Pak. J. Biochem. Mol. Biol. 2011; 44(1): 27-31

Physicochemical analysis and quality evaluation of intermediate moisture in apple slices

Salma Iman[1], Shah Bano[2], Shaukatullah[1] and Haseena Naz[3]*
[1]Food Technology Center, PCSIR Laboratories Complex, Peshawar,
[2]Department of Food Science & Technology and [3]Department of Plant Pathology,
Khyber Pukhthunkhwa Agricultural University, Peshawar, Pakistan

Abstract: The present study was conducted to investigate the physiochemical analysis, sensory evaluation and quality assessment of intermediate moisture (IM) in apple slices. Special emphases were paid to have maximum shelf life of the slices by controlling the moisture under suitable temperature and proper storage. The stored apple slices (20-30ºC) were evaluated for pH, acidity, ash, moisture content and for sensory qualities after two years of its preparation. During storage, the acid content of intermediate moisture (IM) slices increased from 0.43-0.47% and pH decreased from 3.94 to 3.79. The ash content decreased from 99.35 to 98.24%, while the moisture content increased from 7.17 to7.86%. During sensory evaluation, sample T2 prepared in sucrose: glucose (7:3), potassium metabisulphite and ascorbic acid retained best color, texture and also obtained maximum mean score (6.8) for overall acceptability during storage. Results showed that storage had a significant ($p<0.05$) effect on the quality of the prepared IM apple slices. Hence the apple slices kept under intermediate moisture (IM) prove maximum durability and long-life under proper and controlled storage facilities.

Keywords: Apple slices, Physiochemical, analysis, moisture, storage**.**
Received: December 10, 2010 **Accepted**: February 14, 2011
***Author for correspondence**: slmiman@yahoo.com

INTRODUCTION

The apple is the promiscuous fruit of the apple species *Malus domestica* in the rose family *Rosaceae* and is perennial[1]. The apple tree is originated in Central Asia. There are more than 7500 cultivators of apples. The cultivators vary in their yield and size of tree even when grown on the same rood stock[2]. From production point of view China is 1st with 35%, USA is 2nd with 7.5%, Iran at position No. 3rd and Pakistan at position No.11[3]. Compared to many other fruits and vegetables, apples contain low quantity of vitamin-C but are a rich source of antioxidant compounds[5]. Apple fruits prevent colon cancer and also help in heart diseases, weight loss, cholesterol leveling like most other fruits and vegetables[6]. It is also a good source of energy, Vitamin-A, calcium, phosphorus and iron[9].

Apple is mostly consumed as fresh fruit, but due to its perishable nature, it cannot be stored for a longtime. In order to preserve the apple fruit durable for a long period and make the apple available during the off-season, it is processed to prepare juices, jams, jelly, canned apple slices and dehydrated apple slices, etc. Most consumers prefer dehydrated foods for their high nutritional value, pleasant taste and due to their availability throughout the year. Foods with high-water content are liable to deteriorative changes such as microbial, enzymatic spoilage, non-enzymatic browning and hydrolytic and oxidative reactions. It is important to reduce the level of water from the food in order to prohibit the survival of such factor of spoilage. Food dehydration refers to the removal of water from foods under controlled conditions that cause minimum or ideally no other changes in the food properties. Fruits and vegetables dried to intermediate moisture (IM) level with the addition of adequate amount of preservatives are of good color, flavor and have better dehydration characteristics. In the 1980s, the committee for intermediate moisture foods (IMF) of France's National Center for Coordination of Research on Food and Nutrition proposed the definition for intermediate moisture foods: "food products of soft texture, subjected to one or more technological treatments, consumable without further preparation and with a shelf stability of several months, assured without thermal sterilization, nor freezing or refrigeration, but by an adequate adjustment of their formulation: Composition, pH, additives and mainly aw (water activity) which must be approximately between 0.60-0.84 measured at 25 °C.

The IMF is getting more popular in recent years as compared to fully dehydrated foods. The IM foods have generally acceptable eating quality and reasonable storage stability under ambient conditions. Generally less drying time and lower temperatures are required for IMF[17]. The IMF with the moisture content of 28% or less with added preservative are stable and are less prone to microbial spoilage[18]. The IMF can be consumed without rehydration and is shelf stable without refrigeration and thermal processing. Therefore, these foods have the potential applications in developing countries, military and space rations or in any other situations where the refrigeration or thermal processing facilities are inadequate[11]. Hence IM foods show great potential for utilizing surplus

produce in the developing countries due to acceptable quality characteristics.

Generally they contain moderate levels of moisture, of the order of 20-50% by which is less than is normally present in natural fruits, vegetables or meats and more moisture than is left in conventionally dehydrated products. Aditionally, IMF has dissolved in this moisture, concentration of solutes sufficient to decrease below that required to support microbial growth. As a consequence IMF does not require refrigeration to prevent microbial deterioration. Breakage of the package and subsequent food spoilage do not occur in IMF even if the packages are damaged, IMF are not readily subject to spoilage because of their low aw. During peak harvest season, a large quantity of this valuable fruit is wasted due to improper handling and lack of preservation facilities[7]. Apart from minimizing the wastage of fruit, preservation of apple is also necessary because of its rich nutritional value.

MATERIALS AND METHODS

IM apple slices were evaluated for physicochemical characteristics in the year 2004-05 in the Department of Food Science and Technology, Khyber Pukhtunkhwa Agricultural University, Peshawar. The slices of acceptable size and shape were selected and divided into five lots for physicochemical analysis (Table 1).

Table 1: Scheme of study.

Treatment	Sweetener	Chemical preservatives	Anti-oxidants
T1	Glucose	Potassium metabisulphite	Citric acid
T2	Sucrose: glucose (7:3)	Potassium metabisulphite	Ascorbic acid
T3	Fructose	Potassium sorbate	Ascorbic acid
T4	Sucrose	Potassium sorbate	Citric acid
T5	Sucrose	Potassium sorbate	Ascorbic acid

Physicochemical Analysis

pH

The pH was determined with the help of Inolab Digital pH meter. The results were expressed as solute slices (Brix) as described in AOAC[13].

Acidity, moisture and ash

The IM apple slices were analyzed for acidity according to the procedure specified earlier[14] as mentioned in AAOC[13], while moisture and ash content by the standard methods described in AACC[12],[17].

Sensory evaluation

The product was evaluated for color, texture and overall acceptability by the method as described by Larmond (1977)[16], using 9 Point Hedonic Scale (1-9). A panel of 10 judges (students and staff of the Department of Food Science and Technology) were selected on the basis of their experience in sensory evaluation.

Statistical analysis

The results were analyzed statistically by using randomized complete block design (RCBD) as recommended[19] and the means were separated by applying LSD test as recommended[22].

RESULTS AND DISCUSSION

pH

The pH of the samples T1, T2, T3, T4 and T5 on the opening of the pack was 3.82, 3.96, 3.86, 4.01 and 4.08, which was decreased to 3.54, 3.87, 3.74, 3.90 and 3.90 respectively during two months of storage period. For treatments, maximum mean values were recorded in sample T4 (3.96) and sample T5 (3.96) followed by T2 (3.91), while minimum mean value was recorded in sample T1 (3.69) followed by T3 (3.80). In a similar study, Kinh *et al.*[15] observed a significant increase in acidity and a decrease in pH during the storage life of apple products.

Acidity

The % acidity of the samples T1, T2, T3, T4 and T5 was 0.42, 0.67, 0.73, 0.20 and 0.13%, which increased to 0.52, 0.63, 0.76, 0.25 and 0.20% respectively during two months storage period. For treatments maximum mean values were recorded in sample T3 (0.69%) followed by T2 (0.63%), while minimum mean values were recorded in sample T5 (0.20%) followed by T4 (0.26%) The overall mean values for % acidity significantly ($p<0.05$) increased from 0.43 to 0.47% during storage. Maximum increase in acidity was observed in sample T5 (53.84%) followed by T4 (25%), while minimum increase was observed in sample T3 (4.10%) followed by T2 (5.97%) during storage. This result is in accordance with the findings of Ruck JA[14] and Cecilia & Maia[9], who reported an increase in total acidity of apple product during storage.

Ash

The ash content of apple slices T1, T2, T3, T4 and T5 was 99.13, 99.27, 98.67, 99.75 and 99.95%, which increased to 99.40, 94.94, 97.82, 99.58 and 99.76% respectively during two months storage period. For treatments maximum mean values were recorded in sample T5 (99.76%) followed by T4 (99.59%), while minimum mean values were recorded in sample T2 (95.47%) followed by T3

(98.00%). The overall mean values for % ash significantly ($p<0.05$) decreased from 99.35 to 98.24 % during storage. Maximum decrease in ash was observed in sample T2 (4.36%) followed by T3 (0.86%), while minimum decrease was observed in sample T4 (0.17%) followed by T5 (0.19%) during storage[12].

Moisture

The moisture content of the samples T1, T2, T3, T4 and T5 on opening of the pack was 8.25, 8.49, 5.34, 8.87, and 4.90%, which increased to 9.02, 8.83, 7.30, 8.02 and 6.15%, respectively during two months storage period. For treatments maximum mean values were recorded in sample T1 (9.03%) followed by T2 (8.69%), while minimum mean values were recorded in sample T5 (6.2%) followed by T3 (7.31%). The overall mean values for moisture content significantly ($p<0.05$) increased from 7.17 to 7.86 %during storage. Maximum increase in moisture content was observed in sample T3 (36.70 %) followed by T5 (25.51%), while minimum increase was observed in sample T2 (4.00%) followed by T1 (9.33%) during storage. This may be due to reopening of the sealed packs weekly for analysis. These results are in agreement with the findings of Levi *et al.*[17], who concluded an increase in moisture content in some tropical fruits during storage.

Sensory evaluation

Color

IM apple slices were sensory evaluated by a panel of ten judges selected from the staff and students of the department of Food Science and Technology, Pukhtoonkhwa Agricultural University, Peshawar. The average mean score of samples T1, T2, T3, T4, and T5 decreased from 7.2, 7.1, 6.9,6.9 and 6.7 to 5.9, 6.0, 6.2, 5.8 and 6.0, respectively. The overall mean score of these samples decreased from 6.7 to 6.0 during storage. Maximum decrease in color score was observed in sample T1 (18.05 %) followed by T4 (15.94%), while minimum decrease was observed in sample T3 (10.14%) followed by T5 (10.44%) during storage (Table 2).

Texture

The average mean score of texture of samples T1, T2, T3, T4, and T5 decreased from 6.5, 7.6, 7.7, 6.8 and 7.0 to 5.7, 6.9, 6.9, 6.1 and 7.0 respectively during two months storage. The average mean scores of these samples decrease from 7.0 to 6.3. Maximum decrease in texture score was observed in sample T1 (12.30%) followed by T3 (10.38%), while minimum decrease was observed in sample T2 (9.21%) followed by T5 (9.23%) during storage (Table 3).

Overall acceptability

The mean score of over all acceptability of samples T1, T2, T3, T4, and T5 decreased from 6.9, 7.3, 7.3, 6.7 and 6.6 to 5.9, 6.8, 6.4, 6.0 and 5.7 respectively (Table 4). The over all mean score of these samples decreased from 6.96 to 6.16 during storage. Maximum decrease was recorded in sample T5 (15.62%) followed by T1 (13.04%), while minimum decrease was recorded in sample T2 (8.0%) followed by T4 (8.95%). Our results showed that the sample T2 prepared with sucrose fructose (7:3) potassium metabisulphite and ascorbic acid obtained maximum mean score (6.8) for overall acceptability. Similar results were obtained earlier[10], who showed that slices prepared with sucrose/glucose (7:3) solutions had highest overall acceptability during the storage[8, 20] and found that using sucrose: glucose as mixture and humectants is the best formulation for maintaining functional properties in food products.

The mixture of sweeteners with added potassium metabisulphite, ascorbic acid and citric acid produced best quality product which can be kept for longer period of time. Similar effect of sweeteners used for the preparation of IM guava and soya product was reported[21]. The statistical analysis showed that the treatments and storage intervals had a significant ($p<0.05$) effect on the pH, acidity color, texture and overall acceptability, while storage intervals had a non significant effect on the ash and moisture of IM apple slices. The overall physicochemical analysis of the apple slices were recorded and the actual readings before and after storage for the parameters i.e. pH, acidity, ash and moisture have also been notified in table 5.

CONCLUSION

It can be concluded from these results that for the preparation of shelf stable intermediate moisture apple slices, sucrose:glucose along with ascorbic acid, citric acid and potassium metabisulphite is the best sweetener and chemical preservative combination which can maintain physicochemical characteristics during storage. Proper storage under controlled moisture can increase the over all acceptability due to long shelf life. There is a great potential for the fruits products in the export sector to earn billions of foreign exchange, provided some special concessions are allowed to industries. Proper packing material, sugar and modernized storage facilities be made available to processing units on concessional prices as compare to the existing high rates.

REFERENCES

1. Potter DI, Esikson T, Evans RC, Smedwork JEE, Morgan DR, Kerr. Robertson KR, Arsenault MP, Dikson TA and Campbell CST. Phylogeny and classification of rosaceae plant systematic and evaluation. 2007; 266: 5-43.
2. Apple. "*Malus domestica*" Natural England. http.//www plant press .com. wild life/0523apple.Php. Retrieved, 2008.

Table 2: Mean score of judges for color of IM apple slices**.**

Storage intervals (Days)										
Treatment	1	7	14	21	28	35	42	49	%Dec	Means*
T1	7.2	7.2	7.0	7.0	6.5	6.4	6.3	5.9	18.05	6.68a
T2	7.1	7.1	6.9	6.8	6.6	6.5	6.3	6.0	15.49	6.66ab
T3	6.9	6.9	6.7	6.5	6.5	6.4	6.3	6.2	10.14	6.55bc
T4	6.9	6.9	6.8	6.7	6.5	6.3	6.2	5.8	15.94	6.51c
T5	6.7	6.5	6.5	6.3	6.2	6.1	6.0	6.0	10.44	6.28d
Means*	6.9a	6.9ab	6.7bc	6.6c	6.4d	6.3de	6.2e	5.9f	-	-

*****Figures with different small letters are statistically different ($p<0.05$) from one another.

Table 3: Mean score of judges for texture of IM apple slices.

Storage intervals (Days)										
Treatment	1	2	3	4	5	6	7	8	%Dec.	Means*
T1	6.5	6.5	6.4	6.1	6.0	5.9	5.9	5.7	12.30	6.12c
T2	7.6	7.5	7.3	7.1	7.1	7.0	7.0	6.9	9.21	7.18a
T3	7.7	7.5	7.4	7.4	7.3	7.2	7.0	6.9	10.38	7.30a
T4	6.8	6.7	6.6	6.5	6.4	6.4	6.3	6.1	10.29	6.47b
T5	7.0	6.8	6.8	6.9	7.0	6.9	7.3	7.0	9.23	6.17c
Means*	7.0a	6.9b	6.8c	6.6d	6.5de	6.5ef	6.4f	6.3g	-	-

*****Figures with different small letters are statistically different ($p<0.05$) from one another.

Table 4: Mean Score of Judges for overall acceptability of IM apple slices.

Storage intervals (Days)										
Treatment	1	2	3	4	5	6	7	8	%Dec.	Means*
T1	6.9	6.8	6.7	6.3	6.0	5.9	5.4	5.9	13.04	6.23cd
T2	7.3	7.2	7.1	7.0	7.0	6.9	6.9	6.8	8.00	7.82a
T3	7.3	7.2	7.1	6.9	6.8	6.6	6.5	6.4	12.16	6.85b
T4	6.7	6.6	6.5	6.4	6.3	6.2	6.1	6.0	8.95	6.35c
T5	6.6	6.4	6.2	6.1	6.0	5.9	5.8	5.7	12.62	6.08d
Means*	6.9a	6.8ab	6.7bc	6.5cd	6.4de	6.3ef	6.1f	6.1f	-	-

*****Figures with different small letters are statistically different ($p<0.05$) from one another.

Table 5: Physiochemical analysis of Intermediate moisture (IM) apple slices.

S.#	Sample	pH		Acidity		Ash		Moisture	
		Before storage	After storage	Before storage	After storage	Before storage	After storage	Before storage	After storage
1	T1	3.82	3.54	0.42	0.52	99.13	99.40	8.25	9.02
2	T 2	3.96	3.87	0.67	0.63	99.27	94.94	8.49	8.83
3	T 3	3.86	3.74	0.73	0.76	98.67	97.82	5.34	7.30
4	T 4	4.01	3.90	0.20	0.25	99.75	99.58	8.87	8.02
5	T 5	4.08	3.90	0.13	0.20	99.95	99.76	4.90	6.15

3. Dedicated to successful Global Apple Marketing. Apple Industry, Key facts. 2008.
4. Boyer JIL and Ruilin RH. Apple phytochemicals and their health benefits. Deptt. of Food Science and Institute of comparative and environmental toxicology, USA. *Nutr. J.*, 2004; 3: 5.
5. Washington state Apple Advertising Commission, "Apple keeps your family healthy. http://www bestapples.com/healthy/.retrieved. 2008
6. Chaudhry MI and Malik MN (editor). Fruit crops in horticulture." 1st edition, National Book Foundation, Islamabad. 1994: 471-473.
7. Khan RD, Stehli LS, Wei MP and Munir S. Activity and mobility of water in sugar solutions and their theological characteristics". *Sarhad J. Agric.*, 2001; 6: 47-49.
8. Cecilia E and Maia GA. Storage stability of cashew apple juice preserved by hot fill and aseptic process. Department of Food Technology, University of Ceara, *Brazil CEP*, 2002; 60511-110.
9. Ayub MA, Zeb J and Khattak MAK. Effect of various sweeteners on chemical composition of guava slices. *Sarhad. J. Agric*., 2005; 21: 131-134.
10. Brockmann MC. Development of Intermediate moisture foods for military use. *Food. Technol. Chicago*, 1970; 24: 896-900.

11. AACC. (American Association of Cereal Chemists), approved method of American Association of Cereal Chemist, St. Pauls Minnessota, USA, 2000
12. AOAC. Official methods of analysis. Association of official analytical chemists". 17th ed, Washington, D. C. 2002.
13. Ruck JA. Chemical methods for analysis of fruit & vegetable products, Deptt. of Agri. Canada, 1963.
14. Kinh A, Dunne CP and Hoover DG. Preparation and preservation of apple pulp with chemical preservatives and mild heat. *J. Food Prot.,* 2001; 28: 111-114.
15. Larmond E. Laboratory Methods of Sensory Evaluation of Foods. Publication 1637 Department of Agri. Ottawa, Canada. 1997.
16. Levi A, Gagel S and Juven BJ. Intermediate moisture tropical fruits products for developing Countries 11. Quality characteristics of papaya. *J. Food Technol*., 1983; 20: 163-175.
17. Levi A, Lan YM and Kocher F. Intermediate moisture tropical fruit products for developing countries 11. Quality characteristics of papaya. *J. Food Technol*., 1985; 20: 163-175.
18. Steel RGD and Torrie JH. Principles procedures of statistics". McGraw Hill Book Pub. Co. New York, USA, 1980.
19. Nelson and Steinberg. Effect of solute on rheology of soy flour and its Components". *J. Food Sci.,* 1982; 47: 792.
20. Chochron WC and Cox GM. Experimental Design John Willey and sons, Inc. New York, 1967.