the stem from six different trees (5 to 7 years old). According to Sauveur and Broin matured leaves contain more biochemical composition than young leaves[20]. Harvesting was done in the evening.

Transportation: Aerated baskets were used. The leaves along with a few stems were placed in a vegetable crates loosely and transported from collection site to processing site. Transportation was done during the cooler part of the day i.e., during evening right after the harvest[20].

Processing: Processing started immediately after arriving at the processing lab. It included stripping the leaflets, weighing them into 100g each for 18 experimental units using weighing machine (Diethelm Limited, HR-200, measurement precision of ± 0.1g) followed by washing in the running water to remove dust and was washed again in 1% saline solution for 5 minutes to remove spoilage microbes[20]. Later the leaves were washed in clean water. After that the samples were spread in a tray in thin layer and dried using different treatments. Milling was done simultaneously in a grinding machine (Kinematica, PX-MFC 90 D, particle size = 0.25mm).

Packaging and storage: Similar to recommendation of Sauveur and Broin moringa leaf powder was stored in clean, dry and opaque containers that do not affect the quality of the product[20]. Each container was sealed properly to prevent absorption of moisture. Moringa leaf powder was stored in a refrigerator (Shizuka Seiki, GB 14H) at 4°C for proximate composition analysis[21].

Biochemical analysis: Determination of weight and proximate composition i.e. moisture content, fat, protein, ash, fibre and carbohydrate contents were done at the *College of Natural Resources Laboratory by adopting CNR, Laboratory protocols.* Soxhlet extraction principle was used to estimate fat content. Weendes method was used for crude fibre estimation and protein content was determined using Kjeldal method.

Determination of individual effect of drying time and temperature: To determine the individual effect of time and temperature on proximate composition of moringa leaf powder, one variable was kept constant while other was being compared. Further, to determine the effect of drying time on the biochemical constituents, temperature was kept constant i.e., T1, T2 and T3 were compared which were 4 hours, 5 hours and 6 hours respectively at constant temperature of 50ºC and T4, T5 and T6 were compared which were 4 hours, 5 hours and 6 hours respectively at constant temperature of 60ºC. To measure the effect of temperature, time was kept constant i.e., T1 and T4 were compared which were 50ºC and 60ºC, respectively both at constant drying time of 4 hours. T2 and T5 were compared which were 50ºC and 60ºC, respectively at constant drying time of 5 hours, and T3 and T6 were compared which were 50ºC and 60ºC, respectively at constant drying time of 6 hours.

Statistical analysis: Data was analysed using IBM-SPSS (International Business Machines Corporation-Statistical Package for the Social Sciences version 23.0). The effect of different treatments on proximate composition of moringa leaf powder was determined using parametric test, Two-way ANOVA (Analysis of Variance). Post hoc Bonferroni test was conducted to determine significant difference between those treatments that had significant effect.

Results and discussion

Effect of different treatments on weight and biochemical composition of moringa leaf powder: Weight**:** The weight of tray dried moringa leaf powder decreased with increase in temperature (Table-1). The maximum weight was obtained from T3 (42.04g/100g) and minimum weight from T5 (40.67g/100g). Drying time had no significant effect on weight of the moringa

leaf powder, p = .367. However, significant effect on weight was observed with increase in drying temperature, p = .041. Thus, moringa leaf powder dried at 50ºC (T1, T2 and T3) had significantly higher weight content compared to moringa leaf powder dried at 60ºC (T4, T5 and T6).

The drying temperature result corroborates with the study of Manchekar and associates[22]. Their study concludes reduction in weight content with increase in temperature. Similar result was obtained by Agasimani et al.[23].

The drying time result of this study contradicts with the study of Gupta and Shukla[24] who reported significant difference in weight of carrot and onion slices with increase in time from 4 hours to 5 hours. The difference in the result could be due to moringa leaf loosing moisture faster than the carrot and onion slices. Further, Premi et al. also observed that moisture loss of moringa leaf was faster at the beginning than at the end[19]. This indicates decrease in weight of the moringa leaf powder could be significant before 4 hours but not significant after 4 hours.

Moisture content: The moisture content of the moringa leaf powder samples ranged from 2.40% in T6 to 5.40% in T1 (Table-1). Drying time had significant effect on moisture content, p = .006. Thus, moisture content of samples dried at 4 hours (T1 and T4) is significantly higher than those dried at 6 hours (T3 and T6), p = .005 but there was no significant effect on moisture content with increase in drying time by 1 hour i.e., 4 hours to 5 hours (T2 and T5), p = .135 and 5 hours to 6 hours, p = .297.

Drying temperature had highly significant effect on the moisture content of moringa leaf powder. Samples dried at 50^0C (T1, T2 and T3) had significantly higher moisture content compared to samples dried at 60^0C (T4, T5 and T6), p = .000.

There was a decrease in the moisture content of all the samples with increase in drying time and temperature. This result is in agreement with the study of Olabode et al. and Alakali et al.[14,15]. They have reported decrease in moisture content of a moringa leaf powder with increase in temperature. Decrease in moisture content was due to diffusion leading to net movement of moisture from the leaves to the air. At higher drying temperature moisture content decreases faster due to increased rate of heat supply to the leaves[25]. At high temperature, low moisture content hampers activity of spoilage microorganisms thus improving shelf life of a moringa leaf powder.

However, according to Derossi et al. high temperature results in increased incidence of non-enzymatic browning due to production of brown melanoidin pigments in vegetables[26]. The moisture content is in the range mentioned by Alakali et al.[15] The range of moisture content was appropriate for further processing and storage. Idah et al.[28] also made similar conclusions regarding moisture content in tomatoes.

Fat content: Fat content of the sample ranged from 14.24g/100g to 13.47g/100g (Table-1). The highest fat content was observed in samples dried at 50ºC for 4 hours (T1) and the lowest in samples dried at 60ºC for 6 hours (T6). When individual effect of time and temperature was determined, there was no significant effect of drying time on the fat content, p = .831. However, drying temperature had significant effect on the fat content, p = .005. This shows that fat content decreased significantly with increase in drying temperature from 50ºC (T1, T2 and T3) to 60ºC (T4, T5 and T6).

The decrease in fat content with respect to increase in temperature was due to increase in protein denaturalization resulting in decrease in both protein and fat contents. This result is in agreement with the study of Alakali et al. and Gernah and Sengev[15,27]. The fat content is within the range reported by Price and Fuglie[29,30].

Protein content: Crude protein content of moringa leaf powder was 34.12g/100g in T1 and as drying time and temperature increased it decreased to 27.65g/100g in T6 (Table-1). Drying time had significant effect on the protein content of moringa leaf powder, p = .000. The decrease in protein content of the sample dried at 4 hour (T1 and T4) was highly significant compared to the sample dried at 6 hours (T3 and T6), p = .000. There was a significant decrease in protein content of the sample with change in drying time by 1 hour i.e., 4 hours to 5 hours (T2 and T5), p = .027 and 5 hours to 6 hours, p = .001.

Drying temperature had highly significant effect on protein content of the moringa leaf powder, p = .000. Thus, with increase in temperature from 50ºC (T1, T2 and T3) to 60ºC (T4, T5 and T6) highly significant decrease in the protein content was observed.

The significant decrease in protein content with increase in drying time and temperature could be explained by the study of Meyerzon and Janine, who stated very high temperature and long duration might effect protein content due to denaturation of protein cells[31,32]. The protein content obtained is 8 to 11 times more compared to cow's milk (3.29g/100g) and 13 times more than amount obtained from spinach[28]. The protein content of this study is within the range specified in the study of Ali et al.[13]; Olabode et al.[14] and Joshi and Mehta[33].

Fibre content: The crude fibre content of the sample increased when drying time and temperature was increased. Crude fibre ranged from 9.19g/100g in T1 to 9.58g/100g in T6 (Table-1). Drying time had no significant effect on the fibre content of moringa leaf powder, p = .46. However, there was a significant effect of drying temperature on the fibre content of moringa leaf powder, p = .024. Thus, when drying temperature increased from 50ºC (T1, T2 and T3) to 60ºC (T4, T5 and T6) there was highly significant increase in fibre content of moringa leaf powder. This result corroborates with the study conducted by Alakali et al.; Kumar et al. and Gernah and Sengev[15,12,27], which concludes increase in fibre content with respect to increase in temperature.

Table-1: Effect of different treatments on weight and proximate composition.

Parameters	Samples (dried leaf powder)					
	T1	T2	T3	T4	T5	T6
Weight (g)	41.78±0.59	41.72±0.56	42.04±0.41	41.16±0.19	40.67±0.22	41.51±0.08
Moisture (%)	5.40±0.23	4.80±0.00	4.73±0.18	2.93±0.67	2.87±0.67	2.40±0.20
Fat (g)	14.24±0.16	14.12±0.08	14.01±0.37	13.52±0.14	13.51±0.30	13.47±0.13
Protein (g)	34.12±0.07	33.13±0.28	32.05±0.14	29.06±0.08	28.73±0.18	27.65±0.35
Fibre (g)	9.19±0.02	9.27±0.06	9.31±0.02	9.42±0.01	9.48±0.24	9.58±0.11
Ash (g)	11.24±0.01	11.24±0.03	11.29±0.02	11.52±0.03	11.54±0.02	11.54±0.03
Carbohydrate (g)	25.81±0.19	27.43±0.28	28.59±0.56	33.56±0.16	33.88±0.28	35.36±0.05

T1 = 50ºC at 4 hours. T2 = 50ºC at 5 hours. T3 = 50ºC at 6 hours. T4 = 60ºC at 4 hours. T5 = 60ºC at 5 hours. T6 = 60ºC at 6 hours.

The leaves contain a good amount of fibre. Moringa leaf powder (100g) could provide half of the daily requirement (16g to 32g) of fibre intake of our body[15]. The fibre content of this study was comparatively lesser than in the studies conducted by Alakali et al.; Olabode et al. and Joshi and Mehata[15,14,33], as they found 11.3g/100g to 12.1g/100g of fibre, 17.26 g/100g to 17.56g/100 g of fibre and 17.46g/100g to 17.66g/100g of fibre respectively. The difference in result could be explained due to different sample collection site with different climatic and edaphic factors. Difference in drying time and temperature of the equipment where Alakali et al.[15] dried moringa leaf at 40ºC, 50ºC, 60ºC and 70ºC for 2 hours; Olabode et al.[14] dried at 60ºC, 70ºC and 80ºC for 24 hours and Joshi and Mehta[33] dried at 60ºC for 1 hour. Further, different moringa variety under study and different drying method (oven drying) used in all three studies could explains the slight increase in fibre content of the moringa leaf powder compared to this study.

Ash content: The ash content of the sample increased when drying time and temperature was increased. The ash content of samples increased from 11.24g/100g to 11.54g/100g when temperature and time increased from 50ºC and 4 hours (T1) to 60ºC and 6 hours (T6) (Table-1). There was no significant effect of drying time on the ash content of moringa leaf powder, p = .378. However, drying temperature had highly significant effect on ash content of moringa leaf powder, p = .000. Thus, with increase in drying temperature from 50ºC (T1, T2 and T3) to 60ºC (T4, T5 and T6) there was significant increase in ash content of moringa leaf powder.

The result corroborates with the study of Alakali et al.; Olabode et al.; Gernah and Sengev[15,14,27] who concludes increased ash content as drying temperature increases. However, ash content of this study was comparatively higher. Higher ash content can be explained by higher fibre content of this study, difference in geographical location of sample site collection and different variety of *M. oleifera* used by Alakali et al.; Olabode et al. and Gernah and Sengev[15,14,27]. Further, different time of collection and different maturity stage while collecting the leaf sample in the study of Alakali et al.[15] also explains higher ash content of this study.

Ash content represents inorganic residue that remains after the destruction of organic matter. It shows the mineral content of the sample[34]. The higher ash content in this study reveals higher mineral content compared to moringa leaf powder of other studies.

Carbohydrate content: Carbohydrate content of the sample increased with increase in time and temperature. Lowest carbohydrate content was 25.81g/100g in T1 and highest was recorded 35.36g/100g in T6 (Table-1). There was a highly significant effect of drying time on the carbohydrate content of moringa leaf powder, p = .000. The increase in carbohydrate content of the sample dried at 4 hours (T1 and T4) was highly significant when compared to the sample dried at 6 hours (T3 and T6), p = .000. Carbohydrate content of the sample increased significantly with change in drying time by 1 hour i.e., 4 hours to 5 hours (T2 and T5), p = .022 and 5 hours to 6 hours, p = .003.

The effect of drying temperature on carbohydrate content of the moringa leaf powder was highly significant, p = .000. This concludes that as drying temperature increases from 50ºC (T1, T2 and T3) to 60ºC (T4, T5 and T6) there is a significant increase in carbohydrate content of moringa leaf powder.

The increase in carbohydrate content of this study with increase in time and temperature is according to the result of Alakali et al. and Gernah and Sengev[15,27]. Rapid caramelization of sugars

at high temperature explains the increase in the carbohydrate content[35]. The carbohydrate range is in agreement with the result of Joshi and Mehta[33] but it is slightly lower than the result of Alakali et al.; Olabode et al. and Satwase et al.[15,14,34]. Lower carbohydrate content could be explained by difference in drying time and temperature employed, where Alakali et al.[15] dried moringa leaf at 40ºC, 50ºC, 60ºC and 70ºC for 2 hours; Olabode et al.[14] dried at 60ºC, 70ºC and 80ºC for 24 hours and Satwase et al.[34] dried at 60ºC for 4 hours. Different variety of *M. oleifera* used for the study and difference in the geographical locations of the collection site also explain the lower carbohydrate content in this study. According to Adayemi et al.[36] difference in collection and extraction method can also effect proximate composition. Thus, different result could be attributed to different collection and extraction method used. Further, lower carbohydrate content in this study could be due to different drying method (oven drying) employed in the study of Alakali et al. and Olabode et al.[15,14].

Conclusion

The study showed significant effect of both drying time and temperature on the moisture, protein and carbohydrate contents of moringa leaf powder. There was no significant effect of drying time on the weight, fat, fibre, and ash contents. However, drying temperature had significant effect on all the parameters including weight, fat, fibre and ash contents. Thus, this study concludes that higher temperature reduces moisture content prolonging its shelf life. However, lower temperature and shorter duration T1 (50ºC and 4 hours) retains maximum amount of protein contents compared to higher drying temperature and longer drying time.

Recommendations: The variety of *M. oleifera* used in this study is unknown, thus there is a need to determine variety of *M.oleifera* native to Bhutan.

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