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Quality Evaluation of Dehydrated (Sun and Solar Drying) Cabbage and Rehydration Properties

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Abstract:

The study was concerned with drying of cabbage (Brassica oleracea or variants) by using solar drying and sun drying method. Fresh cabbage slices thickness of single layer, were placed in trays and drying commenced in the solar dryer and Sun dryer. The chemical composition of fresh and dehydrated cabbage leaf were determined. The results showed that the dried products gave substantially higher solid content as well as protein, fat & ash. Among the packaging systems (single layer low-density polythene bag, double layer low-density polythene bag, high density polythene bag and low quality market polythene), double layer low-density polythene bag product absorbed less moisture and showed higher shell-life. Solar drying product is different from sun drying products. Sun drying consumed long time. The results showed that dehydrated cabbage products were in acceptable conditions for periods up to three months. Organoleptic taste testing showed that all the developed products were accepted by

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the panelists using 1-9 hedonic scale. Double layer low-density polythene bag products were ranked as "like very much". In Solar and Sun drying there is no temperature control in the system. So, the effect of temperature on the rate of drying cannot be determined.

Key words: Cabbage, sun drying, solar drying, rehydration

INTRODUCTION

Cabbage is a leafy green or purple biennial plant, grown as an annual vegetable crop for its dense-leaved heads. It is a kind of necessary vegetable in daily life because of containing a variety of vitamin C and vitamin E. Its production is increasing almost every year. The spoilage of large quantity of vegetables occurs due to seasonal glut coupled with inadequate and non-technological post harvest handling, transportation, storage and lack of processing facilities. Cabbage is highly perishable vegetable because of its higher moisture content and for prolonging its self life, requires immediate processing by removal of high amount of moisture (Y. Zhao et al, 2013). Drying is an effective method to preserve agricultural products, there are several kinds of dryers could be considered to dehydrate seeds, leaves etc but we must pay attention to two or more things such as drying quality, energy consumption and environmental benefit etc. When fuel oil and coal are used in traditional dryer's heater, greenhouse gas CO_2, pollutant SO_2, and dusty would be released, they will inevitably contribute to greenhouse effect, acid rain and actinic smoke pollution in certain conditions with other pollutants. However heat pump dryer is a kind of energy-efficient dehydrator, it has some advantages than traditional dryers such as lower energy consumption, convenient controlling in temperature and humidity, high efficiency of drying waste heat recovery and slighter environmental pollution than other drying equipments (Li Jin Goh et al., 2011; Ronak et al., 2010). Rehydration is a complex process aimed at the restoration of raw material properties when dried material is contacted with water. Pre-drying treatments, subsequent drying and rehydration process induce many changes in structure and composition of plant tissue (Lewicki, 1998), which result in impaired reconstitution properties. Hence, rehydration can be considered as a measure of the injuries to the material caused by drying and treatments preceding dehydration. There are a large number of research reports in which authors measure the ability of dry material to rehydrate. However, there is no consistency in procedures used, nor in nomenclature. The ratio between the dry material mass and water mass varies from 1:5 to 1:50, temperature of rehydrating water is from room temperature to boiling. Time of rehydration varies from 2 min. to 24 h. Rehydrating water is either still or occasionally stirred. Rehydrated material is either blotted with tissue paper, filtered off on filter paper with a slight vacuum or drained on a sieve. In no case is the initial water content of the dry material taken into account. The objective of this study was to analyze the proximate composition of fresh (edible) & dehydrated cabbage, to study the rehydration of dehydrated cabbage, to study the storage stability & sensory attributes of dehydrated cabbage, to assess the microbial load in the dehydrated cabbage.

Materials and Methods

Materials

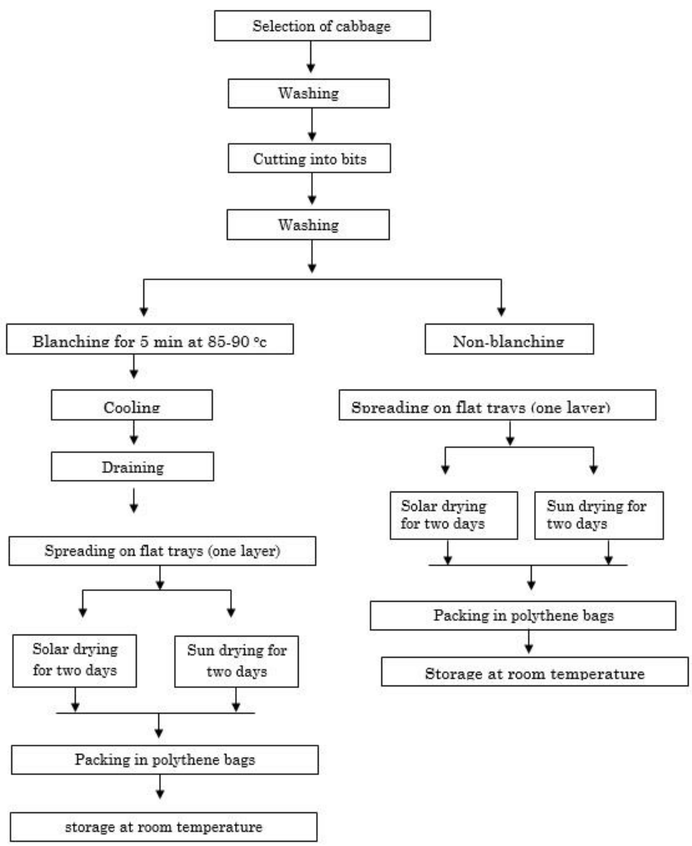
The cabbages were collected from local market. The trays and other chemicals required for processing and packaging of products were used from the laboratory stock.

Methods

Procedures/ methods applied to conduct this study are:

- Cabbage selection, sorting, washing, blanching.
- Processing sample by solar & sun drying.
- Packaging.
- Chemical analysis.
- Rehydration behavior studies.
- Development of product.
- Sensory evaluation
- Storage studies
- Microbial effect on dehydrated cabbage.

Sample preparation



Cabbage selection

Sound, mature and fresh cabbages were selected.

Sorting

The breakage and off colored selected cabbages were picked out from raw selected vegetables.

Washing

The well-graded selected cabbages were washed thoroughly using clean and safe water to remove foreign matter and dust.

Blanching

- Cabbages were first washed, drained, sorted, trimmed & cut as for cooking fresh.
- One gallon of water was used per pound of prepared cabbages.
- Cabbages were put into blancher (wire basket, coarse mesh bag or perforated metal strainer) and lowered into boiling water for 3 min at 85-90^{o}c.
- A lid was placed on the blancher and started counting blanching time immediately.
- Cooled immediately in cold water for the same time used in blanching. Stirred cabbage slices several times during cooling.
- Cabbage slices were drained thoroughly.

Solar drying and Sun drying

Direct solar dryer was used for solar drying of cabbage slices. Direct solar drier is a dryer in which clear polythene is spread over a wooden frame. A black surface was placed under the cover of polythene and trays of iron net placed on the black surface and materials to be dried are placed on it. The black surface as well as the samples absorbs the solar radiation quickly, as a result, there is an increase in the heat inside the dryer, which causes faster removal of moisture from the product undergoing drying. Also a sun drying cabbage slices were dried in direct sun light. In Solar and Sun drying there is no temperature control in the system. So, the effect of temperature on the rate of drying cannot be determined. Fresh cabbage slices thickness of single layer, were placed in trays and drying commenced in the solar dryer and Sun dryer.

Packaging

To assess the effects of packaging the following packaging materials were used to package the dried cabbage slices.

1. Single layer low-density polyethylene (SLLDP).
2. Double layer low-density polythene (DLLDP).
3. High density polythene (HDP) and
4. Low quality market polythene (LQMP).

Each pack contained 250 gm dried cabbage slices, sealed and stored at room temperature (25- 30^{0}C).

Proximate Composition and Statistical Analysis

The raw and dried samples were analyzed for their moisture, ash, fat, protein and Vitamin-C contents. Experiments were performed in triplicate and the results were expressed as mean ± SD. The statistical analysis was carried out by using SPSS 17.0, and Microsoft Excel 2007. A value of $P < 0 .05$ was considered to indicate statistical significance

Moisture

Moisture content was determined adopting AOAC (1984) method.

Ash

AOAC method 14.006 (1984) was used to determine the total ash content.

Fat

AOAC method 7.045 (1984) was used to determine crude fat content of the samples

Protein

Protein content was determined using AOAC (1984) method 2.049.

Vitamin-C

Vitamin-C content of fresh and dried cabbage were determined using the method of Ranganna (1992).

Rehydration ratio

The rehydration properties were determined by immersion in distilled water (Planinic et al. 2005). About 5gm dried sample were weighed and placed in a glass with 400ml distilled water at normal temperature, 50^{o}c and 60^{o}c. After 15min, the sample was removed from bath; the surplus water was removed with tissue paper and then weighted. This process was repeated after 30, 60, 120 & 240min. Lewicki (1998) proposes to calculate the ratio of rehydration from the following equation:

Rehydration ratio = mass of rehydrated sample / mass of dried sample

Preparation of fried vegetable (dehydrated cabbage)

Table 1 : Recipe for Preparation of fried vegetable (dehydrated cabbage)

Ingredient	Amount
Dehydrated cabbage	50 gm
Salt, turmeric	Approximately
Onion (pest)	10 gm
Garlic (pest)	3 gm
Ginger (pest)	3 gm
Green chilli	2 no.
Cumin	2 gm

Flow sheet:

25 gm dried cabbage sample was taken

↓

Rehydrated this sample in 60^{o}c water temperature for 45 min

↓

Drained out water from this sample

↓

Putting soybean oil in a pan and placing on fire

↓

Cooking with a little water to make highly soft

↓

Adding salt, onions, turmeric, garlic, ginger and green chili at a desired amount

↓

Mixing properly

↓

Sometime later add cumin for increasing the flavor

↓

Cooking until a desirable color, flavor & texture is not produced

↓

When desirable color, flavor & texture is obtained, put off the pan from fire

↓

Cooling & serve for eating

Sensory Evaluation

A testing panel evaluated the consumer's acceptability of developed products. The panelists (10) were selected from the students and teachers of the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh. The panelists were requested to assign score for characteristics color, flavour, texture and overall acceptability of various fried dried cabbage. The scale was arranged such that: 9 = Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much and 1 = Dislike extremely. The results were evaluated by analysis of variance (ANOVA) and Duncun's Multiple Range Test (DMRT) procedures of the statistical analysis system (SAS, 1985)

Storage Studies

Shelf life of the processed of dried Cabbage slices packaged in single layer low-density polyethylene, double layer low-density polythene, high-density polythene & low quality market polythene, was assessed at room temperature (25-30 ^{0}C). Each pack contained 250 gm dried Cabbage slices. Total storage time was 3 months. The different parameters used for assessing the quality of products were colour, flavour, texture & moisture content. The observations were made initially at an interval of 30 days up to 90 days. The vegetables with treatment are as follows:

Sample 510 → solar dried non blanching sample → packed in SLLDP
Sample 511 → solar dried blanching sample → packed in DLLDP
Sample 512 → sun dried non blanching sample → packed in HDP
Sample 513 → sun dried blanching sample → packed in LQMP

Microbiological Study

Counting of yeast and mould

Yeast and mould count of different dehydrated cabbage samples were also determined according to the "Recommended method for the Microbiological Examination of Food", Published by American Public Health association (APHA, 1967).

Preparation of media:

In this study potato Dextrose Agar (PDA) was used to enumerate the yeast and mould count of different samples. The media was prepared in the laboratory according to the method described in the "Laboratory Manual". The formula of preparation of PDA media is given in Table 2.

Table 2: Preparation of PDA media

Ingredients	Amounts
Infusion from 200 gm potato Dextrose, Commercial Agar, Shredded Tartaric Acid, U.S.P., 10% solution sterilized.	1000 ml 20 gm 15 gm 2.5 ml/100ml

Two hundred g of previously peeled and sliced potato was taken in 1000ml of distilled water and boiled for an hour. After boiling, straining was done through double thickness of a clean cloth. Then 20 g of commercial dextrose and 15g of agar were added to the potato infusion solution. Later, for complete dissolution the mixture was heated and dispensed into several 200 ml screw cap bottles and sterilized at 121 ^{0}C (6.795 kg pressure /sq. inch) for 20 minutes. The media was then stored at refrigeration temperature. Before pouring into petridishes the media was melted through boiling and around 2.5 ml of 10% tartaric acid was added per 100 ml of media (at 45^{0}C) to reduce the pH value to 3.5 ± 0.1.

Preparation of dilution blanks:

One thousand ml of distilled water was taken into a sterilized flask. The phosphate buffer solution was prepared as per recommendation of the "Recommended Method for the Microbiological Examination of Food" (APHA. 1967). Then the buffer solution was added to the distilled water at the rate of 1.25 ml/ 1000ml and the pH was adjusted to 7.2. The dilution water was then dispensed into several dilution bottles at the rate of 100ml each. Later the dilution blanks were sterilized in an autoclave at 121 ^{0} C (6.795 kg. pressure / sq. inch) for 15 minutes. The sterilized dilution blanks were kept in a refrigerator until use. Pipette, petridishes and glasswares were also sterilized at 121 ^{0} C for 15 minutes in an autoclave.

Making of dilution and procedures of plating:

Making of dilution and procedures of plating for counting yeast and mould was done per making of dilution and procedures of plating for counting bacteria except for the media Potato Dextrose Agar.

Incubation for colony counting:

After solidification of agar, the plates were inverted and incubated at 25^{0}C for 5 days. After incubation, the plates were taken out from the incubator and colonies were counted. Finally, the colony number was multiplied by the dilution and the count per gram of sample was recorded.

Results and Discussion

Proximate Composition of Fresh Cabbage Leaf

The fresh cabbage leaves were analyzed for moisture, protein, fat, ash and vitamin-C content and results are given in Table 3.

Table 3 : Composition of fresh cabbage leaf

Parameter	Composition (wb)
Moisture contents (%)	91.2
Protein (%)	1.77
Fat (%)	0.1
Ash (%)	0.6
Vitamin C (mg/ 100g)	46.3

Moisture

The moisture content of leaf cabbage was 91.2% (Table 3). The value was higher than those found Afroze (2003), Swamination et al. (1972) and lower than those found Ferdous (2004), Bose (1985), Anonymus (1997) who reported 86.8, 90.2, 91.40, 91.90 & 92.40 respectively. The variation in the composition of fresh cabbage leaf might be due to difference in variety, soil property, growing condition, harvesting period, maturity stage etc.

Ash

The ash content of fresh cabbage leaf was 0.6% (Table 3), which is higher than those found Ali (1992) who reported 0.5%. The value is lower than those found Ferdous (2004), Afroza (2003) who reported 0.8, 1.0% respectively.

Fat

The fat content of fresh cabbage leaf was 0.1% (Table 3), which is significantly lower than those mentioned by Ferdous (2004), Afroza (2003), Anonymus (1997) who reported 0.2, 0.7 and 0.2% respectively. The value was similar with Swaminathan et al. (1972) & Bose (1985), who reported 0.1%.

Protein

The protein content of fresh cabbage was 1.77% (Table 3). This value is nearly consistent with Ferdous (2004), Swaminathan et al. (1972), Bose (1985), Anonymus (1997) who reported 1.8, 1.8, 1.8 & 1.4% respectively and significantly lower than those mentioned by Afroza (2003) who reported 2.5%.

Vitamine C

The vitamine C content of fresh cabbage was 46.3(mg/100gm) (Table 3), which is significantly higher than those mentioned by Ferdous (2004), who reported 37.7(mg/100mg) & lower than Mazumder (2006), who reported 50.82(mg/100mg).

Proximate Composition of dried Cabbage slices

The dried cabbage samples were analyzed for moisture, protein, fat, ash and vitamin-C content and results are given in Table 4.

Table 4 : Composition of dried Cabbage samples

Parameter	Sample 510 (wb)	Sample 511 (wb)	Sample 512 (wb)	Sample 513 (wb)
Moisture contents (%)	8.33	8.84	8.42	8.95
Protein (%)	17.3	17.6	17.1	16.3

Fat (%)	3.44	2.33	3.2	2.1
Ash (%)	9.43	8.77	8.6	8.1
Vitamin C (mg/100g)	15	0.45	13	0.34

Sample 510 → solar dried non blanching sample → packed in SLLDP
Sample 511 → solar dried blanching sample → packed in DLLDP
Sample 512 → sun dried non blanching sample → packed in HDP
Sample 513 → sun dried blanching sample → packed in LQMP

The compositions of solar & sun dried cabbage samples are shown in Table 4. During drying most of the water in the samples are vaporized so the moisture content is so less and consequently solid content increased. This increased solid content results the increased protein & ash content. The fat content is also increased in the dried sample which represents no oxidation of fat during drying (Kamruzzaman, 2005). But the vitamin-C content is very low in blanched sample due to heat.

Rehydration

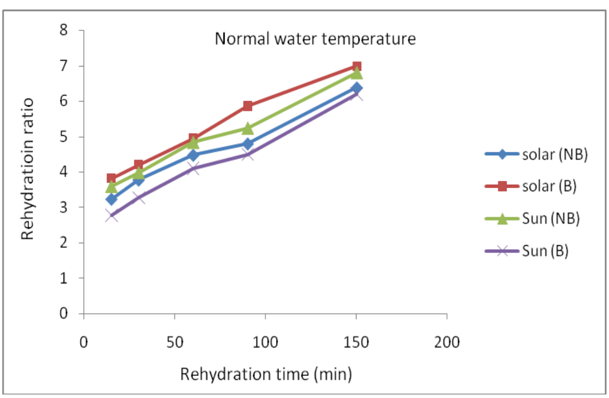


Fig. 1 : Rehydration curves-for different samples at normal water temperature.

Here, NB- non blanching sample. B- blanching sample.

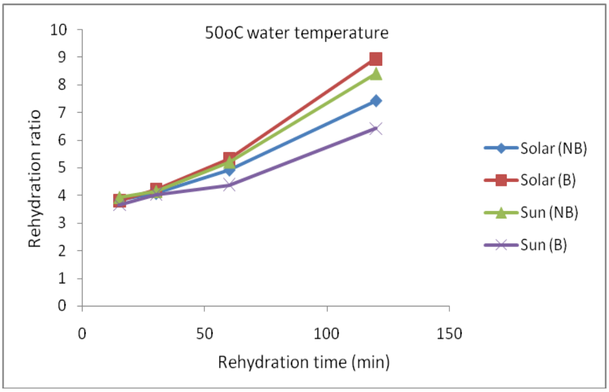


Fig. 2 : Rehydration curves- for different samples at 50^{0}c water temperature.

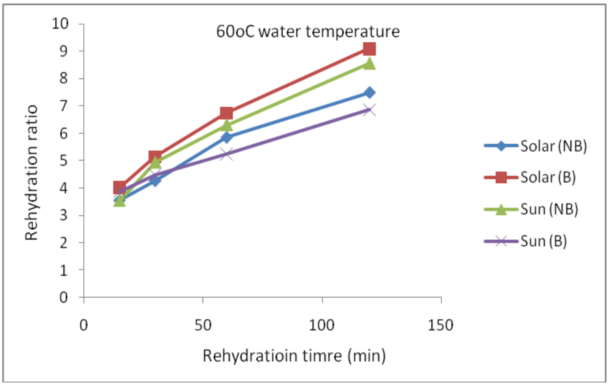


Fig. 3: Rehydration curves-for different samples at 60^{0}c water temperature.

One of the most important characteristics of a dried product is the rehydration ratio. The results for rehydration ratio are shown in Fig 1, 2, & 3. The dehydrated cabbage samples, which were rehydrated at normal, 50^{0}c & 60^{0}c water temperature. As seen in Fig. 1, 2, & 3 rehydration ratio was increased with the increase of rehydration time, being faster during the initial period of the first 150 min., and slower afterward. In Fig 1, 2, & 3. rehydration ratio is higher at normal water temperature than 50^{0}c & 60^{0}c water temperature. Similar findings were reported by Mazza and Lemaguer (1980) for onion, Kaymak-

Ertekin(2002) for green and red peppers & Planinic et. al. (2005) for carrot.

Storage Studies

Table 5: Effect of storage on the quality of the dried cabbage packed in different polythene materials.

Sample	Storage time (month)	Parameters			
		Colour	flavour	Texture	Moisture (%)
510	0	Greenish	Natural	Firm	8.33
	1	Light Greenish	Natural	Firm	9.2
	2	Off greenish	Acceptable	Firm	9.64
	3	Blackish	Acceptable	Firm	9.8
511	0	Yellowish	Natural	Less firm	8.84
	1	Light Yellowish	Natural	Less firm	8.86
	2	Off Yellowish	Acceptable	Firm	8.89
	3	Dark Yellowish	Acceptable	Firm	9.00
512	0	Greenish	Natural	Less soft	8.42
	1	Light Greenish	Natural	Firm	8.49
	2	Light greenish	Natural	Less firm	8.5
	3	Light greenish	Acceptable	Firm	8.56
513	0	Yellowish	Natural	Less soft	8.95
	1	Light Yellowish	Acceptable	Less firm	9.0
	2	Dark Yellowish	Acceptable	Firm	9.0
	3	Dark Yellowish	Spoiled	Firm	9.5

Sample-510: Single layer low-density polyethylene (SLLDP).
Sample-511: Double layer low-density polythene (DLLDP).
Sample-512: High density polythene (HDP) and
Sample-513: Low quality market polythene (LQMP).

From Table 5. it was seen that only the colour of dried cabbage sample-510 & 512 was changed from greenish to light greenish after one month of storage. These may be due to enzymatic or non-enzymatic browning initiated during drying. But in sample-511 & 513, the color changed from yellowish to light yellowish after one month of storage. These may be occur due to samples are blanched before drying. The flavours of the samples are not changed during three month storage. While the texture became firm after one month of storage. Thus sample-

510 & 513 stored in single layer low density polythene & low quality market polythene respectively, may not be stored for more than 3 months due to higher moisture uptake and sample-511 & 512 are fine during storage period due to lower moisture uptake. Sample-511 packed in double layer low quality polythene was the best product with respect to colour, flavour and texture through out this storage period of 3 months with the test amount of moisture gain or uptake of moisture of any packaged food sample is due to permeability of packaging material, hygroscopicity of food product, temperature etc.

Sensory Evaluation of Dehydrated Cabbage

The single layer solar & sun dried cabbage samples were subjected to sensory evaluation in order to assess degree of acceptability in terms of colour, flavour, texture and overall acceptability. The results are presented in Table 6. A two way analysis of variance (ANOVA) (Appendix-II) was carried out and the results showed that there was significant ($p < 0.05$) differences in colour acceptance among four types of dried cabbage samples as the calculated F-value (8.7892) was greater than the tabulated F-value (2.96).The result showed Table 6. that the colour of sample-511 was the most preferred securing 8.4 out of 9 points and ranked as “like very much”. The colour of sample-512 securing the second highest score of 8.1 out of 9 points and the colour of sample-510 securing the third highest score of 7.9 out of 9 & ranked as “like moderately”. While Sample-513 is comparatively less acceptable securing the lowest score (6.7), though this sample was ranked as “like slightly”.

Table 6. Mean score for colour, flavour, texture and overall acceptability of dehydrated cabbage product.

Samples	Sensory attributes			
	Colour	Flavour	Texture	Overall acceptability

510	7.9[a]	7.3[bc]	7.3[ab]	7.7[ab]
511	8.4[a]	8.2a	8.0[a]	8.4[a]
512	8.1[a]	7.8[ab]	7.6[a]	8.0[a]
513	6.7[b]	6.5[c]	6.8[b]	7.1[b]
LSD(P<0.05)	0.7295	0.8360	0.7505	0.7494

Sample 510 → Single layer low-density polyethylene (SLLDP).
Sample 511 → Double layer low-density polythene (DLLDP).
Sample 512 → High-density polythene (HDP).
Sample 513 → Low quality market polythene (LQMP).

In case of flavor a two-way analysis of variance (ANOVA) (Appendix II) was carried out and the results showed that there were significant differences in flavor acceptance among the products as the calculated F value (6.4687) was greater than the tabulated F value (2.96). As shown in Table 6. sample-511 was the most acceptable in flavor preference among the samples securing the highest score (8.2) and ranked as "like very much". This was followed by sample-510, sample-512 and Sample-513 securing 7.3, 7.8 and 6.50 respectively and was equally acceptable and the samples could be ranked as "like moderately". In case of texture of products there were significant differences among the samples at 5% level of significance (Appendix-II) as calculated F (3.8216) value was higher than tabulated value of F (2.96). As shown in Table 4.4 Sample-511 was the most acceptable in texture preference among the samples securing the highest score (8.0) and ranked as "like very much". Sample-512 securing the second highest score of 7.6 out of 9 points could be ranked as "like moderately". While Sample-513 is secured the lowest score (6.68) with a ranking of "like slightly".

A two-way analysis of variance (ANOVA) (Appendix-II) was carried out and the results showed that there were significant ($p<0.05$) differences in overall acceptability among four types of dried cabbage samples product as the calculated F-value (4.5) was greater than the tabulated F-value (2.96). The result showed Table 4.4 that for overall acceptability Sample-

511 is securing the highest score (8.4) could be ranked as “like very much”. Sample-512 secured the second highest score of 8.0, while Sample-510 is secured 7.7& Sample-513 is secured the lowest score (7.1) with a ranking of “like slightly”.

From the above, it is clearly seen that from all considerations, dried cabbage leaves packed in double layer low density polythene and subsequently stored in high density polythene was the most acceptable product with a ranking of “like very much”. It was closely followed by the product packed in single layer low density polythene which secured a “like moderately” ranking. Product packed in a low quality market polythene however, could be ranked as “like slightly”. It may be mentioned here that the products where stored for 3 months at room temperature.

Microbiological Study

The number of mould and yeast was observed after 90 days of storage in the dried cabbage samples. In this experiment, there was no any yeast in all the types of sample in different packaging system at different storage temperature. There was no mold found in sample-511, which is packed in double layer low-density polythene at room temperature (RMT). In this condition mold was found in other three samples namely Sample-510, 512 and 513. It was evident that the total number of mould was found maximum in sample-513. The total number of mould was found less in samples-512. In this case, only one colony-forming unit (log cfu/ml) was found. For sample-510 there were two colony forming unit (log cfu/ml) was found and for the sample-513 there were three colony forming unit (log cfu/ml). For all the four samples colony was found in dilution number 1. The results were shown in Table 7.

Table 7 : Total count of mould of dried cabbage samples at room temperature after 90 days of storage

Sample	No. of Colony	No. of total	Total count (Log. cfu/ ml)
510	2	2×10	1.34
511	0	0×10	1.00
512	1	1×10	0.00
513	3	3×10	1.49

So it had been shown that dried cabbage samples stored in double layer low-density polythene at room temperature (RMT) was susceptible for mould growth after 90 days of storage.

The result of microbiological status of this study corresponds to the study of Rangana and Bajaj (1966). They reported that SO_2 is widely used in the preservation of plant origin food like fruit juices, pulps, partially beverages and concentrates etc. This result is also partially in agreement with the findings on Desrosier (1963). He reported that microorganisms could be killed by lifting and irradiation.

The numbers of colony formed in petridishes were shown in figures.

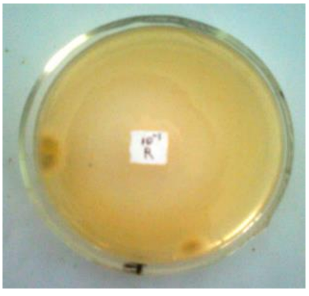


Fig. 4 : Colony formed in petridish of sample-510(1st dilution)

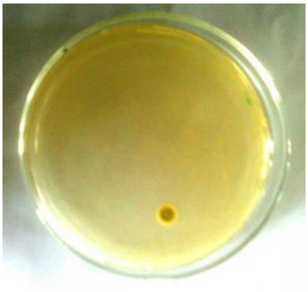


Fig.5 : Colony formed in petridish of sample-512 (1st dilution)

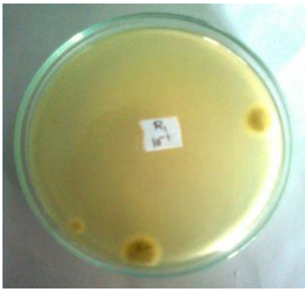


Fig.6 : Colony formed in petridish of sample-513 (1st dilution)

Summary and Conclusion

This research work was carried out to explore the commercial processing of dehydrated cabbages from locally available fresh cabbage. The fresh cabbages were collected from the local market and were analyzed for proximate composition. Dried cabbage samples were stored in four types of polyethylene bag at room temperature (25-30^{0}C).

The fresh cabbage contained 91.2% moisture, 1.77 % protein, 0.1 % fat, 0.6% ash and 46.3 % vitamin-C where the solar dried non blanching sample contained 8.33 % moisture, 17.3 % protein, 3.44 % fat, 9.43 % ash and 15% vitamin-C respectively, the solar dried blanching sample contained 8.84 % moisture, 17.6 % protein, 2.33 % fat, 8.77 % ash and 0.45% vitamin-C respectively, the sun dried non blanching sample contained 8.42 % moisture, 17.1 % protein, 3.2 % fat, 8.6 % ash and 13 % vitamin-C respectively & the sun dried blanching sample contained 8.95 % moisture, 16.3 % protein, 2.1 % fat, 8.1% ash and 0.34% vitamin-C respectively. The studies on the effect of packaging materials during storage showed that moisture content of samples packaged in double layer low density polythene was the lowest and those packaged in low quality market polythene gave the highest moisture content during storage period. Among the packaging systems, double layer low density polythene was the most effective. The colour and flavour of the fresh cabbage leaf were retained in the dried leaf to a remarkable degree when packaged in double layer low density polythene. The reconstitution property in water was excellent for dried leaf.

Four types of dried cabbage leaf product were prepared from fresh cabbage leaf and tested organoleptically by a panel of 10 judges. . Results of test panel showed that sample-511 secured the highest score (8.4) out of 9.0 on the basis of overall acceptability among the samples and was ranked as "like very much". On the other hand sample-512 secured the second highest score (8.0) ranking of "like very much". And Sample-510 secured 7.7, ranking of "like moderately". But sample-513 is not acceptable after 4 month of storage. From the results it is concluded that with Sample-511 was the most preferred product with respect to all the quality attributes. These indicated that dried leaf product is more suitable than fresh leaf.

The study indicates that there is a good prospect of dried cabbages for production of diversified and value added leaf products. Through processing the market value of dried cabbage product may be increased and production can be maximized. Thus farmers would be benefited and encouraged to expand production. Dried cabbage product can be successfully and economically preserved by drying processes.

Every year a substantial amount of cabbages are cultivated in Bangladesh and it is widely consumed as popular vegetable. During peak season farmers are bound to sell their produce at a very low price. But if farmer can preserve their produce by effective and economic way, they will be able to get proper price and get encouraged to maximize production. Solar and Sun drying systems may be used for large scale in our country and commercial used as foreign country, respectively. Dehydrated and processed products can be sold at high price in off-season in both local and foreign market and the country may earn much needed foreign exchange for industrial and economical development. Furthermore, since farmer would get proper price for their produce, productivity would be increased and sustained. Further research should be carried out for developing ways and means to improve rehydration quality of the dehydrated products.

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REFERENCES

Afroza, S. 2003. Study on the preparation of pickles and chutneys from mixed vegetable. MS Thesis, Dept. of food Technology and Rural Industries, BAU, Mymensingh, pp 58.

Ali, S.M.K 1992. Desio Khaddu Drobber postimane, published by nutrition & food science institute, DU, pp 7, 42.

APHA, American Public Health Association. 1967. Recommended methods for the Microbiological Examination of Food APHA, Inc. New York. pp. 53-59.

Anonymous. 1997. Nutrition Garden. Sept., Indian Institute of Horticulture Research. pp-14.

AOAC Methods. 1984. Official Method of Analysis 12th edition. Association of Official Agricultural Chemistry, Washington, DC, USA

Bose, T.K. 1985. Fruits of India: Tropical and Subtropical. Nayaprakash, 206 Bidhan Sarani, Calcutate-700000, India. pp. 250

Desrosier, N.W. 1963. The Technology of Food Preservation, Revised Edn. The AVI Publishing Co., Inc., U.S.A. 40-279.

Ferdous, R. 2004. MS Thesis, Dept. of food Technology and Rural Industries, BAU, Mymensingh, Bangladesh

Kamruzzaman, M. 2005. Development of dehydrated arroids (*Colocasia esculenta*) and indirect solar dryer. MS thesis. Department of Food Technology and Rural Industries. Bangladesh Agricultural University, Mymensigh, Bangladesh. p. 45-46.

Kaymak-Ertekin, F. 2002. Drying and rehydration kinetics of green and red peppers. J. Food. Sci. 67, 168-175.

Lewicki, P. P., Witrowa-Rojchert, D. and Nowak, D. 1998. Effect of pretreatment on kinetics of convection drying of onion. Drying Technology. Poland. 121(1&2): 83-100.

Li Jin Goh, Mohd Yusof Othman, Sohif Mat, Hafidz Ruslan,Kamaruzzaman Sopian, 2011. Review of heat pump systems for drying application. Renew. Sustain. Energy Rev. 15,4788–4796.

Mazumder, A. R. 2006. Effect of refrigeration and freezing on quality of different selected vegetables. A project report, Dept. of food Technology and Rural Industries, BAU, Mymensingh, pp 17.

Mazza, G. & LeMaguer, M. 1980. Dehydration of onions. Some theoretical and practical considerations. Journal of Food Technology,

Planinic, M., Velic, D., Tomas, S., Bilic, M. & Bucic, A. 2005. Modelling of drying and rehydration of carrots using pelegs model. Eur. Technol. 221, 446-451.

Rangana, S. and Bajaj, K. 1966. Hand Book of Analysis of quality control for fruit and vegetable products. 2nd. Ed. Tata Me Grow-Hill Co. Ltd., New Delhi.

Ranganna, S. 1992. Hand book of analysis of quality control for fruit and vegetable products. 2nd Ed. TATA McGraw-Hill Pub. Co. Ltd. New Delhi, India.

Ronak, Daghigh, Mohd Hafidz Ruslan, Mohamad Yusof Sulaiman,Kamaruz zaman Sopian, 2010. Review of solar assisted heat pump drying systems for agricultural and marine products. Renew. Sustain. Energy Rev. 14, 2564–2579.

SAS. 1985. *SAS user's guide: Statistics*, 5th ed.Cary, N.C.: SAS Institute, Inc.

Swaminathan, M and R.K. Bhagavan. 1972. Our Food. 7th edition, Published by Ganesh and Co. Madras, India. pp. 180-182.

Zhao Yang, Enlong Zhu, Zongsheng Zhu, Juan Wang, Siyuan Li; 2013 "A comparative study on intermittent heat pump drying process of Chinese cabbage (Brassica campestris L.ssp) seeds"

APPENDIX I

Table1.1: Different rehydration ratio of dehydrated cabbage leaves against time at normal water temperature.

Time, hour	Rehydration ratio			
	solar dried non blanching sample	solar dried blanching sample	sun dried non blanching sample	sun dried blanching sample
15	4.24	3.42	4.6	3.74
30	4.78	3.5	4.84	4.28
60	5.48	4.64	5.84	5.5
90	5.8	5.26	6.24	6.1
150	7.38	8.98	7.8	7.76

Table1.2: Different rehydration ratio of dehydrated cabbage leaves against time at 50^{0}c water temperature.

Time, hour	Rehydration ratio			
	solar dried non blanching sample	solar dried blanching sample	sun dried non blanching sample	sun dried blanching sample
15	3.82	3.62	3.92	3.66
30	4.06	3.96	4.14	4.04
60	4.16	4.56	4.7	4.38
120	4.42	6.28	5.62	6.42

Table1.3: Different rehydration ratio of dehydrated cabbage leaves against time at 60^{0}c water temperature.

Time, hour	Rehydration ratio			
	solar dried non blanching sample	solar dried blanching sample	sun dried non blanching sample	sun dried blanching sample
15	3.56	3.02	3.54	3.88
30	4.28	3.74	4.34	4.48
60	4.86	4.42	4.58	5.24
120	5.14	5	4.82	6.66

APPENDIX II

Table 2.1: Sensory evaluation data of dehydrated cabbage

Table 2.1.1: Rating score for color of dehydrated cabbage

Judge No.	Sample-510	Sample-511	Sample-512	Sample-512	Total
1	7	8	6	7	28
2	7	9	9	6	31
3	9	8	8	6	31
4	8	9	9	8	34
5	8	9	8	6	31
6	9	8	8	7	32
7	7	7	9	6	29
8	8	9	9	7	33
9	9	9	7	7	32
10	7	8	8	7	30
Total	79	84	81	67	311
Average	7.9	8.4	8.1	6.7	

Table 2.1.2: ANOVA (Analysis of variance) of colour

Sources of variance	Degree of freedom	Sum of squares	Mean squares	F- value	
				Calculated	Tabulated (5%)
Products	3	16.675	5.558	8.7892	2.96
Judges	9	7.225	0.803	1.2694	
Error	27	17.075	0.632		
Total	39	40.975			

Table 2.1.3: Duncun's Multiple Range Test (DRMT) for colour

LSD = 0.7295, Sx = 0.2514, $p < 0.05$

Sample	Original order of means	Sample	Ranking order of means
510	7.9a	511	8.4a
511	8.4a	512	8.1a
512 513	8.1a 6.7b	510 513	7.9a 6.7b

Table 2.1.4: Rating score for flavor of dehydrated cabbage

Judge No.	Sample-510	Sample-511	Sample-512	Sample-513	Total
1	8	9	6	5	28

2	7	7	7	7	28
3	8	8	9	6	31
4	7	9	8	7	31
5	7	8	8	6	29
6	6	7	9	8	30
7	7	8	6	6	27
8	8	9	8	6	31
9	8	9	8	8	33
10	7	8	9	6	30
Total	73	82	78	65	298
Average	7.3	8.2	7.8	6.5	

Table2.1.5: ANOVA (Analysis of variance) of flavour

Sources of variance	Degree of freedom	Sum of squares	Mean squares	F- value	
				Calculated	Tabulated (5 %)
Products	3	16.1	5.367	6.4687	2.96
Judges	9	7.4	0.822	0.9911	
Error	27	22.4	0.830		
Total	39	45.9			

Table 2.1.6: Duncun's Multiple Range Test (DRMT) for flavour

LSD = 0.836, Sx = 0.2881, $p < 0.05$

Sample	Original order of means	Sample	Ranking order of means
510	7.3bc	511	8.2a
511	8.2a	512	7.8ab
512	7.8ab	510	7.3bc
513	6.5c	513	6.5c

Table 2.1.7: Rating score for texture of dehydrated cabbage

Judge No.	Sample-510	Sample-511	Sample-512	Sample-513	Total
1	7	8	6	7	28
2	8	6	7	6	27
3	8	8	8	7	31
4	7	9	7	6	29
5	6	8	8	8	30
6	7	7	8	6	28
7	7	9	9	6	31
8	8	8	7	8	31
9	8	9	8	7	32
10	7	8	8	7	30
Total	73	80	76	68	297

Average	7.3	8.0	7.6	6.8	

Table 2.1.8: ANOVA (Analysis of variance) of texture

Sources of variance	Degree of freedom	Sum of squares	Mean squares	F- value	
				Calculated	Tabulated (5 %)
Products	3	7.675	2.558	3.8216	2.96
Judges	9	6.025	0.669	1.0	
Error	27	18.075	0.669		
Total	39	31.775			

Table 2.1.9: Duncun's Multiple Range Test (DRMT) for texture

LSD=0.7505, Sx = 0.2587, $p < 0.05$

Sample	Original order of means	Sample	Ranking order of means
510	7.3ab	511	8.0a
511	8.0a	512	7.6a
512 513	7.6a 6.8b	510 513	7.3ab 6.8b

Table 2.2.1: Rating score for overall acceptability of dehydrated cabbage

Judge No.	Sample-510	Sample-511	Sample-511	Sample-513	Total
1	8	8	7	6	29
2	8	9	7	8	32
3	8	8	9	7	32
4	7	9	8	8	32
5	9	8	8	6	31
6	7	8	9	8	32
7	8	9	9	7	33
8	8	7	8	7	30
9	7	9	7	8	31
10	7	9	8	6	30
Total	77	84	80	71	312
Average	7.7	8.4	8.0	7.1	

Table 2.2.2: ANOVA (Analysis of variance) of overall acceptability

Sources of variance	Degree of freedom	Sum of squares	Mean squares	F- value	
				Calculated	Tabulated (5 %)
Products	3	9.0	3.0	4.50	2.96
Judges	9	3.4	0.378	0.5667	

Error	27	18.0	0.667		
Total	39	30.4			

Table 2.2.3: Duncun's Multiple Range Test (DRMT) for overall acceptability

LSD=0.7494 , Sx =0.2583, $p < 0.05$

Sample	Original order of means	Sample	Ranking order of means
510	7.7ab	511	8.4a
511	8.4a	512	8.0a
512	8.0a	510	7.7ab
513	7.1b	513	7.1b

APPENDIX III

Name of tester -- Date -----------------

Product --

HEDONIC RATING TEST OF -------------------- (1-9).

Please test the sample and give numerical score ranging from 1 to 9 in the appropriate space.

Parameters	Sample- 1	Sample- 2	Sample- 3
Colour			
Flavour			
Texture			
Overall acceptability			

Hedonic scale used:

Like extremely = 9
Like very much = 8
Like moderately = 7
Like slightly = 6
Neither like nor dislike = 5
Dislike slightly = 4
Dislike moderately = 3
Dislike very much = 2
Dislike extremely = 1

Signature