ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 45(2): 157-164, June 2020

QUALITY CHARACTERISTICS AND SENSORY EVALUATION OF CABBAGE (*Brassica oleracea* L. var. *capitata*) AND LIME (*Citrus aurantiifolia*) READY TO SERVE TS BEVERAGE

J. INTHUJA[1], T. MAHENDRAN[2] AND M. B. F. JEMZIYA[3]

Abstract

The experiment was conducted to formulate the low calorie cabbage-lime blend Ready-to-Serve (RTS) functional beverage. Considering the results of preliminary studies, six formulations of the low calorie functional RTS beverage were prepared by blending different ratios of cabbage and lime juice (27:3, 24:6, 21:9, 18:12 and 15:15) including control, where only cabbage juice was added. The prepared formulations were subjected to nutritional and sensory evaluation after the formulations were done. Nutritional parameters including titrable acidity, pH, vitamin C, total sugar and total soluble solids were analysed. Sensory attributes of color, aroma, taste, appearance (cloudiness) and overall acceptability were evaluated using a seven point hedonic scale. The nutritional analysis of the fresh low calorie RTS beverage showed the increasing trend in titrable acidity (from 0.32% to 1.3% as citric acid), vitamin C (from 8.35 mg/100 ml to 17.75 mg/100 ml), total sugar (from 2.75% to 4.99%), and total soluble solids (from 4.64 ° Brix to 5.17 °Brix) with the increase of lime juice from 3% to 15%. The pH was reduced when the lime juice concentration increased. The sensory assessment of fresh low calorie RTS beverage revealed that there were significant ($p < 0.05$) differences among the sensory attributes. The highest overall acceptability was observed in the formulation with 18% cabbage juice and 12% lime juice with ideal functional qualities.

Keywords: RTS beverage, cabbage juice, lime juice, nutritional analysis and sensory attributes

Introduction

Consumer demands for healthy and nutritious food products with a fresh-like appearance have undergone a continuous rise during recent years. Fruits and vegetables have always of an elite status among the healthy foods. At present, beverages are by far the most active functional food category because of convenience and possibility to meet consumer demands for container contents, size, shape, and appearance, as well as ease of distribution and storage for refrigerated and shelf-stable products. Healthy beverages, particularly those that offer functional ingredients such as botanicals, minerals, and antioxidants, are increasing in demand. Moreover, they are an excellent delivering means for nutrients and bioactive compounds ω-3 fatty acids, plant extracts, fiber, prebiotics and probiotics (Sanguansri and Augustin, 2009).

[1&2]Department of Agricultural Chemistry, Faculty of Agriculture, Eastern University, Sri Lanka, [3]Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka.

Cabbage (*Brassica oleracea* L. var. *capitata*) is one of the most popular vegetable crops of the family Brassicaceae grown around the world. It is nutrient rich and economically important vegetable crop with higher amount of vitamins A, C, K, folic acid, fiber, flavonoids, proteins, minerals and are connected with secondary metabolites called glucosinolates contributed to anti-carcinogenic properties (Sarikamis *et al*., 2009).

Lime *(Citrus aurantifolia*) belonging to the family Rutaceae, is a fruit crop which is an excellent source of vitamin C, and are often used to accent the flavors of foods and beverages. Citrus is likely the most widely established fruit for direct human consumption in the world due to its pleasant flavor, sour taste and attractive color. Further, lime juice contains saponins, alkaloids, tannins, phenolics, flavonoids and terpenoids (Robinson, 2006).

A combination of cabbage and lime could lead to the production of delightful and delicious beverages with improved organoleptic quality and high nutritive value. With the above facts in view, in the present study, a low calorie cabbage-lime blend ready RTS functional beverage was developed and its physicochemical characteristics, microbial quality and sensory acceptability were evaluated.

Materials and Methods

Procurement of materials

Healthy fresh and firm white cabbage heads dense with shiny, crisp and brightens leaves, free of cracks, bruises and blemishes were purchased from the wholesale market in Batticaloa, Sri Lanka. Matured healthy key limes were acquired from local market in Batticaloa, Sri Lanka. Artificial sweetener (aspartame) and permitted color (E142) were purchased from United Pharmacy, Colombo and Cargill, Batticaloa, Sri Lanka, respectively.

Extraction of Cabbage juice

Fresh cabbage outer covers were removed and the remained cabbage head were washed under running distilled water. The thick outer leaves were collected, sliced into 2 cm thick pieces. Then the cabbage slices were steam blanched at 80±2 °C for 2-3 minutes as stated by Burtness in 2014. Two hundred gram of blanched cabbage pieces and 200 ml of distilled water were blended with a blender (Model Smeeth) and filtered using a cheesecloth to obtain the juice. The juice was kept in a refrigerator at 4 °C.

Extraction of Lime juice

Limes were washed and cleaned thoroughly. Then the fruits were washed again with distilled water. The limes were cut and squeezed to extract the juice. A cheese cloth was used to filter the juice from the pulp. Juice was then kept in a refrigerator at a temperature of 4 °C.

Treatments of the study

The experiment consisted of six treatments which namely C: 30% Cabbage juice only, F_1: 27% Cabbage juice and 3% Lime juice, F_2: 24% Cabbage juice and 6% Lime juice, F_3: 21% Cabbage juice and 9% Lime juice, F_4: 18% Cabbage juice and 12% Lime juice and F_5: 15% Cabbage juice and 15% Lime juice

Preparation of cabbage-lime juice blend

For having 100 ml of RTS beverage, 70 ml of water was added to 30 ml juice and 0.032 g of aspartame and 3 drops of permitted color (E142) were added equally to all of the treatments and was heated at 60 °C for 10 minutes. Then it was allowed to cool for 30 minutes. After that sodium metabisulfite was added at the rate of 70 ppm to the formulations.

Microbial, physico-chemical and sensory evaluation

After the preparation, microbial analysis, sensory evaluation and chemical analysis were completed by agar method, seven point hedonic scale and standard AOAC 2016 techniques to all of the formulations respectively to determine the quality of RTS beverages.

Sensory evaluation

The sensory attributes including color, taste, aroma, cloudiness and overall acceptability were evaluated by a trained 30 member's panel. Ranking test was used to evaluate the perceptible differences in intensity of an attribute among samples. They were asked to rank the coded samples for the intensity of a specific characteristic, by ordering the samples from the most intense to the least intense.

Chemical analysis

The chemical quality parameters such as pH, titrable acidity, total sugars, total soluble solids and vitamin C content were analyzed after the preparation of the RTS beverage using the recommended standard AOAC (2016) methods. Analysis was carried out for three replicates of each formulation.

Statistical Analysis

The treatments were designed in Completely Randomized Design (CRD). Data on sensory attributes were analyzed using Friedman's test (Rayner and Best, 1990) and chemical properties were performed using ANOVA at 95% significant level. Duncan's Multiple Range Test (DMRT) was used to determine the significance of the differences between the means of the measured parameters.

Results and Discussion

Physico-chemical analysis of cabbage juice and lime juice

The chemical properties of juice have direct effect on ultimate quality of Ready-To-Serve (RTS) beverages (Table 1). The value of TSS, pH, titrable acidity, vitamin C and total sugar were remained in close agreements with the results of Champa *et al.* (2007), Frederick *et al*. (2016) and Gyorene and Varga (2006) in cabbage and Carolina *et al*. (2011), Jamil *et al.* (2015) and Hariharan and Mahendran (2016) in lime.

Table 1. Chemical analysis of cabbage juice and lime juice

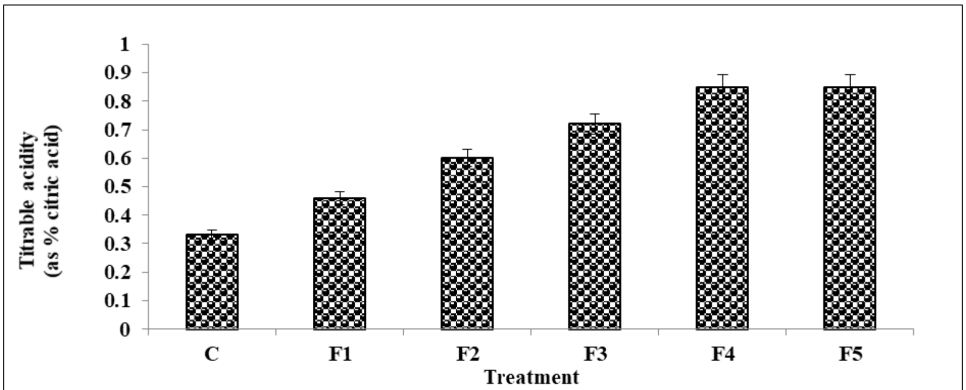
Chemical parameters	Cabbage	Lime
Total Soluble solids (TSS)	5.20 ± 0.01	6.80 ± 0.02
pH	5.73 ± 0.02	2.68 ± 0.01
Titrable Acidity (as % of citric acid)	0.61 ± 0.01	5.48 ± 0.02
Vitamin C content (mg/100 ml)	26.26 ± 0.12	37.82 ± 0.15
Total sugar (%)	4.10 ± 0.11	1.56 ± 0.12

The values are means of triplicates ± standard error

Nutritional analysis of low calorie cabbage-lime blend RTS functional beverage

Titrable acidity

The titrable acidity of fresh formulations of cabbage and lime juice blend RTS beverage increased gradually with the rate of increase of lime juice in the treatments (Fig.1). Maximum acidity was found in F_5, closely followed by F_4 and minimum value was recorded in control. According to the Sri Lanka Standard Institute Specifications, the limits of acidity for RTS preparation are 0.3-1 % as anhydrous citric acid (SLS 729:1985) (Sri Lanka Standard Institute, 2007).



Vertical bars indicate the standard error

Fig. 1. Titrable acidity of cabbage-lime blend RTS beverage.

pH

The pH of low calorie cabbage-lime blend RTS functional beverages is shown in Table 2. The highest pH value was recorded in control and the lowest pH value was recorded in F_5. The presence of free hydrogen ions and buffering capacity of the juices influence the pH value of the beverage (Shubhangi, 2002). Significant valuation ($p > 0.05$) was noted with the increasing concentration of lime juice. This might be due to increase in titrable acidity, as acidity and pH are inversely proportional to each other (Bhardwaj, 2005).

Total Soluble Solids (TSS)

Total soluble solids (TSS) increased significantly ($p > 0.05$) when the concentration of lime juice increased in RTS beverages. Maximum TSS was found in F_5 and its minimum value was recorded in F_1. Similar trend in TSS have been reported by Kausar *et al*. (2016) in ready to serve Aloe vera-lemon functional drink.

Table 2. The pH and Total Soluble Solids (TSS) of RTS functional beverages

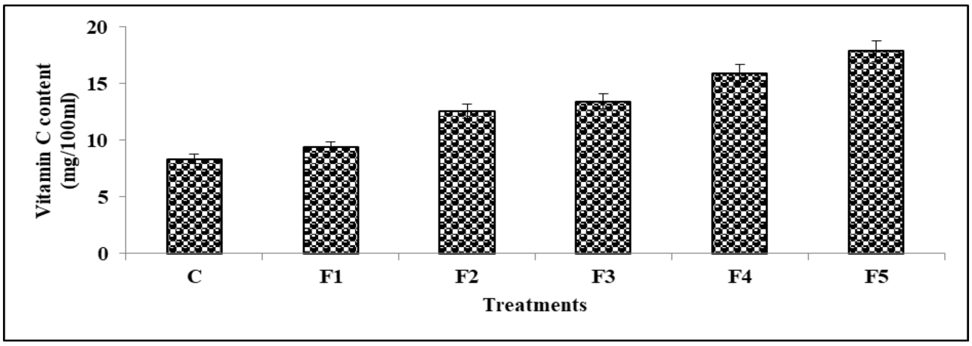
Formulations	pH	TSS (°Brix)
C	5.64 ± 0.01^a	4.64 ± 0.01^f
F_1	3.98 ± 0.06^b	4.21 ± 0.01^e
F_2	3.80 ± 0.03^c	4.51 ± 0.02^d
F_3	3.64 ± 0.04^d	4.82 ± 0.01^c
F_4	3.54 ± 0.02^e	4.91 ± 0.02^b
F_5	3.17 ± 0.04^f	5.17 ± 0.01^a

The values are means of triplicates ± standard error

Figures with different letters in the same column are significantly different at $p<0.05$ by DMRT (95% level).

Vitamin C

The vitamin C content significantly increased ($p > 0.05$) from 8.35 to 17.75 mg/100 ml with an increase in the concentration of lime juice from 0 to 15% in the RTS beverage formulations (Fig. 2). Maximum vitamin C content was found in F_5 treatment and minimum vitamin C found in the control. The reason of increasing vitamin C may be due to concentration of lime juice present in the treatments. Afreen *et al,* (2016) reported similar increasing trend in vitamin C content when the sour orange juice concentration were increased in RTS Beverage from carrot with sour-orange juices.

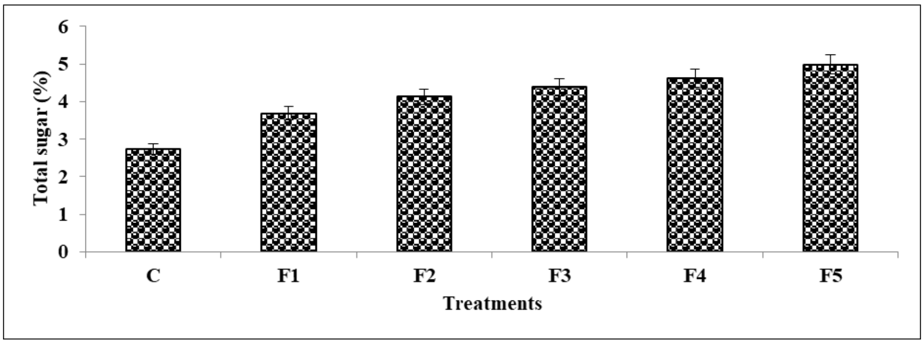


Vertical bars indicate the standard error

Fig. 2. Vitamin C content of low calorie cabbage-lime blend RTS beverages.

Total Sugars

Fig. 3 indicates the total sugars of fresh low calorie cabbage juice and lime juice blend RTS beverage. Maximum total sugar content (as sucrose) for RTS preparation is 5 % (SLS 729:1985). The total sugar content increased significantly ($p < 0.05$) from 2.75 % to 4.99 % with an increase in the concentration of lime juice from 0 to 15 % in the RTS beverage formulations. This may be because of the acid hydrolysis of polysaccharides, which resulted in increase in soluble sugars content. Similar increasing trend in total sugar content was reported in ginger-lime RTS functional beverage, sweetened by Palmyra sugar candy, blended beverage of pummel, sapota blended with jackfruit and avocado and Jamun based blended beverages by Hariharan and Mahendran (2015), Pooja *et al*., (2012), Totad *et al*., (2014) and Priyanka *et al*., (2015) respectively.



Vertical bars indicate the standard error

Fig. 3. Total sugar (%) of low calorie cabbage-lime blend RTS beverages

Sensory analysis of fresh low calorie cabbage-lime blend RTS functional beverage

The sensory evaluation of the fresh cabbage-lime blend RTS functional beverage revealed that, there were significant differences among the properties including color, taste, aroma and overall acceptability with an exception of overall acceptability of the formulations as the increase in lime juice from 3 % to 15 %. Mean scores of formulations according to Friedman's test are shown in Table 3. The treatment F_4 (RTS beverage with 18% cabbage juice and 12 % lime juice) had the highest mean value score of (6.1) overall acceptability and had the higher scores in color, aroma, taste, cloudiness compared to other formulations. Along with, the treatment F_3 also reflects the properties of the treatment F_4.

Table 3. Sensory analysis of low calorie cabbage-lime blend RTS functional beverage

Treatments	Color	Taste	Aroma	Appearance (Cloudiness)	Overall acceptability
C	$5.1{\pm}0.17^{b}$	$3.6{\pm}0.03^{b}$	$3.1{\pm}0.09^{c}$	$3.6{\pm}0.11^{b}$	$3.8{\pm}0.02^{c}$
F_1	$5.5{\pm}0.18^{ab}$	$3.7{\pm}0.02^{b}$	$5.5{\pm}0.01^{ab}$	$3.7{\pm}0.05^{b}$	$5.1{\pm}0.03^{ab}$
F_2	$5.6{\pm}0.06^{ab}$	$4.4{\pm}0.19^{b}$	$5.6{\pm}0.11^{ab}$	$4.4{\pm}0.02^{b}$	$5.3{\pm}0.01^{ab}$
F_3	$4.9{\pm}0.18^{b}$	$5.6{\pm}0.16^{a}$	$6.2{\pm}0.03^{b}$	$5.9{\pm}0.13^{a}$	$5.9{\pm}0.05^{a}$
F_4	$6.2\ {\pm}0.01^{a}$	$6.1{\pm}0.06^{a}$	$6.3{\pm}0.16^{a}$	$6.1{\pm}0.01^{a}$	$6.1{\pm}0.01^{a}$
F_5	$4.6{\pm}0.19^{b}$	$4.4{\pm}0.17^{b}$	$6.4{\pm}0.01^{a}$	$5.8{\pm}0.12^{b}$	$4.8{\pm}0.01^{ab}$

The values are means of 30 replicates ± standard error

The means with the same letters in the same column are not significantly different from each other at 95 % level based on Friedman's test of significant Sensory attributes were measured using seven point hedonic scale

Conclusion

The chemical and sensory evaluation of fresh low calorie cabbage-lime blend RTS beverage showed that RTS functional beverage prepared with 18 % cabbage juice and 12 % lime juice was the most preferred formulation. The formulation of low calorie cabbage-lime blend RTS functional beverage is a way of new product development strategy which simplifies the market penetration.

References

Afreen, S. M. M. S., K. Premakumar and Y. Inthujaa. 2016. Preparation of Ready-To-Serve (RTS) beverage from carrot with sour-orange Juices. *Int. J. Innov. Res. Sci. Eng. Technol.* **5**(2): 1992-1998.

Bhardwaj, R. L. 2005. Studies on preservation of kinnow mandarin juice and its blends. Ph.D. Dissertation, Department of Horticulture, SKN, Collage of Agriculture, Jobner, RAU-Bikaner.

Burtness, C. 2014. 'Vegetables and Herbs', Food Safety. University of Minnesota extension. (Retrieved from https://www.extension.umn.edu/food/food safety/preserving/vegetablesherbs/blanching-vegetables/ on 01.02.2018).

Carolina, N. R., L., Carvalho, F. F. R., Borchetta and J. Edgar. 2011. Nutritional value of organic acid lime juice. *J. Food. Sci. Tech*. **31:** 918-922.

Champa, W. A. H., K. B. Palipane, W. A. P. Weerakkody and M. D. Fernando. 2007. Maturity indices for harvesting cabbage (*Brassica oleraceae* L.) variety Green Coronet. *Tropical Agricultural Research*. **19:** 254-264.

Doughari, J. H. and A. M. Elmahmood. 2007. Effect of some chemical preservatives on the shelf life of Sobo drink. *Afr. J. Microbiol. Res*. **2**: 5-6.

Frederick, S., G. Moses and A. P. Leticia. 2016. Quality evaluation and sensory profile of mixed fruit juice from cabbage and orange. *Asian J Agric Food Sci*. **4**(4): 202-211.

Gyorene, K. G. and A. L. Varga. 2006. A comparison of chemical composition and nutritional value of organically and conventionally grown plant derived foods. *J. Sci. Food Agric.* **147**(43): 2081-90.

Hariharan, G. and T. Mahendran. 2016. Physico-chemical, sensory and microbial evaluation of ginger-lime RTS functional beverage, sweetend by palmyra sugar candy. *Imp. J. Interdiscip. Res.* **2**(5): 1545-1552.

Jamil, N., R. Jabeen, M. Khan, M. Riaz, T. Naeem, A. Khan, N. Sabah, S.A. Ghori, U. Jabeen, Z. A. Bazai, A. Mustaq, S. Rizwan and S. Fahmid. 2015. Quantitative assessment of juice content, citric acid and sugar content in oranges, sweet lime, lemon and grapes available in fresh fruit market of Quetta city. *Int. j. sci.: basic appl. res.* **15:** 21-24.

Kausar, H., S. Parveen, S. Saeed, B. Ishfaq and M. A. Ali. 2016. Development and Standardization of ready to serve aloe vera-lemon functional drink. *Journal of Environmental Science, Toxicology and Food Technology*. **10**(4): 47-52.

Pooja, B., K. N. Sreenivas and B. S. Sreeramu. 2012. Development of cost-effective palatable and shelf-stable blended beverage of pummelo (*Citrus grandis* Linn.). *Fruits*. **67**: 249-256.

Priyanka, N., A. V. D. Dorajeerao, V. Sudhavani and K. Umakrishna. 2015. Physico-chemical characters and sensory evaluation of jamun based blended beverages during storage. *Pl. Archives*. *15*(2): 939-946.

Rayner, J. C. W. and D. J. Best. 1990. A comparison of some rank tests used in taste-testing. *J. R. Soc. N. Z.* **20**(3): 269-272.

Robinson, N. 2006. Integrated traditional Chinese medicine. *Complement. Ther. Clin. Pract.* **12**(2): 132-140.

Sarikamis, G., A. Balkaya and R. Yanmaz. 2009. Glucosinolates within a collection of white head cabbages (*Brassica oleracea* var. *alba*) from Turkey. *Afr. J. Biotechnol*. **8:** 5046-5052.

Sri Lanka Standard Institute. (2007). Schedule of accreditation. (Retrieved from http://www.slab.lk/Support/Scopes/SLS-%20Microbiology.pdf)

Shubhangi, A. J. 2002. Nutrition and dietetics. 2nd edition. Tata McGraw-Hill Publishing Company Ltd, India. pp. 488-458.

Totad, B. M., M. Ramakrishna and K. N. Sreenivas. 2014. Development of value added products from sapota (*Manilkara achrus*) blended with jackfruit and avocado. *Int. J. Proc. Postharvest Technol*. **5**(1): 48-53.

ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 45(2): 165-174, June 2020

EFFECT OF PLANTING DATE ON PHENOTYPIC CHARACTERS, HARVESTED LEAVES AND SEED YIELD OF MUSTARD GREEN (LAI SHAK) IN SYLHET REGION

M. I. NAZRUL[1] AND S. T. ZANNAT[2]

Abstract

A field trial was conducted at farming system research and development (FSRD) site, South SurmainSylhet under AEZ-20 during two consecutive years of 2017-18 and 2018-19 to find out the suitable planting date for successful and economic production of leaves and seed yield of mustard green (*Brassica juncea*). The experiment was laid out in randomized complete block design having five different dates of seedling transplant viz. 15 October, 30 October, 15 November, 30 November and 15 December with four dispersed replications.The seedlings transplanted on 15 November recorded significantly the highestnumber of harvested leaves plant^{-1}, weight of single leaf, harvested leaf yield (35.07 t ha^{-1}), siliqua plant $^{-1}$ and weight of 1000-seed and seed yield (1.38 t ha^{-1}) of mustard green. The highest gross return (Tk. 862800 ha^{-1}) and net return (Tk. 627300 ha^{-1}) with benefit cost ratio (BCR) of 3.66 was obtained from 15 November planting followed by 30 October planting. Conversely, the lowest gross return (Tk.611620 ha^{-1}), net return (Tk. 376120 ha^{-1}) and BCR (2.59) were recorded from 15 December planting. So, last October to mid-November planting would be suitable for economic production of leaves and seed yield of brown mustard in Sylhet region of Bangladesh.

Keywords: Mustard, Indian mustard,leaf mustard, planting date, seed yield.

Introduction

Brown mustard (*Brassica juncea* L.) belonging to the family Cruciferae is a variable species cultivated for centuries as a vegetable and oil crop and is also a widespread weed. It is known by diverse common names, which include Indian mustard, leaf mustard and brown mustard among many others (Grubben and Denton, 2004). In Bangladesh, it is also known as Lai Shak. The leaves, seed and stem of this mustard variety are used as edible. Traditionally, it is very popular vegetable for the people of north east region of our country. The leaves are used in African (Grubben and Denton, 2004); also used in many Indian dishes in Gujarati and Northern province of Vietnam, mustard greens is regarded as one of the main vegetable crops being consumed in large volume (Ha, 2011). It is nutritionally rich in protein, fat, vitamin and minerals; especially high in vitamin A and vitamin K (USDA Nutrient Database). Normally, it is growing as vegetable over the winter season in Sylhet region. Occasionally, early and late sowing may or may not provide maximum profit to the farmers. Timely sowing

[1]Principal Scientific Officer, [2]Scientific Officer, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh.

may allow sufficient growth and development of a crop to obtain a satisfactory yield. The seed yield and maturity of mustard plants are greatly influenced by environmental conditions regardless of proper sowing of times. Mustard sowing at optimum time gives higher yields due to suitable environment that prevails at all the growth stages (Kumar *et al*., 2018). The growth and yield of mustard are profoundly affected by sowing time (Mondal and Islam, 1993; Shivani and Kumar, 2002;Alam *et al.,* 2014).Mustard green (Lai Shak) also one of the vegetable crops to be considered for optimum planting time to get more yields and economic return. Very early planting often works well but can be risky to the growers due to unpredictable weather. On the contrary, late planting also may hamper the production potential mainly due to temperature or variation for particular crops. The optimum time of transplant may help plants to expose in to the most favorable environment for better growth and good yield, as well as escape the insect and disease infestation. Keeping this view in mind, the present study was undertaken to finding out optimum planting date for maximum yield of leaves and seed of mustard green.

Materials and Methods

The experiment was conducted at farming system research and development (FSRD site, South Surma, Sylhet during *rabi* seasons of two consecutive years2017-18and 2018-19, experimental site located at 24°6′ N latitude and 91°36′ E longitude in Bangladesh. The site belongs to the Eastern Surma-Kushiyara Floodplain soil under Agro Ecological Zone (AEZ-20), which falls into grey heavy silty clay loams on the ridges and clay in the basins. General fertility status is moderate; having organic matter content of soil is low to medium (1.05-1.82%). The soil was clay loam in texture and acidic in nature pH ranges 5.4-6.24. The experimental field was also a piece of well drained high land with moderately even topography.

The monthly mean maximum and minimum air temperature and rainfall during the study period are presented in Figure 1. The mean annual minimum temperature is 9.15-24.05 ˚C and the mean annual maximum temperature is 29.70-37.65 ˚C. However, monthly mean maximum and minimum air temperature was 35.83 and 9.53 ^{0}C, during the crop growth period.

Rainfall of the area is uni-modal, usually occurring during April to October, and total annual rainfall reached to 4310mm; whereas in January no rain at all and lowest amount of rainfall occurs in November followed by December. The crop received monthly total rainfall1766 mm during the crop growing period.

The experimental treatments consist of five different dates of seedling transplant viz. 15 October, 30 October, 15 November, 30 November and 15 December. The experiment was laid out in randomized complete block design with four dispersed replications. The brown mustard (Lai shak) seedlings were raised by following farmer’s agronomic cultural practices. The unit plot size was 5 m x 4

m. Ten days old seedlings were transplanted by maintaining the spacing of 30 cm× 15 cm.

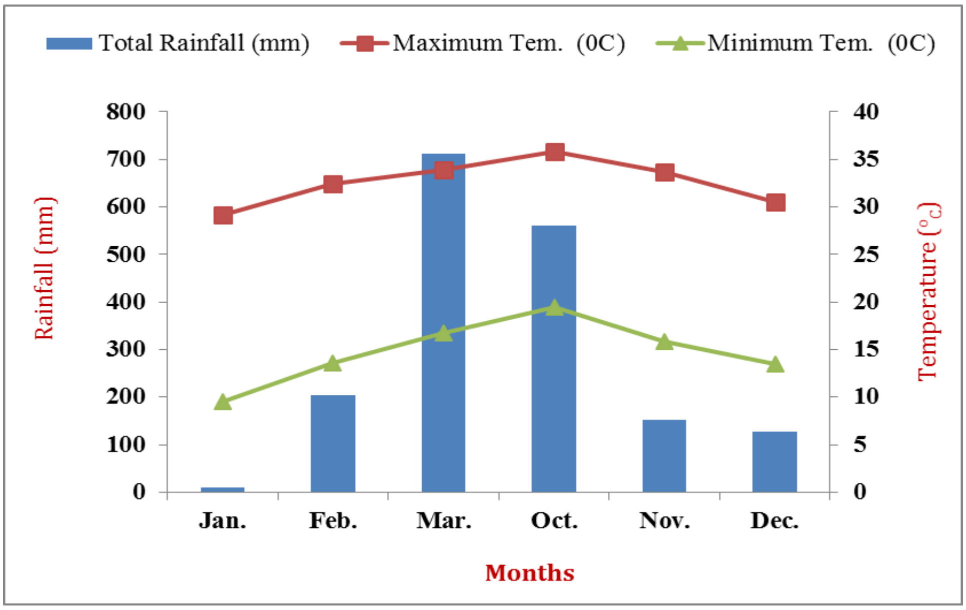


Fig. 1.Average of two years monthly mean air temperature (maxi & mini) and monthly total rainfall (mm) during crop growth period *(Source: Metrological Department, Sylhet)*.

Fertilizer nutrients 170-96-140 kgha^{-1} of NPK along with cow dung (5 tha^{-1}) was applied. Full dose of cowdung, one third MoP and urea and rest of the fertilizers were applied during final land preparation. Remaining urea and MoP was applied in 2 splits at 10 and 25 days after transplant followed by earthingup and irrigation. Tilt and Bavistin @ 0.5 ml and 2 g/L was sprayed at seeding and siliquae development stage, respectively to control blight. Bioneem plus 1 EC (Azadiractin) @ 1 ml/L was sprayed to control aphid at the time of flowering. Ten plants were selected randomly from each plot to record data. Marketable green leaves harvesting was started at 20-25 days after transplant (DAT).During experimentation 5-7 harvests were done and average of 2-3 leaveswere collected from each plant. On the contrary, the harvesting of mustard siliquae was started from 1st week of February to end of March in both years. Seed yield was weighted and convert it as t ha^{-1} at 9-10 % moisture level. Data on yield and yield attributes of mustard green (Lai shak) for the two years were similar and therefore pooled. The data were analyzed statistically and the means were compared by using LSD test at 5 % level of probability. The gross economic return was also calculated on the basis of prevailing market price of the commodities.

Results and Discussion

Planting time significantly influenced to the plant height of mustard green (Table 1). The tallest plant (187.97 cm) was measured from 15 November transplanting and it was significantly different from rest of the planting dates. The shortest plants (162.84 cm) were recorded from 15 December transplanting time. Prevailing weather conditions during the whole crop growing season have a direct association with the phenological developments in the crop plants, which modulate yield formation (Akhter *et al.*, 2016). Mondal and Wright (1989) reported that a temperature range 5-15 ^{0}C is optimum for the normal growth and development of mustard plant. Above and below this range, temperatures reduced growth rate by reducing plant height and dry matter accumulation. In Sylhet, the daily mean and minimum temperatures during October 25 ^{0}C and 18^{0}C, respectively was quite favorable for quick seed germination and crop stand establishment of mustard. The crop received 531mm total rainfall during the crop period which hampered the normal growth and leaves production whereas in January no rain and lowest amount of rainfall (43 mm) occurs in November followed by February (175 mm). Moreover, the sharp fall of both the mean and minimum temperatures from the first week of November and onwards shorten the period of inflorescence initiation in mustard and rapes (Islam *et al*., 1994). Number of branches plant^{-1}was significantly affected by planting dates (Table 1). Maximum number of branchesplant^{-1} (12.28) was produced by 15 November planting which was statistically similar to that of 30 October planting. November 15 planted plants received comparatively low temperature (15.9 ^{0}C) during vegetative growth which probably influenced produced more branches.

Early (15 October) and late (15 December) planting gave the lowest number of branchesplant^{-1}. Early sowing of crop faced somewhat lower temperature at early growth stage which hampered the normal growth and development of crop. The crop sown on December 15 (Late) produced lower number of branches might be due to short growing period and lower temperature in vegetative growth stage. Similar trend was observed in case of the base girth of mustard green in different transplanting dates (Table 1). The highest base girth (4.68 cm) was recorded from 15 November planting. It might be due to favorable weather conditions mainly temperaturehelp for the growth and development of plant.

The highest number of marketableharvested leaves plant^{-1} (21.84) was obtained from the planting date 15 November. It was significantly different from all other planting dates (Table 1). The lowest number of harvested leaves plant^{-1} (15.18) was recorded from 15 December sowing and it was statistically similar to 15 October planting.It might be due to variation in prevailing weather condition in delayed sowing which adversely affects the yield attributes.The results of present study are in agreement with the findings of Khaton (2004) in mustard.The size of mustard green leaves is important due to use as vegetable purpose. However, the leaf size at harvest was enhanced by different planting dates (Table 1). Maximum leaf size (53.42 cm × 23.99 cm) was found at 15 Novemberand 30 October (50.00 cm × 21.78 cm) planting, respectively. The lateplanting *i.e.* 15 December gave the smaller size of harvested leaves might be due to crop faced low temperature at the time of emergence as well as 50% flowering stage. The variation of single leaf weight at harvested was influenced by different transplanting time (Table 1). The highest weight (21.95 g)of single harvested leaf was recorded in 15 November which was statistically similar to those of 30 October (20.69 g) and 30 November (20.65 g) plantings. The lowestweight of single harvestedleaf(19.35 g) was recorded when transplanting was done at 15 December.

Number of siliquae plant^{-1} was significantly affected by planting dates (Table 2). The highest number of siliquae plant^{-1} (838) was obtained from 30 October which was statistically similar to 15 November and 30 November plantings but dissimilar to15 October and 15 Decemberplantings.Earlier planting (15 October) crops received convenient soil moisture condition and relatively warmer temperature (18.45 ^{0}C) during vegetative growth and favorable temperature(20-25 ^{0}C) during 50% flowering. This finding was in conformity with the findings of Mondal *et al*. (1999) who stated that the 30 October planting produced the highest number of siliquae plant^{-1} and reduced in the late (15 December) transplanting. Pandey *et al*. (2007) and Khavse *et al.*, (2014) reported that maximum temperature (>30ºC) and lower temperature (<14ºC) during flowering and pod development stage of the crop were favorable for mustard crop. Planting dates significantly influenced the number of seeds siliqua^{-1} of mustard green (Table 2). The highest number of seeds (18) siliqua^{-1} was produced in 15 November and it was significantly different from rest of the planting dates. October 30 and 30 November plantings gave statistically similar number of seeds sliqua^{-1}. The lowest number of seeds (13) siliqua^{-1} was recorded from 15 December transplant which was statistically identical with 15 October planting. These results are in agreement with the findings of Mondal *et al.* (1999).

Thousand seed weight also differed significantly among the planting dates (Table 2). The highest 1000-seed weight (1.43 g) was recorded in 15 November planting which was significantly different from all others planting dates. Transplanting dates 15 October, 30 October and 30 November gave statistically identical 1000-seed weight. In contrast, the lowest weight of 1000-seeds (1.19 g) was found in delaying of transplantation (15 December) which was statistically identical with 15 October and 30 October plantings. In delayed transplant crops faced low temperature (12.95 ^{0}C) at the time of emergence as well as 50 % flowering of the plants which hampered the growth. Moreover shorter growing period and higher temperature at the time of seed filling period caused reduction of seed size.

Mondal *et al.* (1992) stated that 1000-seed weight reduced with the delayed planting time after 15 November.

The brown mustard has 25-32 leaves at lower layers of plant; during experimentation 16-22 marketable leaves were harvested and rest of the leaves (8-10) remain attached to the plant for completing the seed production process. Hereafter, flowering branches with small leathery or curley leaves also appeared in plants. The harvested leaf yields(g plant^{-1} and t ha^{-1})were found significant with respect to dates of transplant (Table 2). Transplant in 15 November gave the maximum yield (426.12 g plant^{-1}, 35.07 t ha^{-1}) of harvested leaves. The yield of harvested leaves increased up to 15 November plantingand hereafter decreased. A significant variation was observed among the effect of transplanting time of mustard green in respect of seed yield (Table 2). The highest seed yield (1.38 t ha^{-1}) was recorded from 15 November transplant. This happened probably due to the phenological phase coincided with optimum temperature resulted in higher number of siliqua plant^{-1}, seeds siliqua^{-1} and 1000-seed weight. The lowest seed yield (1.13 t ha^{-1}) was recorded in late planting (15 December). This might be due to shorter growing period and higher temperature (Fig.1) at the time of seed filling caused reduction in yield components and thereby seed yield. The lowest seed yield was also obtained from crop sown on 15 October possibly due to adverse effect of high temperature (Fig. 1) at the vegetative phase.

There are many studies (Angadi *et al.*, 2000; Morrison and Stewart, 2002; Young *et al*., 2004) related with thermo-tolerance in oilseed brassicas at the flowering stage, but little progress has been made so far in understanding the heat tolerance at seedling stage in *Brassica*. Weather data indicating that plants of 15 November planting were received congenial environment during crop period for growth and flowering. Lobell and Asner (2003) reported each degree centigrade increase in average growing season temperature may reduce crop yields up to 17%. Alam *et al*.(2014) mentioned that time of planting generally varies depending on the climatic condition of the region and the variety to be grown. In general, sowing time of mustard in Bangladesh is confined to a period ranging from mid-October to mid-November (Lakra *et al.,* 2018, Biswas, 1989 and Mondal *et al.,* 1999) but with the change of variety and location, various optimums have been suggested (Mondal *et al.,* 1992).Kalra *et al*. (1985) and Begna and Angadi (2016) also stated that delaying in planting dates reduced the seed yield of mustard. Stover yields of mustard green also affected by planting dates (Table 2). The maximum stoveryield (4.80 t ha^{-1}) was recorded when crop was transplanted on 15 November followed by 30 October. It might be due to the cumulative effect of plant height and harvested leaf yield. The minimum stover yield (2.76 t ha^{-1}) was recorded when transplantation was done on 15 December.

Table 1. Effect of different transplanting dates on phenotypic characters of brown mustard (Pooled of two years)

Planting dates	Plant height at harvest (cm)	Branches plant^{-1} (no.)	Base girth (cm)	Marketable harvested leaves plant^{-1}(no.)	Leaf size at harvest		Weight of single leaf at harvest (g)
					length (cm)	width (cm)	
15 October	170.84	8.34	3.76	15.42	46.72	22.07	19.96
30 October	177.57	12.19	4.16	18.72	50.00	21.78	20.69
15 November	187.97	12.28	4.68	21.84	53.42	23.99	21.95
30 November	178.14	9.47	3.95	17.47	49.51	21.66	20.56
15 December	162.84	8.77	3.59	15.18	45.23	20.32	19.35
CV (%)	2.85	7.45	4.94	7.62	5.32	3.76	4.39
LSD $_{(0.05)}$	9.35	1.44	0.49	2.55	3.21	1.49	1.36

Table 2. Effect of different transplanting dates on yield and yield attributes of brown mustard (Pooled of two years)

Planting dates	Siliquae plant^{-1} (no.)	Seeds siliqua^{-1} (no.)	1000-seed weight (g)	Harvested leaf yield		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
				Plant^{-1} (g)	(t ha^{-1})		
15 October	766	15	1.22	328.53	26.04	1.16	3.68
30 October	838	16	1.21	383.49	32.14	1.30	4.05
15 November	819	18	1.43	426.12	35.07	1.38	4.80
30 November	814	15	1.27	351.58	28.09	1.24	3.64
15 December	744	13	1.19	305.96	24.09	1.13	2.76
CV (%)	15.84	5.55	3.38	7.65	4.56	5.00	5.57
LSD $_{(0.05)}$	23.33	1.66	0.08	19.49	2.41	0.12	0.39

Economics

Economic viability is an important indicator for selection of treatment to the end users. The gross return and gross margin were varied among the treatments, due to price variation of product in the market with the time of harvest (Table 3). Maximum total gross return (Tk. 862800 ha^{-1}) was found from 15 November transplant followed by 30 October plantation. On the contrary, 15 December planting gave the lowest total gross return (Tk. 611620 ha^{-1}). The net return was also varied with five different transplanting time of brown mustard. The highest net return (Tk. 627300 ha^{-1}) and benefit cost ratio (3.66) was obtained when planting was done on 15 November followed by 30 October (Tk. 558400 ha^{-1} &3.37). Conversely, the lowest net return (Tk. 376120 ha^{-1}) and BCR (2.59) was noticed from 15 December planting.

Table 3. Economic analysis of brown mustard at different transplanting dates (Pooled of two years)

Treatments	Gross return (Tk. ha^{-1})				Total cost (Tk. ha^{-1})	Net return (Tk. ha^{-1})	Benefit cost ratio (BCR)
	Leaf as vegetable	Seed	Stover	Total			
15 October	520800	127600	7360	655760	235500	420260	2.78
30 October	642800	143000	8100	793900	235500	558400	3.37
15 November	701400	151800	9600	862800	235500	627300	3.66
30 November	561800	136400	7280	705480	235500	469980	3.00
15 December	481800	124300	5520	611620	235500	376120	2.59

Price (Tk.kg^{-1}): brown mustard (Lai shak): 20.00; seed: 110.00,non-seed: 30.00, stover: 2.00

Conclusion

From two years results it was revealed that last October to mid-November planting could be suitable for economic production for both leaves and seed of brown mustard in Sylhet region of Bangladesh.

Acknowledgements

Authors are grateful to acknowledge the Bangladesh Agricultural Research Institute, Gazipur and Metrological Department, Sylhet for providing financial and logistic support.

References

Akhter, S., L. Singh, A. Saxena, R. Rasool, S. Ramzan, and I. Showqi. 2016. Agro meteorological indices for brown sarson (*Brassica rapa* L.) sown under different dates of sowing in temperate region of Kashmir. The Bioscan, 11(1): 279-283.

Alam, M. M., F. Begum, and P. Roy. 2014. Yield and yield attributes of rapeseed-mustard (*Brassica*) genotypes grown under late sown condition. Bangladesh J. Agril. Res. 39(2): 311-336.

Angadi, S. V., H. W. Cutforth, P. R. Miller, B. G. McConkey, M. H. Entz, S. A. Brandt, K.M. Volkmar. 2000. Response of three *Brassica* species to high temperature stress during reproductive growth. Can. J. Plant Sci. 80:693-701.

Begna, S. H. and S. V. Angadi. 2016. Effects of Planting Date on Winter Canola Growth and Yield in the Southwestern U. S. American J. of Plant Sciences, 7: 201-217. http://dx.doi.org/10.4236/ajps.

Biswas, K. P. 1989. Effect of sowing time on the yield and yield attributes of two mustard varieties. Bangladesh J. Agric. 14 (4): 317-320.

Grubben, G. J. H. and O. A. Denton. 2004. Plant Resources of Tropical Africa 2. Vegetables.PROTA Foundation, Wageningen; Backhuys, Leiden; CTA, Wageningen.

Ha, T. M. 2011. "Production of safe vegetables in Thai Nguyen province", Technical report, Australia Awards Alumni Program - Small Grant Scheme No. 16, Hanoi.

Islam, N., O. M. Choudhury, N. A. Sarder and S. M. R. Karim. 1994. Effects of sowing date on growth and development of mustard and rapes. Prog. Agric. 5(1): 23-29.

Kalra, U. K., T. P. Yadava and A. L. Bhola. 1985. Effect of sowing date, nitrogen and row spacing on growth, yield attributes and yield of Indian mustard. Agricultural Science Digest 3-4: 177-178.

Khaton, M. 2004. Study of canopy structure and flower production in mustard. M. S. Thesis. Dept. Crop Bot., Bangladesh Agric. Univ., Mymensingh.

Khavse, R., R. Singh, N. Manikandan and J. L. Chaudhary. 2014. Influence of Temperature on Rapeseed-Mustard Yield at Selected Locations in Chhattisgarh State. Current World Environment. Vol. 9(3):1034-1036.

Kumar, A., M. Lal, N. Mohan, M. Kumar, N. Kumar. 2018. Effect of different sowing dates on yield and yield attributes of Indian mustard (*Brassica juncea* L.) Genotypes, Int. J. Pure App. Biosci. 6(2):848-853.

Lakra, R. K., P. Alam and Ali Nayar. 2018. Effect of Sowing Time and Crop Geometry on Productivity of Mustard (*Brassica juncea*L.) Under Irrigated Condition of Jharkhand.Int. J. Curr. Microbiol. App. SciSpecial Issue-7: 777-781.

Lobell, D. B. and G. P. Asner. 2003. Climate and management contribution to recent trends in US agricultural yields. Science 299:1032.

Mondal, M. R. I. and M. A. Islam. 1993. Effect of seed rate and date on yield and yield components of rapeseed. Bangladesh Journal of Agriculture Science, 20(1), 29-33.

Mondal, M. R. I. and M. J. Wright. 1989. Environmental effect on plant growth, morphological characters, yield, oil content and fatty acid composition of canola rapeseed. M. S. Thesis, Cornell University, Ithaca, New York, U.S.A.

Mondal, M. R. I., M. A. Islam and M. A. Khaleque. 1992. Effect of variety and planting date on the yield performance of mustard / rapeseed. Bangladesh J. Agril. Sci. 19 (2): 181-186.

Mondal, M. R. I., M. Biswas, M. M. Hydar-Ali and M. A. Akbar. 1999. Response of rapeseed genotype ' Dhali' to seed rate and seeding date. Bangladesh J. Agril. Res. 24(1): 83-90.

Morrison, M. J. and D. W. Stewart. 2002. Heat stress during flowering in summer *Brassica*. Crop Sci. 42(3):797-803.

Pandey, V., R. P. Vadodaria, B. K. Bhatt, V. J. Patel, J. Talati, A. M. Shekh. 2007. Influence of environmental parameters on mustard yield and its quality. Journal of Agro-meteorology. 9(1): 49-55.

Shivani and S. kumar. 2002. Response of Indian mustard (*Brassica juncea*) to sowing date and row spacing in mid-hills of Sikkim under rainfed conditions. Indian J Agronomy 47 (3): 405-410.

USDA Nutrient Database-https://www.nutrition-and-you.com/mustard-greens.html

Young, L. W., R. W. Wilen, P. C. Bonham-Smith. 2004. High temperature stress of *Brassicanapus*during flowering reduces micro- and megagametophyte fertility, induces fruitabortion, and disrupts seed production. J. Exp. Bot. 55:485-495.