

**NUTRITIONAL EVALUATION AND UTILIZATION
OF SWEET CORN FOR PRODUCT DEVELOPMENT**

By

**RENU PANDEY
2008HS70M**

*Thesis submitted to CCS Haryana Agricultural University in partial
fulfilment of the requirements for the degree of :*

**MASTER OF SCIENCE
IN
FOODS AND NUTRITION**

*Department of Foods and Nutrition
I.C. College of Home Science
CCS Haryana Agricultural University
Hisar – 125004*

2011

CERTIFICATE – I

This is to certify that this thesis entitled, “**Nutritional Evaluation and Utilization of Sweet Corn For Product Development**”, submitted for the degree of **Master of Science**, in the subject of **Foods and Nutrition** to the CCS Haryana Agricultural University, is a bonafide research work carried out by **Renu Pandey** under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

Dr. (Mrs.) Asha Kawatra
Major Advisor
Professor
Deptt. of Foods and Nutrition
CCS HAU, Hisar - 125004

CERTIFICATE – II

This is to certify that this thesis entitled, **“NUTRITIONAL EVALUATION AND UTILIZATION OF SWEET CORN FOR PRODUCT DEVELOPMENT”**, submitted by **Renu Pandey** to the CCS Haryana Agricultural University in partial fulfillment of the requirements for the degree of **Master of Science**, in the subject of **Foods and Nutrition**, has been approved by the Students Advisory Committee after an oral examination on the same.

MAJOR ADVISOR

HEAD OF THE DEPARTMENT

DEAN, POSTGRADUATE STUDIES

CERTIFICATE –III

FORMAT FOR P. G. THESIS

It is certified that the thesis submitted by Ms. Renu Pandey, Adm. No. 2008HS70M, M. Sc. student of this department has been checked and found as per specification of the format circulated by the Dean, PGS vide his Memo No. PGS/A-1/09/6926-90 dated 26. 8. 09

MAJOR ADVISOR

PROFESSOR AND HEAD

UNDERTAKING OF THE COPY RIGHT

I **Renu Pandey**, Adm. No. **2008HS70M** undertake that I give copy right to the CCS HAU, Hisar of my thesis entitled “**Nutritional Evaluation and Utilization of Sweet Corn for Product Development**”.

I also undertake that, patent, if any, arising out of the research work conducted during the program shall be filed by me only with due permission of the competent authority of CCS HAU, Hisar.

Signature of student

ACKNOWLEDGEMENT

He chose me; I am glad, "he showed me the path." The ALMIGHTY GOD is over truly honoured, he led, guided me without whose blessings my present thesis would not have existed. It is indeed farcical to pen in few words the fulsome contribution of few some who made a difference in our life when right from the cradle to the grave, we are touched by so many hands, which on hindsight, we are never ever in position to acknowledge. But to be fair, I acknowledge the true "Guru" who has provided different colours to the rainbow of my life because without his blessings we can never cross the cold deserts of cynicism and dismay.

Although thanks are poor expression of debt of gratitude one feel yet there is no better way to express it. With sincerity and immense pleasure, I feel great pride and privilege to express profound sense of gratitude and infinite in debtness to my esteemed Major Advisor, Dr. (Mrs.) Asha Kawatra, Professor and Head, Department of Foods and Nutrition for her close supervision, sincere counsel, help, suggestions encouragement exhaustive not only limited to this work, but will also take me a long way in my life.

I wish to convey my heartiest appreciation for patience, understanding and round the clock help extended to me by my Co-Major Advisor Dr. (Mrs.) Salil Sehgal, Professor, Department of Foods and Nutrition.

I am immensely thankful to the members of my advisory committee Dr. (Mrs.) Shashi Madan, Professor, Department of Plant Breeding ;Dr. (Mrs.) Veena Manocha, Associate Professor and Jt Director HRM; Dr. J.C. Kaushik, Professor and Head, Department of Forestry for evincing keen interest in the study, providing necessary help and for critically going through this manuscript.

I am immensely indebted to Department of University, Uchani, Karnal for providing research material and spirited cooperation all through my research work.

I am greatly obliged to other teaching and non-teaching staff of Department of Foods and Nutrition for their timely help in completion of this study.

All words fail to express the debt of gratitude to my mother, Smt. Meena Pandey and my Father Mr. Nand Kishore Pandey, who are like incarnation of God on this earth, so I bow my head to my parents for making me what I am and for bringing me where I am. Everlasting love showed by my brothers, Pregnesh, Pretish, Satish and Mayank and loving sisters, Pooja, Kalpana and Teena is duly acknowledged, as they are the harbinger to hope for me.

The instrument of acknowledgement would remain unturned if I do not express my loving thanks to my friends Himanshi, Pari, Honey, Gunjan, Shashi Di, Mamta Di, Sumit, Ankita Di, Shipra Di, Jyoti Di, and Shivani Di, making every moment of my life memorable during my stay in hostel and for their valuable help and support throughout my work.

Cherished moments spend with my sweet and loving friends, Nisha, Kavita, Aditi and Yogesh will remain unforgettable.

Last but not the least I am sincerely thankful to all who helped me directly or indirectly and whose names I could not mention in the endeavour.

I have no words to express, about the experience and opportunities HAU has provided me in these years. I was blessed with a lot of friends and the moments I spent here are the most memorable moments in my life.

(RENU PANDEY)

Dated : January 2011

Place : Hisar

CONTENTS

CHAPTER	TITLE	PAGE NO.
I	INTRODUCTION	1-3
II	REVIEW OF LITERATURE	4-14
III	MATERIALS AND METHODS	15-35
IV	RESULTS	36-65
V	DISCUSSION	66-78
VI	SUMMARY AND CONCLUSION	79-82
	LITERATURE CITED	i-vi
	APPENDIX	

LIST OF TABLES

Table No.	Description	Page No.
4.1	Proximate composition of sweet corn (g/100g, dry matter basis)	37
4.2	Carbohydrate content of sweet corn (g/100g, dry matter basis)	38
4.3	<i>In vitro</i> protein and starch digestibilities of sweet corn (on dry matter basis)	38
4.4	Vitamin content of sweet corn (on as is basis)	39
4.5	Total mineral content of sweet corn (mg/100g, dry matter basis)	39
4.6	Mean scores of sensory characteristics of Soup and Salad prepared from sweet corn.	40
4.7	Mean scores of sensory characteristics of Cutlet, Manchurian and <i>pulav</i> prepared from sweet corn.	41
4.8	Mean scores of sensory characteristics of Dry Vegetable and <i>Kofta</i> Curry prepared from sweet corn.	41
4.9	Mean scores of sensory characteristics of <i>Halwa</i> and <i>Kheer</i> prepared from sweet corn.	42
4.10	Mean scores of sensory characteristics of Pickle prepared from sweet corn.	43
4.11	Effect of storage on proximate composition of dehydrated sweet corn (g/100g, dry matter basis)	44
4.12	Effect of storage on available carbohydrates content of dehydrated sweet corn (g/100g, dry matter basis)	46
4.13	Effect of storage on mineral content of dehydrated sweet corn (g/100g, dry matter basis)	48
4.14	Organoleptic acceptability of Soup prepared from dehydrated sweet corn at different storage interval	50
4.15	Organoleptic acceptability of "Cutlet" prepared from dehydrated sweet corn at different storage interval	51
4.16	Organoleptic acceptability of Dry Vegetable prepared from dehydrated sweet corn at different storage interval	52
4.17	Organoleptic acceptability of <i>Kheer</i> prepared from dehydrated sweet corn at different storage interval	53
4.18	Effect of storage on proximate composition of frozen sweet corn (g/100g, dry matter basis)	55
4.19	Effect of storage on available carbohydrates content of frozen sweet corn (g/100g, dry matter basis)	57
4.20	Effect of storage on mineral content of frozen sweet corn (g/100g, dry matter basis)	59
4.21	Organoleptic acceptability of Soup prepared from frozen sweet corn at different storage interval	61
4.22	Organoleptic acceptability of Cutlet prepared from frozen sweet corn at different storage interval	62
4.23	Organoleptic acceptability of Dry Vegetable prepared from frozen sweet corn at different storage interval	63
4.24	Organoleptic acceptability of <i>kheer</i> prepared from frozen sweet corn at different storage interval	64

LIST OF FIGURES

Fig. No.	Description	Page No.
I	Percent reduction of proximate composition during storage of dehydrated sweet corn	44
II	Percent reduction of available carbohydrates during storage of dehydrated sweet corn	46
III	Percent reduction of total minerals during storage of dehydrated sweet corn	48
IV	Percent reduction of proximate composition during storage of frozen sweet corn	55
V	Percent reduction of available carbohydrates during storage of frozen sweet corn	57
VI	Percent reduction of total minerals during storage of frozen sweet corn	59

LIST OF PLATES

Plate No.	Description	Page No.
1	HSC-1	15
2	Madhuri	15
3	Sweet Corn Soup	25
4	Sweet Corn Salad	26
5	Sweet Corn Cutlet	27
6	Sweet Corn Manchurian	28
7	Sweet Corn <i>Pulav</i>	29
8	Sweet Corn Dry Vegetable	30
9	Sweet Corn <i>Cofta</i> curry	30
10	Sweet Corn <i>Halwa</i>	32
11	Sweet Corn <i>Kheer</i>	32
12	Sweet Corn Pickle	33
13	Dehydrated Sweet Corn	34
14	Frozen Sweet Corn	34

Sweet corn is a member of the *Gramineae* (grass family) along with barley, wheat, and rice. This mutated grass is native to the tropical environments of the America. According to historical accounts, the origin of sweet corn dates back to 1779, when a member of the Sullivan expedition against the Six Nations brought back a few ears of sweet corn, which was called papoon corn. Sweet corn was first offered to public in 1828 by Thorburn. (George, 1955). There are many varieties of sweet corn available, but variety preference is different for each region. Standard yellow sweet corn is the most commonly known variety. Sweet corn varies from normal corn essentially for gene(s) that affect starch synthesis in the seed endosperm where in the recessive sugary (su) allele elevates the level of water soluble poly saccharides (sugars) and decreases starch. Thus the kernels of sweet corn taste sweet especially at 18 to 21 days after pollination. The total sugars in sweet corn ranges from 25-30 percent (Ramachandrappa and Nanjjappa, 2006).

The mutation in sweet corn causes it to produce more sugar than field corn making it popular for human consumption, and at the same time making the storage of sweet corn very difficult. Sweet corn has three main genetic types characterized by the level of sugar they contain.

Normal Sugary (su) is the standard sweet corn commonly grown through the years. Its rich corn flavor and quality are the best if picked and cooked the same day.

Sugary Enhanced (se) varieties have a modifying gene that increases the original levels of sugars in the kernel and extends their flavour. Moisture loss also is slower than normal (su) and tenderness is improved. The result is a sweeter, more tender kernel with good corn flavour that will retain its quality longer than normal (su) corn.

Super sweet or extra sweets have a shrunken (sh) gene, a name that describes the light-weight, wrinkled seed of this group. This gene raises original levels of complex sugars even further, again extending their flavour by slowing conversion to simple sugars and finely to starch. Moisture also is retained in this type, and shelf life is remarkably long. There usually will be more seed per lb. in the super sweet (sh) types due to low seed density (Duffy and Calvert, 2010).

Sweet corn is used as human food at the milk stage of the endosperm development when the kernel is soft, succulent and sweet (Pajic *et al.*, 2004). Unlike field corn varieties, which are harvested when the kernels are dry and fully mature (dent stage), sweet corn is picked when immature (milk stage) and can be harvested in 75- 80 days after planting and eaten as a vegetable, rather than grain (Schultheis, 1994). It is one of the most popular vegetable in the western and advanced countries of the world (ICAR, 2006).

In terms of production, the United States has dominated the world sweet corn, or green maize, market since at least the 1960s. In 2004, Mexico became the second largest producer of sweet corn, a position it still holds today. Other countries who are leading producers of sweet corn include (in order): Nigeria, France, Thailand and Hungary. (ERS 2008) According to USDA reports, commercial sweet corn production for the fresh market in 2009 surpassed a record \$835.8 million in value and over 28.4 million in volume. That same year, commercial sweet corn for processing (frozen and canned) was valued at a record \$335.6 million and totaled a record 3.2 million tons (NASS 2010). Sweet corn is produced for three distinct markets: fresh, frozen and canned. Production within these markets is largely independent of each other. Like other dual-use (fresh and processed) vegetables, the fresh market accounts for the majority of total sweet corn crop value. However, sweet corn is the second-leading processing crop, following tomatoes. The value of sweet corn for freezing continued to rise, reaching \$191.6 million, while the value of sweet corn for canning decreased from 2008, falling to \$144.0 million.

In India maize is mainly grown in Punjab, Haryana, Bihar, Gujrat, Rajsthan, MP, Uttar Pardesh, Bihar and Karnataka (Annual Progress Report, Dir. of Maize Research,2007)and sweet corn growing states are, Punjab, Haryana, Uttar Pardesh, Bihar and Hyderabad. In Haryana its cultivation is mainly confined to periurban areas of cities near NCR region like Sonipat, Gurgaon, Faridabad, Palwal due to convenience in marketing. Few points are taken care of, before its harvesting and transport, due to its perishable nature. Firstly the harvesting should be done either in early morning or at evening, mainly to avoid its rapid conversion of sugar to starch. Secondly its transport should always be in refrigerated form to maintain its taste and freshness.

Sweet corn is the new age super diet for health conscious people. The nutritive value of sweet corn is comparable to several high priced vegetable like cauliflower, cabbage, french beans, fibre content and low in cholesterol (Yodpetch, 1979). Sweet corn is rich in carbohydrates and Sugars and contains useful amounts of vitamins A, B₃ (which supports metabolism, the nervous and digestive systems) and C. It also contains Folic Acid, Fibre, minerals and Protein (Gabhardt and Mattews, 1981). Perhaps the most surprising is that it offers even greater health benefits when cooked. The Sweet corn's antioxidant activity is significantly increased when cooked, helping to battle cancer, heart disease and protect against cataracts (<http://www.mdidea.com>). There is notion that processed fruits and vegetables have a lower nutritional value than fresh produce. Those original notions seem to be false, as cooked sweet corn retains its antioxidant activity, despite the loss of vitamin C. It has been reported that thermal processing at 115⁰C for 25 minutes significantly elevated the total antioxidant activity of sweet corn by 44 per cent and 54 per cent, although 25 per cent vitamin C loss was observed (Dewanto *et al.*, 2002).

Newly developed products such as sweet corn milk and soups are gaining popularity in many countries. New varieties of sweet corn have been developed with improved consistency, taste and shelf life. High quality sweet corn has uniform size and colour (yellow, white or bi colour); sweet plump, tender, well-developed kernels; fresh, tight, green husk; and is free from insect injury, mechanical damage, and decay. Sweetness is the most important factor in consumer satisfaction with sweet corn (Evensen and Boyer, 1986). New ðhigh sugar or sweeterö varieties with longer shelf life are being adopted for consumption (Lertat and Pulam, 2007). The kernels are boiled or steamed, and usually served with butter and salt. In Europe, China, Korea and Japan, they are often used as a pizza, or in salads. It is also consumed corn on the cob which is a sweet corn cob that has been boiled, steamed; the kernels are then eaten directly off the cob or cut off. The data on product development from sweet corn is scanty. There is need to explore various products which can be developed from sweet corn and also to standardize the process like dehydration and freezing to increase their shelf life.

Keeping these points in view, the present study was conducted with the following objectives:

OBJECTIVES

1. To assess the nutritional composition of sweet corn.
2. To process sweet corn for extending shelf life.
3. To utilize sweet corn for product development and assess their organoleptic acceptability.

Sweet corn (*Zea mays L. saccharata*), also called Indian corn, sweet corn, sugar corn, pole corn, or simply corn is a variety of maize with high sugar content. Sweet corn is used as human food in the soft dough stage, when the grain is succulent and soft as reported by Pajic *et al.* (1994). The present investigation was undertaken with an objective to study the nutritional quality of sweet corn and to utilize it for product development. As sweet corn is new introduction in the field of food and nutrition, there is very scanty information available about sweet corn production its nutrition composition, as well as its processing and storage technique. Whatever literature was available about sweet corn, its varieties and hybrid, product development, shelf life and processing has been reviewed and summarized under the following heads:

- 2.1 Sweet corn, its production and shelf life
- 2.2 Nutritional qualities of sweet corn
- 2.3 Product development from sweet corn
- 2.4 Storage and Processing of sweet corn
 - 2.4.1 Dehydration
 - 2.4.2 Freezing

2.1 Sweet corn, its production and shelf life

Sweet corn is the result of a naturally occurring recessive mutation in the genes which control conversion of sugar to starch inside the endosperm of the kernel (Schultheis, 1994).

Standard or conventional sweet corn breeding method has been used to develop commercial hybrids by breeders for more than century. Standard or traditional sweet corn varieties are *su₁* mutants. The *su₁* varieties, at immature milky stage (20 days after pollination), contain 10.2% of sucrose and 22.8% of water soluble poly saccharide(WSP), a creamy texture ,about 3 and 8 times the sugar and WSP contents of field corn, respectively(Creech 1965). The sugary varieties have a creamy texture and good corn flavor and are known for their good germination and seeding vigor. But their kernels can lose their sucrose from 14.4% to 5.7%(about 2.5 times) at room temperature(27.0°C) 24 hours after harvest due to sucrose rapidly converting to starch (Garwood *et al.* 1976). The adoption of newer õhigh sugar or sweeterõ varieties with longer shelf life and new sweet corn products have increased sweet corn consumption.(Lertrat and Pulam,2007).

Trongpanich *et al.*,(1996) studied three different harvesting periods of sweet corn .It was found that yield and sweetness of the corn increased as the harvesting period was increased, even though there was no significant difference between the samples harvested at 18, 20 and 22 days after pollination. The results from proximate analysis of canned whole

kernel corn in brine and in syrup showed that as the harvesting date was prolonged the moisture content of the corn samples decreased with the increase in protein, fat content and the hardening in texture. There was significant difference in color preference between the samples harvested at 18 and 22 days at 5 percent level for the canned samples in brine and at one percent level for the canned sample in syrup. There was no significant difference between the samples both in brine and in syrup on odor, taste, texture and acceptability. The tasters mostly preferred the canned whole kernel sweet corn in brine which harvested at 22 days and the canned whole kernel sweet corn in syrup which harvested at 20 days.

2.2 Nutritional qualities of sweet corn

Fuentes and Ciudad (1974) studied Lysine and protein contents of some Chilean sweet corns (*Zea mays*) and observed that clear grains of 60 sweet corn lines contained 10.6-14.2 g protein and 0.22-0.47 g lysine/100 on dry matter basis.

Sevov *et al.* (1974) observed the inheritance of carbohydrates in the hybridization of sweet corn. And a positive correlation was established between content of total sugars and content of polysaccharides, and a negative correlation between starch content and content of sugars and polysaccharides.

Brewbaker and Banafunzi (1975) reported a range of 46% total sugars, 18% starch, 14.5% protein and 17% oil in sweet corn.

Biochemical characteristics of super-sugar corn and the possibility of its utilization studied by Shmaraev *et al.* (1976). Grain of super-sugar corn harvested at technical maturity and containing 24-30% DM, contained in the grain DM 36.8% total sugar, no or very little dextrin and 21.9% starch compared with 16.7% sugar, 24.2% dextrin and 30.1% starch for Nagrađa. The high sugar content made it possible to harvest the ears during a longer period than that acceptable for sweet corn and to store the harvested ears for a few days without losses of sugar. Grain of super-sugar corn contained more lysine than that of sweet corn. The absence of dextrin was, however, regarded as a negative feature.

Oliveira *et al.* (1991) studied nutritional attributes of a sweet corn fibrous residue. A sweet corn fibrous byproduct with 72.7% neutral detergent fiber (NDF) was chemically and nutritionally characterized. The fiber components were hemicellulose, 67.9%; cellulose 31.4%; and lignin, 0.7%. Effect of maturity on the physical and chemical characteristics of grain of sweet corn cultivars was studied by Cartaya *et al.* (1991) during maturation. Grain turbidity, length, width and hardness all increased with maturity. Pajimaca grains were softer than those of Riqueza. As the cobs matured, the starch and solids insoluble in alcohol increased but moisture content, protein, reducing and total sugars decreased. Moisture content, protein and starch were higher in Pajimaca than in Riqueza grains. Pajimaca was therefore judged to be of better quality than Riqueza, added to which it can be harvested up to 22 d after silking without loss of quality.

Goldman and Tracy (1994) observed kernel protein concentration in sugary-1 and shrunken-2 sweet corn. Changes in endosperm type used for commercial sweet corn (*Zea mays*) production may affect protein levels. The two most widely used endosperm types are sugary-1 (su1) and shrunken-2 (sh2). To determine the effects of endosperm type on protein concentration, kernel N concentrations of dry mature kernels of seven inbreds near-isogenic for su1 and sh2 and of four samples of commercially canned su1 and sh2 sweet corn were calculated. Nitrogen values were converted to protein values using a standard conversion factor for maize. For the dry kernels and the canned samples, significant differences were detected between endosperm types for kernel protein concentration when measured on a weight basis. Averaged over all inbreds, the sh2 dry kernels had 30% more protein than su1 kernels. On a weight basis, the sh2 canned samples averaged 22% more protein than the su1 samples. When compared on a kernel basis, protein concentration of the two endosperm types did not differ. Thus, sh2 sweet corn marketed as a frozen or canned product may be identified as a higher protein product when the serving size is based on weight or calories.

Makhlouf *et al.* (1995) studied some nutritional characteristics of beans, sweet corn and peas. Sweet corn reported to contain 75.7 percent moisture, 6.8mg/100g vitamin C, 1.5g/100g total fibre, 2.0mg/100g calcium, 37mg/100g magnesium, 15.2mg/100g sodium, 0.6 mg/100g iron, on fresh matter basis. Nutritional values were found to be comparable to other vegetables.

Dewanto *et al.* (2002) reported that processed sweet corn has higher antioxidant activity despite the loss of vitamin C. Processed sweet corn has increased antioxidant activity equivalent to 210 mg of vitamin C/100g of corn compared to the remaining 3.2 mg of vitamin C in the sample that contributed only 1.5 per cent of its total antioxidant activity.

Yue-Saju *et al.* (2003) studied the change of carbohydrate and taste quality in the kernels of super sweet corn in the milky maturity stage. Results showed that the soluble sugar and sucrose contents peaked at 16-18 days after pollination, while moisture and reducing sugar decreased. Kernel taste was significantly correlated with sweetness sucrose and moisture. The correlation coefficient between sucrose and taste or between crude fibre and taste were also significant. .

Coskun *et al.* (2006) reported the physical properties of sweet corn. The average length, width and thickness were 10.56 mm, 7.91 mm and 3.45 mm, at a moisture content of 11.54 per cent dry basis, respectively. The bulk density decreased from 482.1 to 474.3 kg m⁻³ with an increase in the moisture content range of 11.54 to 19.74 per cent dry basis.

2.3 Product development from sweet corn

Sweet corn is no longer a delicacy or specialty food reserved for salad bars and Asian restaurants, it is locally produced delicious treat to eat raw or cooked in many recipes.

Prabhavat *et al.* (1999) used sweet corn for development of six formulae of corn beverages which were prepared from sweet corn kernel and cob water extract in the ratio of 1:3, 1:5, 1:7, 1:9, 1:11 and 1:13 by weight, respectively and the cane sugar was added in each formula of corn beverage to improve the taste and made into canned corn beverage. It was shown that canned corn beverage was accepted by taste panelists in term of color, flavor, texture and acceptability.

Baby corn was utilized for the development of various dishes including baby corn soup, *pakora*, *omelette*, *cheela*, chops, bird's nest, *Upma*, *vada*, *chat*, mixed vegetable, dry vegetable, pulao, *raita*, *burfi*, *halwa* and *murabba* (Sarswat *et al.*, 2001). Dehusked baby corn was used by Anitha and Rajalakshmi (2005) to make snack foods and savouries (*vada*, *kofta*, finger fry, *roti* and *raita*), sweet products (*burfi*, *kheer*, *kesari* and *halwa*) and chutney and pickle. Where as baby corn tomato soup, baby corn vegetable soup, salad, *pakora*, *chutney*, baby corn masala, sweet n sour, Manchurian, baby corn chilli, *raita*, pickle, candey, jam, *murrabba*, *burfi*, *halwa*, and *kheer* were the products developed by using baby corn by Dass *et al.* (2008). It was concluded that though sweet corn has a great scope as foreign exchange earner but the lack of knowledge about its users and economic importance and non availability were major constraints for its popularization.

2.4 Storage and processing of sweet corn

Sweet corn shelf life is one of the shortest among fruits and vegetables. This is due to its high metabolic and respiration rates, which lead to severe sugar loss (the most important quality characteristics of sweet corn) and rapid quality deterioration. Although sweetness is the most important quality characteristic in sweet corn (Evensen and Boyer, 1986), the importance of other flavor components in consumer acceptance is also well documented (Williams and Nelson, 1973; Flora and Wiley 1974; Wiley, 1985). For sweet corn, the consensus recommendation is to keep it as close to 0°C as possible during transportation and storage and this may be of even more importance for fresh-cut sweet corn. On the other hand, controlled atmosphere (CA) storage benefits with regard to extension of fruit and vegetable shelf life are well documented (Zagory and Kadar, 1988; Nakhasi *et al.*, 1991) including sweet corn (Deak *et al.*, 1987; Risse and McDonald, 1990; Schouten, 1993; Aharoni *et al.*, 1996).

McNeil and Castelnovo (1997) observed the processed sweet corn situation in selected countries. The smaller US sweet corn pack in 1997, estimated at 2.78 million metric tons, down 7% from 1996, was expected to lower production and stocks for canned sweet corn. According to the Food and Agriculture Organization of the United Nation statistics data, in 2005 the world's sweet corn production for the fresh, frozen and canned food industries by harvest area was about 1.06 million ha. In 2004, the world's top four leading producers were

the US(4.12 million metric tons), Mexico (0.63 million metric tons), Nigeria(0.58 million metric tons) and France (0.50 million metric tons)as reported by Henard (2003).

Shnitzler,(1994) reported that export competition varied from region to region. In Asia, the USA must compete against Canadian and Australian products as well as local production in Japan, Korea, Thailand, Taiwan, China and Malaysia. In Europe, the USA competes with France in the EU as well as Hungary and Israel. McNeil and Castelnovo (1997) reveled that US exports of canned sweet corn in 1997 were forecast at 210 000 tons, up 18% from 1996 based on strong shipments to date. US canned sweet corn exports from January-August, 1997 were 22% ahead of the previous year's volume during the same time period. Japan continues to be the top US market for canned sweet corn. Other major US canned sweet corn markets include Taiwan, Hong Kong and the Korea Republic. US exports of frozen sweet corn in 1997 were forecast at 65 000 tons, up 13% from 1996, also based on strong exports to date. The world's top four leading exporters of canned sweet corn were the US (0.14 million metric tons), Hungary (0.13 million metric tons), France (0.10 million metric tons) and Thailand (0.10 million metric tons). And the world's top four leading exporters of frozen sweet corn were the US (0.07 million metric tons), Hungary (0.04 million metric tons), New Zea-land (0.03 million metric tons) and Belgium (0.04 million metric tons)as reported by Henard (2003).

Global import of canned sweet corn was valued over \$468million in 2004. The top five importing countries were the Russian Federation, Germany, the UK, Japan and the Republic of Korea. Global import of frozen sweet corn was valued over \$218 million. And the top five importing countries for frozen sweet corn were the UK, Japan, Belgium, the U.S. and China. In terms of per capita consumption of sweet corn, the US consumed 2.5 kg per year higher than the EU (1.5 kg per year). Further French per capita consumption was one of highest in Europe (Henard 2003).

Gauhar *et al* (1973) studied about the losses of ascorbic acid in different varieties of sweet corn during processing. Of three varieties, Golden Hammer had the highest ascorbic acid content before canning, but lost most during canning; and Silver Cross had the second highest content before and lost least during canning. The highest ascorbic acid content of the brine in which grains of the varieties were canned, occurred from Lobelle, which had the lowest content in its grains before canning.

Collins and Taylon (1996) observed that the flavour qualities of frozen sweet corn are affected by genotype and blanching. Research showed that total peroxidase activity did not parallel flavour changes in frozen unblanched super sweet (sh2) or sugary enhanced (Su1/Se) sweet corn genotypes. Although changes in total peroxidase activity may not predict flavour changes in all genotypes, the presence or absence of certain per oxidase isozymes may be useful in predicting off flavour development in (Su 1) frozen corn.

Riad *et al.*(2003) reported that controlled atmosphere (CA) storage is beneficial in maintaining the visual quality of fresh-cut sweet corn kernels; sugar and flavor losses were reduced during 10 days storage at 5 °C compared with storage in air. The main benefit of this controlled atmosphere (CA) was to prevent after cooking browning. Preliminary results indicated that after cooking browning was not associated with a Maillard reaction since 5-hydroxymethylfurfural (HMF), the characteristic intermediate compound produced during the Maillard reaction, is not present in cooked sweet corn kernels exhibiting browning. There were no significant changes in the total soluble phenolics content during storage in air or CA, but the soluble phenolic levels decreased with cooking, which suggests that the after cooking brown color may be due to unidentified insoluble phenolic-protein complexes in the cooked sweet corn tissue. The total aerobic microbe count increased with storage and the increase was significantly greater in air. This suggests that the browning could be a response of the sweet corn tissue to the microorganisms, or it may be associated with some product of microbial enzyme activity.

Because Sweet corn is very costly and perishable vegetable, it has a short shelf life due to higher respiration rate. Its shelf life can be increased by subjecting it to processing like dehydration and freezing.

2.4.1 Dehydration

Drying is the process of removing water from the food stuffs to such an extent so that none of the microorganism may penetrate to cause spoilage .The prime objective of drying is preservation by reducing the water activity hence enhancing the shelf life of food stuffs. The other objective is to reduce bulk so that it may be economical to handle, transport and distribute (Dayanand, 1978).

Rosenthal *et al.* (1991) studied the shelf-life of drum-dried high lysine sweet corn pulp (flakes) was investigated by chemical analysis (peroxide and acidity index), nutritional evaluation (PER and apparent digestibility of protein) and sensory evaluation (quantitative descriptive analysis) at 0, 60, 120, 180, 240 and 300 days of storage. The specification for the package to control the shelf-life was based on the water vapour permeability rate of the polyethylene film and hygroscopicity of the product. The selected film, with a water vapour permeability rate of $1.50 \text{ g m}^{-2} \text{ day}^{-1}$ and a thickness of 64 μm , was adequate to guarantee a shelf-life of 6 months under the conditions of storage employed (low light exposure at 23°C), without any indication of deteriorative processes. High peroxide content and sensory quality deterioration, without any change in the nutritional quality of the protein, was detected at 240 days of storage.

Kulesza and Gertig (1976) recorded protein content in the dehydrated peas and noticed decrease in protein content during storage. Ranganath and Dubash (1981) studied the changes in content of ascorbic acid on dehydration of vegetables and reported a loss of 50

percent and 36-39 percent in ascorbic acid content of spinach leaves and sweet potato, respectively when stored at about 24⁰C. During drying of tomatoes, 38.8 percent ascorbic acid was lost and loss was higher in blanched and sun dried soup (Gupta and Nath, 1984). Pawar *et al.* (1985) reported that drying and dehydration of untreated pumpkin slices caused a loss of about 65.89 and 72.23 percent of ascorbic acid and β -carotene respectively. After three months of storage at room temperature (27-30⁰C) loss of ascorbic acid and β -carotene was 27-80 and 37.76 percent respectively.

Kalra *et al.* (1986) studied variations in moisture and total sugars in dried fruit of four varieties of pea (*Pisum sativum*). The moisture content and total sugars varied from 75.6677.2 and 3.34 to 4.97 per cent respectively.

Das *et al.* (1993) observed that the protein content of the stored dehydrated peas of different varieties and maturities showed negligible change. He also reported that starch reduced during processing by 9 to 14 per cent. Retention of starch in the Harbona-B variety of pea was quite high and starch content decreased during the storage period.

Arora and Bakshi (1994) studied effect of storage on physical characteristics and cooking quality of dehydrated peas and carrot. They reported that moisture content varied from 6.01 to 7.41 per cent in the dehydrated peas during storage.

Manimegalai and Ramah (1998) studied the effect of pretreatment on the quality characteristics of dehydrated bitter melon. They reported 20-30 percent loss of ascorbic acid in the stored dehydrated bitter melon samples.

Premvalli *et al.* (2001) studied the effect of blanching and dehydration of seven green leafy vegetables. Retention of Vitamin C during blanching and dehydration was found to be from 37.97 percent and 28 to 74 percent respectively. Comparatively vitamin A retention was better to the tune of 36-94 percent. Suman and Kumari (2002) reported 71 percent loss of β -carotene content in carrot dried by direct sunlight, whereas loss was 52 percent in solar cabinet drying followed by 42 percent loss in hot air cabinet dryer. They also reported a gradual loss of β -carotene during storage in all the three dehydrated carrot products.

Sheriful (2002) studied the storage of dehydrated peas of various varieties for six months. He observed that chlorophyll, protein and total sugar content declined throughout the storage period and the decline-varied from 43.3 to 48.65, 0.19 to 0.31 and 0.85 to 1.23 per cent respectively. Starch and ascorbic acid content also declined and varied from 22.13 to 19.38 and 20.54 to 54.73 mg/100g respectively. Whereas moisture content increased during the storage period. Lal *et al.* (2004) reported a loss of about 2.34 percent ascorbic acid and 30.34 percent of protein during the study of oven dried and un sulphited *kachri* slices stored for three months at different temperatures. In a study of storage of dehydrated peas treated by various blanching treatments starch, alcohol insoluble solid and chlorophyll content declined

during storage. The value of starch, alcohol insoluble solid and chlorophyll content ranged from 27.3 to 43.2 per cent, 49.22 to 60.10 per cent and 27.54 to 40.95 mg/100g respectively (Ruchika, 2004).

Kadam *et al.* (2005) studied the influence of different treatments on dehydrated cauliflower quality and reported that ascorbic acid content declined during the storage of six months. The ascorbic acid content varied from 188.46 to 223.86 mg/100g in cauliflower. Santosh (2005) stored the dehydrated baby corn for three months and analyzed its chemical components and reported that fat and fibre losses in dehydrated baby corn between 7.5 and 9.39 and 1.87 and 6.45 percent, respectively. She also reported a non-significant decline in *in vitro* starch digestibility and iron content, which varied from 2.33 to 6.35 and 1.30 to 4.92 respectively. Tandon (2006) analyzed the dehydrated peas for its nutritional composition and reported gradual decrease in protein, fat, ash, reducing sugar, non reducing sugar and mineral content of dried stored peas for three months.

2.4.2 Freezing

Freezing is one the best methods of preservation which retains natural, colour, flavour and volatile components. Retention of fresh quality is the main objective of freezing. Freezing provides an environment, which inhibits microbial growth, retards chemical reaction rate and action of food enzymes, which are responsible for spoilage at ordinary temperature.

Vliet and Hertog (1972) estimated the sugar content of sweet corn and reported that total sugar of sweet corn varieties remained unchanged under deep frozen (-20°C) condition.

Lee *et al.* (1987) observed the quality of sweet corn stored at different temperatures and duration. To find out the optimum storage temperature and duration, changes in the content of sugars and soluble solids and flavor rate of two sweet corn hybrids (Great Bell and Golden Cross Bantam) and a super sweet corn (Crisp Super Sweet 720) were observed after storing at -20, 0, 5, 10, 15, 20, and 25°C for 1, 3, 5, and 7 days. At the temperatures below 10°C, contents of soluble solids and total sugars and flavor rate were not changed significantly, but at the temperatures higher than 15°C they decreased as storage temperatures increased and duration extended. Storage duration conserving flavor seems to be 7 days at temperatures below 10°C, 3 days at 15°C, and 1-2 days at 25°C. When corn was frozen, flavor rate was a little low compared with corn stored at 0°C although sugar content was higher. Both soluble solids and total sugar contents were positively correlated with flavor rate of cooked corn.

Zhu *et al.* (1992) reported Sugar and soluble solids changes in refrigerated sweet corn. Three sweet corn (*Zea mays* L) genotypes, one cultivar each, were tested for sugar and soluble solids changes at 6 degrees C for 5 days. Genotypes and cultivars were sugary (su), 'Silver Queen'; sugary enhanced (se), 'Incredible' and super sweet (sh 2), 'How Sweet It Is.' Fructose, glucose, sucrose, maltose, total sugars and Brix were measured. Sucrose

predominated. Generally, Brix, fructose, glucose, and sucrose decreased and maltose increased. sh 2 had lowest Brix and highest sucrose and total sugars, and su had highest Brix and lowest sucrose and total sugars, su consisted of 3.8% total sugars (DWB); se, 7.2% and sh 2, 10.9%.

Son-YoungKoo *et al.* (1997) studied the effects of ice cooling storage on chemical components in vegetable corn. This experiment was carried out to obtain the basic information necessary to establish suitable post harvest handling techniques and to maintain the quality of sweet (Danok 2), super sweet (Cocktail 86) and waxy (Chalok 1) sweet corn which is mainly consumed as a vegetable in Korea. The cobs were cooled with ice fragments in an insulated box immediately after harvest and stored in a warehouse at low temperature (0 to 2 degrees C). During the 15 days' short-term storage, changes in chemical components were compared with those of uncooled cobs. The moisture losses of kernels were as high as 7.4-24.4% in uncooled cobs, whilst those of ice-cooled cobs increased their weights by 0.4 to 0.5%. The pericarp and alcohol insoluble solids (AIS) contents increased during storage in all treatments but increased more in uncooled samples. The total sugar loss during storage was lowest in super sweet cobs when they were cooled with ice fragments in insulation box. After 5 days' storage, the ice-cooled samples showed the highest free amino acid contents compared with uncooled cobs stored at room temperature (25 to 30 degrees C) or in the low temperature warehouse. Gamma -Aminobutyric acid (GABA) was detected in all 3 types of vegetable corn.

Turk *et al.* (2001) conducted an experiment on quality changes of sweet corn cultivars during cold storage. All the cultivars decreased in weight at the early than at the late stage of storage. Merit had the highest (8.22%) and Bonanza had the lowest (6.22%) weight loss. The maximum total sugar was found at harvest in Jubilee (6.69%) and the minimum in Merit (5.97%). After 7 weeks of cold storage at 0°C, the maximum sugar content was observed in Reward (5.16%). Maximum starch content and decline were observed in Bonanza. The carotene content of Reward and Bonanza decreased reaching levels of 7.8 and 15.1 per cent, respectively. Total soluble solids were maximum in Bonanza and minimum in Merit, while maximum loss was found in Reward.

Bhobe and Pai (1986) reported 14.14, 16, 17, 29.6 and 16.33 percent loss of ascorbic acid in okra, gherkin, capsicum, coriander leaves and fenugreek leaves, respectively during frozen storage of some Indian green vegetables.

Amaro *et al.* (1988) investigated the effects of frozen storage (at 6 18°C for 45 and 90 days) on mineral contents (Ca, Cu, Fe, K, Mg, Na, P and Zn) of white asparagus (*Asparagus officinalis*). Statistically significant difference were observed during frozen storage in Cu, Fe, K and Mn concentrations but Zn, Ca, Mg, Na and P levels did not show any significant change (Aparicio *et al.* 1989). During storage at 622°C, Ascorbic Acid was retained for a long

duration, the loss being 32.6 per cent after 30 months whereas storage at -18°C resulted in only 24 per cent loss of AA after 60 days. Hugo *et al.* (1989) observed that reducing sugars and starch levels of frozen green beans were slightly reduced during storage period of 60 days.

Michalik and Hallad (1991) studied the freezing quality of different varieties of carrots and found that there was no difference in the content of sugars in fresh, blanched and frozen samples of various varieties. Polo *et al.* (1991) studied the effect of freezing on the mineral (Ca, Mg, Cu, Mn, Ni, and Zn etc.) composition of green beans and peas. Minerals were measured in fresh and frozen stored (-18°C for 7 week) samples. There was no significant loss in the mineral content of vegetables during frozen storage.

Pawar *et al.* (1994) studied the varietal differences in physicochemical characteristics and quality of frozen peas. They reported that there was decline in moisture content of frozen peas during storage of 4½ months and moisture content ranged from 71.01 to 74.10 per cent in various pea cultivars. He also reported a slight decrease in ash content in all the pea cultivars and a remarkable decline in ascorbic acid content during 4½ months of frozen storage period.

Howard *et al.* (1996) reported that ascorbic acid level decreased linearly by about 10 per cent per week during storage of carrot, broccoli and corn at -64°C for 3-12 weeks. Lisiewska and Kmiecik (1996) studied the effects of processing conditions and period of storage on AA retention in frozen broccoli and cauliflower. Freezing resulted in little change of the AA content, which was 15-18 per cent in broccoli and 6-13 per cent in cauliflower during frozen storage.

Oruna-Concha *et al.* (1996) reported that the sugar content was unaffected by frozen storage at -622°C upto 12 months. Similar results have been reported by Lisiewska and Kmiecik (2000). Favell (1997) compared vitamin C content of fresh and frozen vegetables and concluded that there was a rapid loss of ascorbic acid from all the vegetables except carrot, at ambient temperature and this rapid loss was also seen at chill temperatures for spinach and whole green beans. The rate of loss of ascorbic acid from peas, carrots and broccoli was slow at chill temperature.

Statistically significant reduction was detected in the concentration of carotenoids, α -carotene and lycopenes during storage of frozen tomato. Whereas frozen storage of 12 months at -620°C had no effect on total nitrogen, dietary fibre and ash content of frozen tomato cubes (Lisiewska and Kmiecik, 2000).

Jaswinder (2003) reported slight but non-significant decrease in protein content of frozen stored vegetables i.e. beans, okra and capsicum. Santosh (2005) analyzed the frozen baby corn and reported a loss of about 7.51 to 9.39 percent fat, 1.87 to 6.45 percent fibre, 4.38 to 8.77 per cent iron and 2.53 to 7.22 percent in vitro protein digestibility during the storage

of frozen baby corn for three months. Tandon (2006) also analyzed the chemical composition of frozen peas cultivars and reported a gradual loss of 0.50 to 1.64 percent protein, 3.09 to 9.03 percent fat, 1.23 to 4.32 percent ash, 1.89 to 4.38 percent total soluble sugar, 3.36 to 21.73 percent reducing sugar, 0.67 to 2.03 percent iron and 1.52 to 5.66 percent zinc during study of frozen peas for 90 days.

The present investigation entitled, "Nutritional evaluation and utilization of Sweet Corn for product development" was carried out in the Department of Foods & Nutrition, COHS, CCS Haryana Agricultural University, Hisar.

This chapter contains relevant information pertaining to research design and procedures to achieve the planned work. The methods followed for research have been distinctly described under the following heads:

- 3.1 Procurement of material
- 3.2 Nutrition evaluation of sweet corn
- 3.3 Development of food products from sweet corn
- 3.4 Organoleptic evaluation of developed products
- 3.5 Processing of sweet corn
 - 3.5.1 Dehydration of sweet corn
 - 3.5.1.1 Shelf life of dehydrated sweet corn and effect of storage on:
 - 3.5.1.1.1 Nutritional composition
 - 3.5.1.1.2 Product development and its organoleptic acceptability
 - 3.5.2 Freezing of sweet corn
 - 3.5.2.1 Shelf life of frozen sweet corn and effect of frozen storage on:
 - 3.5.2.1.1 Nutritional composition
 - 3.5.2.1.2 Product development and its organoleptic acceptability
 - 3.6 Statistical Analysis

3.1 PROCUREMENT OF MATERIAL

Two genotypes of sweet corn (hybrid HSC-1 and variety Madhuri) were procured from the experimental farms at Regional Research Station, CCS Haryana Agricultural University, Uchani, Karnal.

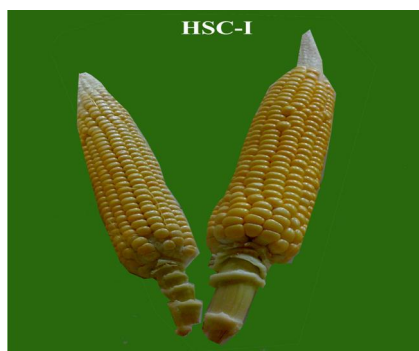


PLATE 1

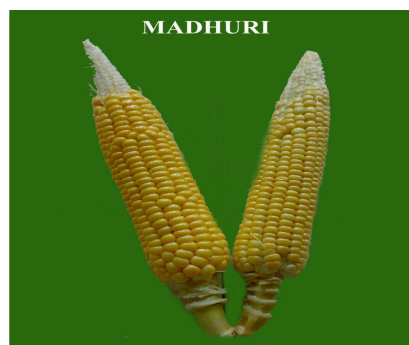


PLATE 2

3.2 NUTRITION EVALUATION OF SWEET CORN

3.2.1 Preparation of sample

Sweet corn was cleaned off the husk material and kernels were removed from cob and dried in the oven at 50°C till moisture free. The dried sample was then ground in an electric grinder (Cyclotec M/s Tecator, Hoiganas, Sweden using 0.5mm sieve size) and packed in air tight polypacks for further analysis.

The ground sample was analyzed for proximate composition, available carbohydrates, total minerals, *in vitro* protein and starch digestibility and vitamins. Moisture and vitamins were analyzed on fresh matter basis and the others on dry matter basis.

3.2.2 PROXIMATE COMPOSITION

3.2.2.1 Moisture

Moisture content was determined by employing the standard method of analysis (AOAC, 2000).

Procedure: About 20-25 gram sample ground into paste and 10 gram was weighed in a petri dish and dried in an oven at 60°C overnight till a constant weight was obtained. The sample was weighed after cooling it in a desiccator.

$$\text{Moisture (\%)} = \frac{\text{Loss in weight (g)}}{\text{Weight (g) of sample}} \times 100$$

3.2.2.2 Crude protein

The total nitrogen was estimated by a standard method of AOAC (2000). A factor of 5.83 was applied to convert the amount of nitrogen to crude protein.

Reagents

- (i) Hydrochloric acid (N/100)
- (ii) Boric acid (4%)
- (iii) Sodium hydroxide (40%)
- (iv) Digestion mixture: 10g K₂SO₄, 0.5g CuSO₄.6H₂O and 2g FeSO₄.
- (v) Mixed indicator solution : Dissolved 0.5 g of bromocresol green and 0.1 g of methyl red in 100 ml 95 per cent ethanol and the solution was adjusted with drops of dilute NaOH to bluish purple colour.

Procedure: Two hundred mg sample was taken and digested with 20 ml concentrated H₂SO₄ and a pinch of digestion mixture. The nitrogen, as ammonical salt, was distilled with 40 per cent NaOH in a Microkjeldahl apparatus. The ammonia thus liberated was absorbed in 10 ml boric acid (4%) solution containing a few drops of mixed indicator and was titrated against standard HCl (N/100). The end point was indicated by the change of colour from bluish-green to pink.

$$\text{Crude protein (\%)} = \frac{0.00014 \times V \times (S-B) \times 100}{V_1 \times W} \times F$$

Where,

- W = weight (g) of sample taken
- V = volume (ml) made
- V₁ = volume (ml) of aliquot taken for distillation
- S = volume (ml) of HCl (N/100) used in titration for blank
- B = volume (ml) of HCl (N/100) used in titration for blank
- 0.00014 = 10ml of 0.1 N HCl neutralize 0.00014g of nitrogen
- F = factor for converting N to protein (5.83)

3.2.2.3 Crude fibre

Crude fibre in the sample was determined using the standard method of analysis (AOAC, 2000).

Reagents

- (i) Hydrochloric acid (%) v/v.
- (ii) Sulphuric acid stock solution (10%) v/v: Diluted 55 ml concentrated sulphuric acid to one litre.
- (iii) Sulphuric acid working solution (1.25%): Diluted 125 ml of stock solution to one litre.
- (iv) Sodium hydroxide stock solution (10%) w/v: Dissolved 100 g of NaOH in distilled water and diluted to one litre.
- (v) Sodium hydroxide working solution (1.25%): Diluted 125 ml stock solution to one litre with distilled water.
- (vi) Antifoam (2%) :Silicon in CCl₄

Procedure: Two gram fat free dried sample was put in one litre tall beaker and 200 ml 1.25 per cent H₂SO₄ and a few drops of antifoam were added. The solution was kept for boiling for 30 minutes under bulb condenser. Beaker was rotated occasionally to mix the contents and to remove the particles from sides. The contents were filtered into another beaker through Buchner funnel. The sample was washed back into the tall beaker with 200 ml 1.25 per cent NaOH and again boiled for exactly 30 minutes. All the insoluble mass was transferred to the sintered crucible (G-1) by means of boiling distilled water till acid free. Residue was washed twice with alcohol and thrice with acetone, and then dried at 100°C to constant weight. The dried material was ashed in a muffle furnace at 550°C for 1 hour. The crucible was cooled in a dessicator and weighed.

$$\text{Crude fibre (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where,

W_1 = weight (g) of sample

W_2 = weight (g) of insoluble matter (weight of crucible+insoluble matter
ó weight of crucible)

W_3 = weight (g) of ash (crucible +ash ó weight of crucible)

3.2.2.4 Fat

Crude fat was estimated by employing the standard method of analysis (AOAC, 2000) using the soxhlet extraction apparatus.

Procedure: Five gram of moisture free sample was taken and transferred to an extraction thimble and then weighed. The thimble was placed in a Soxhlet extractor fitted with a condenser and flask containing sufficient petroleum ether. The extraction was carried out for six hours. After the extraction thimble was removed with the sample from the extraction apparatus and dried in hot air oven to a constant weight. It was cooled in a dessicator and weighed. The loss in weight of the thimble was the estimate of the ether extract in the sample.

$$\text{Fat (\%)} = \frac{\text{Loss of weight (g)}}{\text{Sample weight (g)}} \times 100$$

3.2.2.5 Ash

Ash was estimated by employing the standard method of analysis (AOAC, 2000).

Procedure: Five gram of oven dried sample was weighed in the silica crucible. It was ignited till no charred particles remained in the crucible. The crucible was put in muffle furnace (550^oC) for 5-6 hours till a white ash was obtained. The crucible was then cooled in a dessicator and weighed.

$$\text{Ash (\%)} = \frac{\text{Weight (g) of ash}}{\text{Weight (g) of sample}} \times 100$$

3.2.3 CARBOHYDRATES

Total soluble sugars were estimated by method of Cerning and Guilhot (1973).

Extraction: To 500 mg of the sample, 25 ml ethanol (80%) was added in a round bottom flask. The flask was connected to a condenser and kept on a boiling water bath for 30 min with occasional stirring. The extract was cooled, centrifuged at 8000 rpm for 15 min .The supernatant was collected in a beaker. This procedure was repeated twice, each time taking 25 ml ethanol (80.00%). The extract was kept on a boiling water bath to evaporate ethanol. The residue was dissolved in distilled water and volume was made to 50 ml.

Estimation

3.2.3.1 Total soluble sugars

Total soluble sugars were estimated by method of Yemm and Willis (1954).

Reagents

- (i) Standard sugar solution: Twenty five mg glucose was dissolved in water made to 100 ml. This solution contained 250 μ g glucose per ml, for obtaining a standard curve, 25 μ g to 250 μ g of this solution was used at different concentrations.
- (ii) Anthrone reagent (0.2% anthrone in 70% H_2SO_4): This reagent was prepared fresh daily and allowed to stand for 30 to 40 minutes before use.

Procedure

Ten ml freshly prepared anthrone reagent was pipetted in test tube (150 \times 25 mm) and chilled in ice cold water. One ml sugar extract was taken to 10 ml with water. One ml of the diluted sugar extract was taken layered on the acidic anthrone reagent. After cooling for 3 to 5 minutes, the contents were thoroughly mixed while still immersed in ice cold water. The contents of the tube were heated vigorously in boiling water bath for 10 minutes and then immediately cooled in ice cold water. The absorbance was then read at 620 nm in UV-VIS-Spectrophotometer 118 against a suitable blank.

The amount of sugars was then determined by referring to a standard curve previously prepared with glucose.

3.2.3.2 Reducing sugars

Reducing sugars were estimated by Somogyi's modified method (Somogyi, 1945).

Reagents

- (i) Copper reagent A: Twenty five gram anhydrous sodium carbonate, 25 g potassium sodium tartrate, 20 g sodium bicarbonate and 200 g anhydrous sodium sulphate were dissolved in about 800 ml distilled water and diluted to one litre.
- (ii) Copper reagent B: Fifteen gram $CuSO_4$ was dissolved in 100 ml distilled water containing two drops of HCl.
- (iii) Arsenomolybdate reagent: Twenty five gram ammonium molybdate was dissolved in 450 ml distilled water by warming. Twenty one ml concentrated H_2SO_4 was added with stirring. Three gram sodium hydrogen arsenate was dissolved in 25 ml distilled water with stirring. The solution was poured in a glass stoppered brown bottle and kept in an incubator at 37^oC for 24 hours before use.
- (iv) Copper reagents A and B were mixed in the ratio of 25:1(v/v) before use.
- (v) Standard sugar solution: Twenty five mg glucose was dissolved and made to 100 ml with water. This contained 250 μ g glucose per ml.

Procedure

One ml test extract was taken in blood sugar tube graduated at 25 ml. One ml mixed copper reagent (iv) was added and then heated for 24 minutes in a boiling water bath and cooled. To this, one ml of arsenomolybdate reagent was added, mixed thoroughly and the contents were diluted to 25 ml. A stable blue colour appeared quickly which was read at 520

nm in UV-VIS-Spectrophotometer 118 against a suitable blank. The amount of reducing sugars was then determined by referring to the glucose standard curve.

3.2.3.3 Non-reducing sugars

The amount of non-reducing sugars was calculated as the difference between total soluble sugars and reducing sugars.

3.2.3.4 Starch

Starch from the sugar free pellet was estimated by the method of Clegg (1956).

Reagents

Perchloric acid (52%)

Extraction: Five ml water was added to aforesaid residue of test material and while stirring, 6.5 ml of 52 per cent perchloric acid was added. The contents were stirred continuously for five minutes and then occasionally for next 15 minutes. To this, 20 ml of water was added and centrifuged at 8000 rpm for 20 minutes. The supernatant was collected in a 100 ml volumetric flask. Five ml water was added to the residue and repeated the extraction with 52 per cent perchloric acid stirring occasionally for 30 minutes. The contents of the tube were washed into volumetric flask containing the test extract and made it to 100 ml with water. It was then filtered discarding first 5 ml of filtrate. A suitable aliquot of the test extract (0.2 ml) was used for glucose estimation, using anthrone reagent by the method of Yemm and Wills (1954).

Starch was calculated using the following formula:

$$\text{Starch} = \text{Glucose} \times 0.9$$

3.2.4 IN VITRO DIGESTIBILITY

3.2.4.1 In vitro protein digestibility

In vitro protein digestibility was determined by the modified method of Mertz *et al.* (1983).

Reagents

- (i) Pepsin reagent : 0.1M KH_2PO_4 (pH 2.0) containing 0.2 per cent pepsin , 13.6 g potassium dihydrogen phosphate was dissolved in one litre of distilled water, adjusted pH of the solution to 2.0 and then dissolved 2.0 g pepsin in the buffer.
- (ii) TCA (50%): Fifty gram trichloroacetic acid was dissolved in water and made volume upto 100.

Procedure: 250 g of sample was weighed and transferred to a centrifuge tube. To it, 20ml of pepsin reagent was added. The tube was stoppered and arranged in a shaker incubator maintaining the water temperature at 37°C for 3 hours. Then the centrifuge tube was removed and cooled. Five ml of 50 per cent TCA was added and centrifuged the contents at 10,000 rpm for 10 minutes at room temperature and filtered. Ten ml of aliquot was taken and dried in hot air oven. Dried aliquot was digested for nitrogen determination by Microkjeldahl method

(AOAC, 2000). Digested protein of sample was determined. Protein digestibility was calculated employing the following formula:

$$\text{Protein digestibility (\%)} = \frac{\text{Digested protein}}{\text{Total protein}} \times 100$$

3.2.4.2 *In vitro* starch digestibility

In vitro starch digestibility was assessed as per the method of Singh *et al.* (1982).

Reagents

- (i) Pancreatic amylase: Twenty mg pancreatic amylase was dissolved in 50 ml 0.2 M phosphate buffer (pH6.9).
- (ii) 0.2 M potassium dihydrogen phosphate: 27.28g potassium dihydrogen phosphate was dissolved in distilled water and the volume was made upto one litre.
- (iii) 0.2 M disodium hydrogen phosphate: 35.39 g disodium hydrogen phosphate was dissolved in distilled water and the volume was made to one litre.
- (iv) 0.2 M phosphate buffer (pH 6.9): Fifty ml 0.2 M potassium dihydrogen phosphate was added to 46.8 ml of 0.2 M disodium hydrogen phosphate and the volume was made upto 200 ml.
- (v) Dinitrosalicylic reagent : 3,5 dinitrosalicylic acid (10g), sodium potassium tartrate (300g) and sodium hydroxide (16g) were dissolved in carbon dioxide free water and volume made to one litre . The reagent was stored in brown bottle and protected from carbon dioxide.
- (vi) Standard maltose solution: one hundred mg maltose monohydrate was dissolved in distilled water and volume made to 100 ml.

Estimation: Fifty mg defatted sample was dispersed in 1.0 ml of 0.2 M phosphate buffer (PH 6.9), 0.5 ml of pancreatic amylase was added to the sample suspension and incubated in water bath at 37°C for 2 hours with occasional shaking of test tubes. After incubation, 2 ml dinitrosalicylic reagent was added quickly and heated for 5 minutes in a boiling water bath. After cooling, the solution was made to 25 ml with distilled water and filtered. Absorbance was read at 550 nm.

A blank was run simultaneously by incubating the sample without enzyme. Dinitrosalicylic reagent was added before addition of enzyme solution. Maltose was used as standard and values were expressed as mg maltose released /g sample. Standard curve was prepared by taking 0.2 to1.0 mg maltose released/g sample from a standard maltose solution.

3.2.5 Total minerals

3.2.5.1 Acid digestion

Two gram dried and ground sample was taken in a 150 ml conical flask. To this, added 20ml diacid mixture (HNO₃:HClO₄: 5:1, v/v) and kept overnight. Next day it was

digested by heating till clear white precipitates settled down at the bottom. The crystals were dissolved in double distilled water. The contents were filtered through Whatman No. 42 filter paper. The filtrate was made to 50 ml double distilled water.

3.2.5.2: This acid digested sample was used for the determination of phosphorous, magnesium, iron and zinc. Magnesium, iron, and zinc were determined by Atomic Absorption Spectrophotometer AABQ-20 according to the method of Lindsey and Norwell (1969). Phosphorous was determined colorimetrically.

Phosphorus

Phosphorus was determined colorimetrically by the method of Chen *et al.* (1956).

Reagents

- i) Ascorbic acid (10%)
- ii) Ammonium molybdate (2.5%)
- iii) Reagent C: 6N H₂SO₄, water, 2.5 percent ammonium molybdate and 10 percent ascorbic acid were mixed in the ratio of 1:2:1:1 (v/v) respectively. This reagent was prepared fresh.
- iv) Standard phosphorus solution: 0.351g pure and dry anhydrous monopotassium dihydrogen orthophosphate was dissolved in a few ml water and 10 ml 10N H₂SO₄. the volume was made to one litre with water. This stock contained 80µg P/ml.
- v) Working standard phosphorus solution: Twenty five ml stock solution was diluted to one litre which served as working standard solution and contained 2µg P/ml. Two or three drops of chloroform were added to preserve the solution.

Procedure

Mineral extract (0.1ml, obtained from acid digestion) was pippered in a test tube and volume was made to four ml with water. Four ml reagent C was added and mixed well. The contents were incubated at 37°C in water bath for 90 minutes. It was removed and allowed to cool to room temperature and absorbance was read at 720 nm against a suitable blank. Standard curve was plotted using one to eight µg P.

3.2.6 Vitamins

3.2.6.1 β-carotene

-carotene content in sample was separated by column chromatography and estimated calorimetrically (AOAC, 2000).

Reagents

- i) Acetone (3%) in petroleum ether
- ii) Alumina (aluminium oxide neutral)
- iii) Sodium sulphate anhydrous
- iv) -carotene standard: carotene (50mg) was dissolved in 3 per cent acetone in petroleum ether and diluted to 50 ml (1 mg/ml) with 3 per cent acetone in petroleum ether.

Procedure

Preparation of chromatography column

The chromatography column was filled with aluminium oxide neutral which has been dried at 70°C in a hot air oven. The absorbent was gently pressed down to a depth of 10 cm by tapping or suction. The absorbent was covered with a one cm layer of anhydrous sodium sulphate. The column wetted with 3 per cent acetone in petroleum ether. The column was not allowed to dry at any stage.

Extraction of sample

Weighed 10 g fresh finely cut leaves of vegetable in a conical flask and to this added 30 ml 3% acetone in petroleum ether and allowed it to stand overnight. The extract was then filtered through filter paper (Whatman No. # 1) and residue was washed with 3% acetone petroleum ether until the filtrate was of clear yellow colour. The filtrate was pooled and taken in 500 ml separating funnel. It was then shaken with 50 ml water. Washings were discarded. It was repeated 2-3 times in order to make it acetone free. The solvent was then passed out over dried anhydrous sodium sulphate.

Chromatographic separation of β -carotene

Ten ml extract was taken and concentrated to 2 ml. the condensed extract was poured in to adsorption column followed by 10 ml 3% acetone petroleum ether. The elute containing all the β -carotene was collected and transferred to 25 ml volumetric flask. Volume was made with 3% acetone petroleum ether.

Standard curve

Standard solution (0.1 to 2.0 ml) was taken in 25 ml volumetric flask and volume was made with 3% acetone in petroleum ether. The colour intensity was read at 435 nm on UV-VIS Spectrophotometer.

Concentration of β -carotene was calculated by referring to a standard curve prepared from β -carotene standard solution containing 1 μg β -carotene/ml.

Calculación

$$\beta\text{-carotene } (\mu\text{g}/100\text{g}) = \frac{M \times V_1}{W \times V_2} \times 100$$

Where,

M = Concentration of elute extract obtained from graph

W = Weight of sample taken (g)

V_1 = Volume of extract made (ml)

V_2 = Volume of extract taken for elution (ml)

3.2.6.2 Ascorbic acid

Ascorbic acid in the samples was estimated by titration method of AOAC (2000).

Reagents

- i) Metaphosphoric acetic acid solution: Metaphosphoric (HPO₃) pellets (15g) were dissolved in 40 ml glacial acetic acid and 200 ml distilled water and that solution diluted to 500 ml with distilled water and that solution diluted to 500 ml with distilled water. It was filtered rapidly through filter paper (Whatman # 1) in to glass stoppered bottle.
- ii) Ascorbic acid standard solution (1 mg ascorbic acid / ml): Fifty mg ascorbic acid reference standard (that had been stored in a dessicator away from direct sunlight) was weighed and transferred to 50 ml volumetric flask. It was diluted with metaphosphoric acetic acid solution to a final volume of 50 ml.
- iii) Indophenol standard solution: Fifty mg 2, 6-dichloroindophenol sodium salt (that had been stored in dessicator) was dissolved in 50 ml distilled water, to which 42 mg sodium bicarbonate had been added. When the dye dissolved, it was diluted to 200 ml with distilled water and was filtered through filter paper Whatman # 1 in to amber glass stoppered bottle. Stored the solution away from direct sunlight in refrigerator.

Extraction

To five gram of sample, 25 ml metaphosphoric acetic acid solution was added. The sample was made to a fine paste in pestle and mortar until the suspension appeared one, mixed well and volume was made to 100 ml with metaphosphoric acetic acid solution. Filtered rapidly through Whatman # 1 filter paper.

Estimation

Two ml aliquots of ascorbic acid standard solution were taken in triplicate in each of the three 50 ml conical flasks containing five ml metaphosphoric acetic acid solution. These standard samples were titrated rapidly against indophenol solution from a microburette until light but distinct rose pink colour persisted at least for five seconds. Similarly, blank containing seven ml metaphosphoric acetic acid solution was titrated against indophenol solution. For the sample, five ml metaphosphoric acetic acid solution was added to each of two ml of sample aliquots and titrated against indophenol solution as for blank and standard. Ascorbic acid contents (mg / 100 g) were calculated as follows:

Calculations

$$\text{Ascorbic acid (mg / 100g)} = \frac{Y \times B \times V}{X \times B \times W} \times 100$$

Where,

Y = Volume of dye solution used against sample aliquot

B = Volume of dye solution used against blank

X = Volume of dye solution used against standard

V = Volume of aliquot made

W = Weight of sample (g)

3.3 DEVELOPMENT OF PRODUCTS FROM SWEET CORN

Sweet corn genotypes (HSC-1 and Madhuri) were utilized for the development of variety of products. Recipes of the products developed are given below:

3.3.1 Sweet Corn Soup

Ingredients:

Sweet corn kernels	:	150g
French beans	:	25g
Carrot	:	25g
Butter	:	½tsp
Corn flour	:	1tsp
Salt and black pepper	:	to taste

Method:

- Washed sweet corn kernels.
- Boiled 125g sweet corn kernels and ground to a fine paste.
- Boiled half of total vegetables and strained to get stock.
- Added sweet corn paste to the vegetable stock and boiled for 5 minutes.
- Blanched 25g of chopped french beans, carrot and rest 25g of sweet corn kernels and kept aside.
- Made a paste of corn flour with water, added to the soup and boiled for 5 minutes.
- Added salt and pepper in the soup and boiled on slow flame for 2 minutes.
- While serving, added butter and finely cut and blanched French beans, carrot and sweet corn kernels.

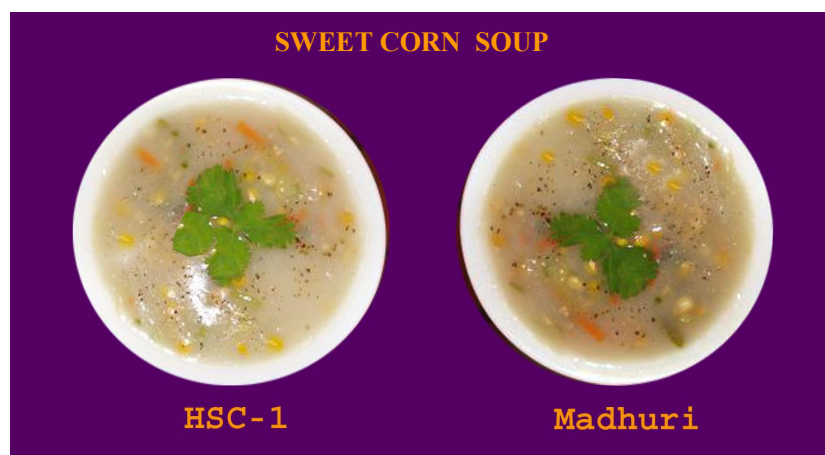


PLATE 3

3.3.2 Sweet Corn Salad

Ingredients:

Sweet corn kernels	:	100g
Lemon	:	½

Green chillis	:	1
Chat masala	:	½ tsp
Salt	:	to taste
Tomato slices	:	for decoration



PLATE 4

Method :

- Washed sweet corn kernels and blanched for five minutes.
- Arranged sweet corn kernels and green chillies over a plate and sprinkled lemon juice over it.
- Sprinkled chat *masala*, salt while serving.
- Decorated with tomato slices while serving.

3.3.3 Sweet Corn Cutlet

Ingredients:

Sweet corn kernels	:	100g
Potatoes	:	100g
Breadcrumbs	:	30 g
Corn flour	:	15 g
Green chillies	:	2
Red chilli powder	:	¼tsp
<i>Garam masala</i>	:	¼tsp
Salt	:	to taste

Method :

- Washed sweet corn kernels and ground to fine paste in grinder.
- Boiled, peeled and mashed potatoes well and mixed with sweet corn paste.
- Added all the spices and mixed well and made cutlets of oval shape from mixture.

- Made batter of corn flour and water.
- Dipped cutlets in batter and rolled in breadcrumbs and fried till light brown in colour.
- Kept fried cutlets on blotting paper and served hot with tomato sauce.

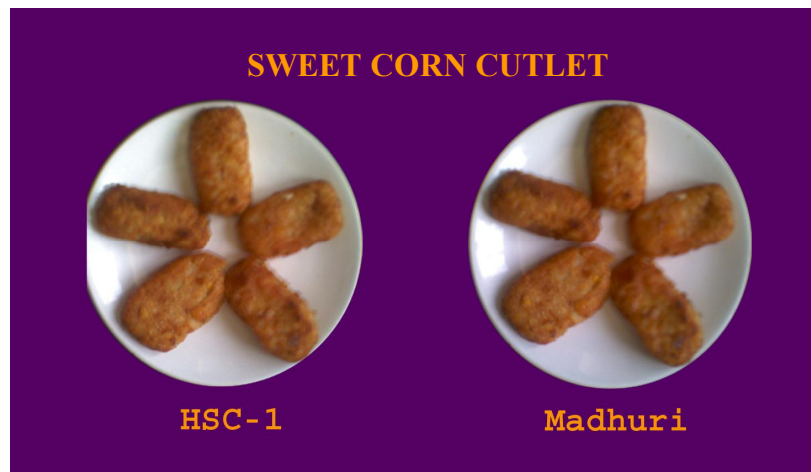


PLATE 5

3.3.4 Sweet Corn Manchurian

Ingredients:

Sweet corn kernels	:	100g
Capsicum	:	30g
Beans	:	20g
Cabbage	:	30g
Peas	:	30g
Green chillies	:	3-4
Garlic	:	6-7 cloves
Soya sauce	:	3-4 drops
Vinegar	:	1tsp
Black pepper	:	½ tsp
Corn flour	:	2 tbsp
Refined flour	:	2 tbsp
Tomato sauce	:	2tbsp
Chilli sauce	:	1 tbsp
Orange-red colour	:	a pinch
Oil	:	for frying
Oil (for sauting Manchurian)	:	1tbsp

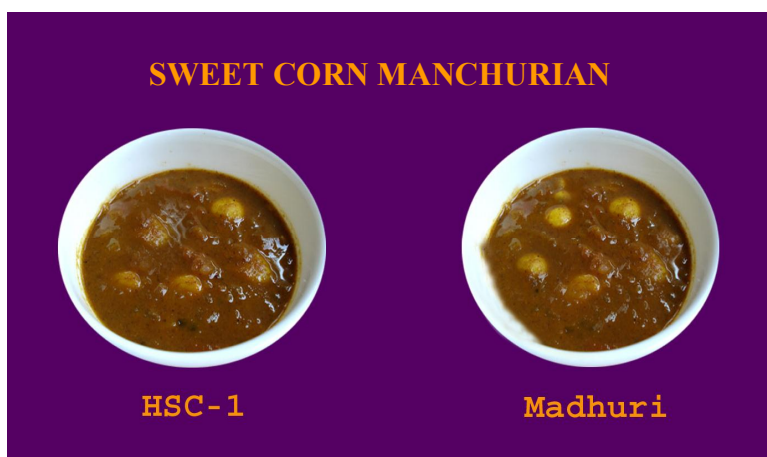


PLATE 6

Method:

- Washed sweet corn kernels and ground to coarse paste in grinder and chopped, beans, cabbage, peas and green chillies finely.
- Mixed all ingredients except vinegar and tomato sauce and half amount of garlic and green chillies and ½tsp cornflour.
- Made balls and fried in preheated oil, drained and kept aside.
- Heated oil in a pan and sauted garlic and green chillies. Added tomato sauce, chilli sauce, vinegar and salt.
- Prepared a thin paste of water and ½tsp corn flour and added to mixture and cooked for two minutes.
- Added fried Manchurian, mixed and cooked for two minutes.

3.3.5 Sweet corn Pulav

Ingredients:

Rice	:	50g
Sweet corn kernels	:	50g
Onion	:	30g
Whole cloves	:	4-5
Bay leaves	:	3-4
Cumin seed	:	¼ tsp
<i>Garam masala</i>	:	½tsp
Salt	:	to taste
Oil	:	2 tsp

Method:

- Soaked the rice for 20 min.
- Washed sweet corn kernels.

- Chopped onion.
- Heated oil in a pan, added cloves, black pepper, bay leaves and cumin seeds, sauted onion and added sweet corn kernels.
- Added blanched sweet corn.
- Added salt and other spice followed by soaked rice.
- Added 100 ml water to the pan.
- Covered the pan and cooked on medium flame till done.



PLATE 7

3.3.6 Sweet Corn Dry Vegetable

Ingredients:

Sweet corn kernels	:	100g
Tomato	:	30g
Onion	:	30g
Garlic paste	:	¼ tsp
Ginger paste	:	¼ tsp
Green coriander	:	few leaves
Red chilli powder	:	½tsp
Cumin seed	:	¼ tsp
<i>Garam masala</i>	:	½tsp
Salt	:	to taste
Oil	:	10 ml

Method:

- Washed sweet corn kernels.
- Chopped onion, tomato and green coriander finely.
- Heated oil in a pan and sauted cumin seeds followed by ginger and garlic paste.

- Added chopped onion and fried till golden brown.
- Added tomatoes, all spices and cooked for 2-3minutes.
- Added sweet corn kernels and cooked till completely done.
- Garnished with coriander leaves.

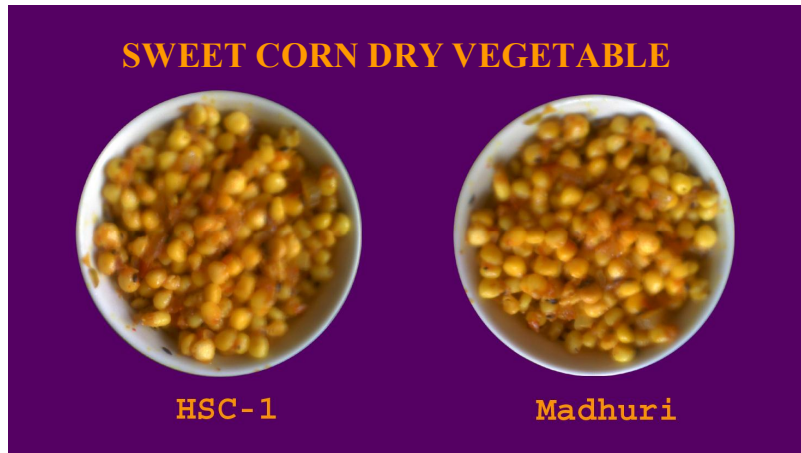


PLATE 8

3.3.7 Sweet Corn *Kofta* Curry

For *Koftas*:

Ingredients:

Sweet corn kernels	:	100g
Bengal gram flour	:	50g
Potatoes	:	50g
Mango powder	:	½tsp
Red chilli powder	:	½tsp
Omum seed	:	¼ tsp
Salt	:	to taste
Oil	:	for frying

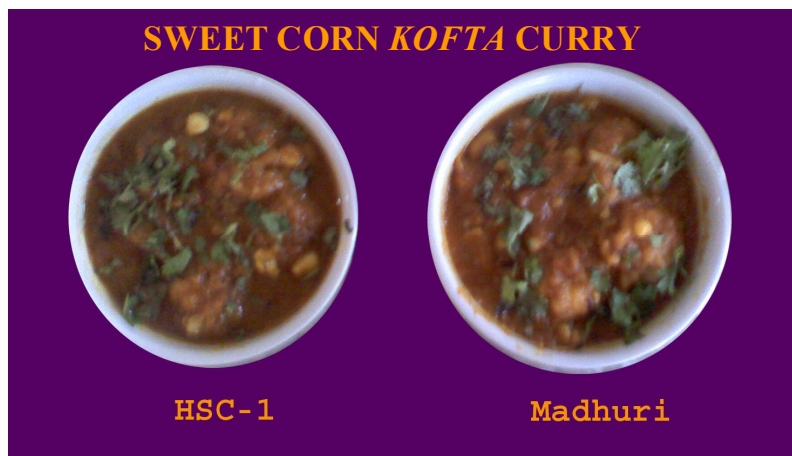


PLATE 9

Method:

- Washed sweet corn kernels and ground to coarse paste in grinder.
- Boiled and mashed potatoes.
- Mixed sweet corn paste, mashed potatoes, bangal gram flour and all spices well.
- Made small balls and deep fried till golden brown.

For Gravy**Ingredients:**

Tomato	:	100g
Onion	:	100g
Ginger	:	small piece
Garlic	:	2-3 cloves
Cumin seed	:	½tsp
Red chilli powder	:	¼tsp
<i>Garam masala</i>	:	½tsp
Salt	:	to taste
Oil	:	1 tbsp

Method:

- Finely ground onion, tomato, ginger and garlic separately.
- Heated oil in a pan and added cumin seeds followed by garlic- ginger paste, onion paste and fried till golden brown.
- Added tomato paste and all other spices and cooked till oil separated, then poured one cup water and cooked on slow flame for thickening of gravy.
- Added *kofta* in gravy and removed from the flame and served hot.

3.3.8 Sweet Corn Halwa**Ingredients:**

Sweet corn kernels	:	100g
Sugar	:	25g
Ghee	:	20g
Water	:	50 ml
Raisin	:	10 g
Almond (chopped)	:	2-3 pieces

Method:

- Washed sweet corn kernels and ground to fine paste in grinder.
- Fried sweet corn paste in ghee on slow flame in thick bottomed pan till golden brown.
- Make sugar syrup of 1 thread consistency in separate pan and added to fried corn paste.
- Cooked till done and decorated with raisins and chopped almond.

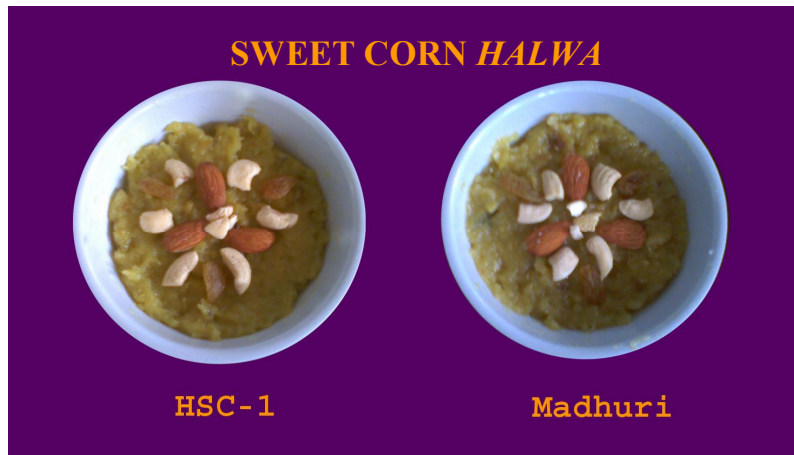


PLATE 10

3.3.9 Sweet corn *kheer*

Ingredients:

Sweet corn kernels	:	30g
Milk	:	250ml
Sugar	:	10g
Cardamom (crushed)	:	¼ tsp.
Dry fruits (almond and raisin)	:	10g

Method:

- Washed sweet corn kernels and ground to coarse paste in a grinder.
- Boiled milk in a pan.
- Added the sweet corn paste and cardamom.
- Stirred continuously till volume became half and kheer was thick.
- Added sugar and cooked for 2-3 minutes.
- Garnished with dry fruits.



PLATE 11

3.3.10 Sweet Corn Pickle

Ingredients:

Sweet corn kernels	:	200g
Aniseeds	:	5g
Red chilli powder	:	5g
Mustard seeds	:	10g
Salt	:	10g
Mustard oil	:	40ml
Vinegar	:	2ml



PLATE 12

Method:

- Washed fresh sweet corn kernels in hot water and dried to remove extra water.
- Roasted mustard seeds, aniseeds separately ground coarsely.
- Heated half of oil in a pan and added aniseeds, mustard seeds and red chilli powder.
- Added sweet corn kernels followed by vinegar, salt and oil.
- Mixed well and filled in clean air tight jar and kept in sun for 10-15 days.

3.4 ORGANOLEPTIC EVALUATION OF DEVELOPED PRODUCTS

All the products prepared from sweet corn were evaluated for organoleptic acceptability by a panel of 10 judges selected from I.C. College of Home Science, CCS Haryana Agricultural University, Hisar. The judges were asked to record the quality characteristics viz. colour, appearance, flavor, texture and taste using 9-point hedonic rating scale as given in Appendix-1. Average of the scores for all these characteristics were expressed as overall acceptability.

3.5 PROCESSING OF SWEET CORN

Sweet corn was subjected to two processing methods i.e. dehydration and freezing to extend its shelf life.

3.5.1 Dehydration of sweet corn

Sweet corn were removed from the cob and dried in oven at 45°C for 26 to 28 hours. The dehydrated sample was then cooled in dessicator and packed in polyethylene packets and sealed (Plate-13).



PLATE 13

3.5.1.1 Shelf life of dehydrated sweet corn and effect of storage on:

The dehydrated sweet corn kernels stored for 90 days at room temperature(25-30°C) and analyzed at interval of 30, 60 and 90 days for parameters listed below:

3.5.1.1.1 Nutritional composition

The dehydrated sweet corn at each storage interval (30, 60 and 90 days) was ground in an electric grinder and was analyzed for proximate composition, carbohydrates and minerals by the methods mentioned earlier in 3.2.

3.5.1.1.2 Product development and its organoleptic acceptability

The dehydrated sweet corn was rehydrated by soaking in water for 10-12 hour. The rehydrated sweet corn was then utilized for the development of sweet corn soup, sweet corn cutlet, sweet corn dry vegetable and sweet corn *kheer* by methods given in 3.3. All the products were evaluated organoleptically by a panel of 10 judges using a 9-point hedonic scale.

3.5.2 Freezing of sweet corn

Sweet corn kernels was removed from cob and packed in polyethylene packets and sealed. The sample was then stored in freezer at -20°C(Plate-14).



PLATE 14

3.5.2.1 Shelf life of frozen sweet corn and effect of frozen storage on:

Frozen sweet corn was evaluated at interval of 30days i.e. 30,60 and 90 days for parameters listed below:

3.5.2.1.1 Nutritional composition

The frozen sweet corn sample at each storage interval (30, 60 and 90 days) was thawed at room temperature and dried in oven at 45°C for 28 hours and then ground in an electric grinder. The ground sample was then analyzed for proximate composition, carbohydrates and minerals by the methods mentioned earlier in 3.2.

3.5.2.2 Product development and its organoleptic acceptability

The frozen sample was kept at room temperature for 30 minutes for thawing and then utilized for the development of sweet corn soup, sweet corn cutlet, sweet corn dry vegetable and sweet corn *kheer* at 30, 60and 90 day of storage, by methods given in 3.3. All the products were evaluated organoleptically by a panel of 10 judges using a 9-point hedonic scale.

3.6 STATISTICAL ANALYSIS

Standard statistical method such as standard error, t test and Analysis of Variance (ANOVA) were used for interpretation of data (Panse and Sukhatme, 1961).

The selected genotypes of sweet corn HSC-I (Hybrid) and Madhuri (variety) were analyzed for their chemical composition and utilized for formulation of some food products. Sweet corn were stored under dehydrated and frozen conditions to increase its shelf-life and effect of storage on its chemical composition was studied. The results of the present study are presented under the following heads:

4.1 Nutritional evaluation of sweet corn

- 4.1.1 Proximate composition
- 4.1.2 Available carbohydrates
- 4.1.3 *In vitro* protein and starch digestibility
- 4.1.4 Vitamins
- 4.1.5 Total minerals

4.2 Organoleptic evaluation of developed products

- 4.2.1 Salad and Soup
- 4.2.2 Cutlet, Manchurian and *Pulav*
- 4.2.3 Dry vegetable and *Kofta* curry
- 4.2.4 *Halwa* and *Kheer*
- 4.2.5 Pickle

4.3 Shelf life of dehydrated sweet corn**4.3.1 Effect of storage on nutritional composition of dehydrated sweet corn**

- 4.3.1.1 Proximate composition
- 4.3.1.2 Available carbohydrates
- 4.3.1.3 Total minerals

4.3.2 Effect of storage on acceptability of products developed from dehydrated sweet corn**4.4 Shelf life of frozen sweet corn****4.4.1 Effect of storage on nutritional composition of frozen sweet corn**

- 4.4.1.1 Proximate composition
- 4.4.1.2 Available carbohydrates
- 4.4.1.3 Total minerals

4.4.2 Effect of storage on acceptability of products developed from frozen sweet corn**4.1 Nutritional Evaluation of Sweet Corn**

Sweet corn was analyzed for proximate composition, available carbohydrates, vitamin, total minerals. *In vitro* starch and *in vitro* protein digestibility was also estimated.

4.1.1 Proximate composition: Mean values of moisture, crude protein, crude fat, total ash and crude fibre content of sweet corn are depicted in Table 4.1.

Moisture content of HSC-I and Madhuri was found to be 70.30 and 72.21 per cent, respectively, on fresh matter basis. The moisture content of both type of sweet corn did not differ significantly. Crude protein content was found to be 13.44 g/100g in HSC-I and 15.30 g/100g in Madhuri, on dry matter basis. The data indicates protein content in Madhuri was significantly higher than protein content of HSC-I.

Table 4.1: Proximate composition of sweet corn (g/100g, dry matter basis)

Proximate Principles	Genotypes		't' value
	HSC-1	Madhuri	
Moisture ^o	70.30±0.11	72.21±0.03	NS
Crude protein	13.44±0.45	15.30±0.04	4.5*
Total ash	4.42±0.02	4.70±0.02	13.57**
Crude fat	2.26±0.01	2.58±0.03	13.43**
Crude fibre	3.76±0.01	3.31±0.01	26.87**

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

^o on fresh matter basis

Crude fat was observed to be significantly higher in Madhuri (2.58%), than in HSC-I (2.26%), on dry matter basis. Ash content of the hybrid (HSC-I) and variety (Madhuri) was found to be 4.42 and 4.70 per cent, respectively on dry matter basis. Values were significantly (P<0.01) higher in Madhuri. Sweet corn contained 3.76 and 3.13 per cent crude fibre in HSC-I and Madhuri, respectively, on dry matter basis. Fibre content of HSC-I was significantly higher than fibre content of Madhuri.

4.1.2 Available carbohydrates

Data on total soluble sugars, reducing sugars, non-reducing sugars and starch are depicted in Table 4.2.

The total sugars were found to be 13.51 per cent in Madhuri which was significantly higher than total sugar of HSC-I which were 11.70 per cent on dry matter basis. The reducing sugars content was 2.81 per cent in HSC-I and 3.40 per cent in Madhuri on dry matter basis. Data indicated significant varietal influence on the reducing sugars content of selected sweet corn genotypes. The non-reducing sugars content in HSC-I and Madhuri was 8.89 and 10.10 per cent, respectively. The non reducing sugars content was significantly (P<0.05) higher in Madhuri than that of HSC-I. The starch content of sweet corn was 57.98 and 53.26 per cent in HSC-I and Madhuri on dry matter basis, respectively. The values indicated that starch content of HSC-I was significantly higher than that of Madhuri.

Table 4.2: Carbohydrate content of sweet corn (g/100g, dry matter basis)

Parameters	Genotypes		't' value
	HSC-1	Madhuri	
Total soluble sugars	11.70±0.11	13.51±0.27	6.02*
Reducing sugars	2.81±0.01	3.40±0.02	20.53**
Non reducing sugars	8.89±0.10	10.10±0.29	3.91*
Starch	57.98±0.14	53.26±0.41	10.79**

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.1.3 *In vitro* protein and starch digestibility

The value of *in vitro* protein and starch digestibility of sweet corn are presented in Table 4.3.

In vitro protein digestibility of sweet corn was found to be 67.78 per cent in HSC-I and 71.25 per cent in Madhuri on dry matter basis. Non significant difference in *in vitro* protein digestibility was observed in both the genotype.

In vitro starch digestibility of HSC-I and Madhuri was observed to be 36.13 and 31.83 mg maltose released per gram, respectively. *In vitro* starch digestibility of HSC-I was significantly higher than that of Madhuri.

Table 4.3: *In vitro* protein and starch digestibilities of sweet corn (on dry matter basis)

Parameters	Genotypes		't' value
	HSC-1	Madhuri	
<i>In vitro</i> protein digestibility (%)	67.38±1.09	71.25±0.12	NS
<i>In vitro</i> starch digestibility (mg maltose released/g)	36.13±0.12	31.83±0.49	8.50*

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.1.4 Vitamins

The vitamin content of sweet corn i.e. HSC-I and Madhuri are depicted in Table 4.4.

The ascorbic acid content of both the genotypes of sweet corn was almost similar i.e. 6.13 (HSC-I) and 5.86 (Madhuri) mg/100g, on as is basis.

The β -carotene content of HSC-I and Madhuri on fresh matter basis was 46.34 and 48.41 μ g/100g, respectively. Madhuri had significantly ($P < 0.01$) higher amount of β -carotene than HSC-I.

Table 4.4: Vitamin content of sweet corn (on as is basis)

Parameters	Genotypes		't' value
	HSC-1	Madhuri	
Ascorbic acid(mg/100g)	6.13±0.23	5.86±0.07	NS
β-carotene(μg/100g)	46.34±0.14	48.41±0.12	11.13**

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.1.5 Total minerals

The mineral content of sweet corn is presented in Table 4.5.

The magnesium content was 253.66 and 252.75 mg/100g in HSC-I and Madhuri respectively, on the dry matter basis. The data indicates magnesium content did not differ significantly in both the genotypes. The zinc content of HSC-I and Madhuri was almost similar and was 5.03 and 5.10 mg/100g, on dry matter basis, respectively.

The iron content of HSC-I and Madhuri was 6.60 and 6.51 mg/100g respectively, on dry matter basis. There was non significant varietal influence on iron content of both the genotypes of sweet corn. The phosphorus content of sweet corn genotypes was 357.19 and 366.98 per 100 g in HSC-I and Madhuri respectively. . The data indicates phosphorus content did not differ significantly in both the genotypes.

Table 4.5: Total mineral content of sweet corn (mg/100g, dry matter basis)

Minerals	Genotypes		't' value
	HSC-1	Madhuri	
Magnesium	253.66±1.96	252.75±1.25	NS
Zinc	5.03±0.01	5.10±0.02	NS
Iron	6.60±0.12	6.51±0.08	NS
Phosphorus	357.19±1.63	366.98±2.34	NS

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.2 Organoleptic Evaluation of Developed Products

Various food products including salad, soup, cutlet, manchurian, *pulav*, dry vegetable, *kofta* curry, *halwa*, *kheer* and pickle were developed utilizing sweet corn. The organoleptic acceptability of the products was adjudged by a panel of ten judges using nine point Hedonic Rating Scale.

4.2.1 Salad and Soup

Mean scores of sensory characteristics of salad and soup are depicted in Table 4.6. Both salad and soup were liked very much by the judges. Colour, flavour, taste and overall acceptability of salad and soup prepared from both the genotypes were in the category of liked extremely. The mean scores for overall acceptability was 8.10 and 8.17 for sweet corn salad whereas same was 8.02 and 8.06 for soup prepared from both the genotypes HSC-I and Madhuri, respectively. There were no significant differences observed in scores of all the sensory attributes of salad and soup prepared from HSC-I and Madhuri.

Table 4.6 : Mean scores for sensory characteristics of Soup and Salad prepared from sweet corn.

Products Genotypes	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
SOUP						
HSC-1	8.10±0.10	8.00±0.01	7.90±0.10	8.00±0.01	8.30±0.15	8.06±0.05
Madhuri	8.10±0.10	8.20±0.13	7.80±0.13	8.00±0.14	8.00±0.01	8.02±0.02
't' value	NS	NS	NS	NS	NS	NS
SALAD						
HSC-1	8.20±0.13	8.10±0.10	8.00±0.00	8.10±0.17	8.20±0.13	8.10±0.07
Madhuri	8.00±0.21	8.10±0.23	8.20±0.20	7.90±0.27	8.20±0.23	8.17±0.18
't' value	NS	NS	NS	NS	NS	NS

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.2.2 Cutlet, Manchurian and Pulav

The mean scores for organoleptic characteristics of cutlet, manchurian and *pulav* are presented in Table 4.7.

Cutlet, manchurian and *pulav* prepared from sweet corn genotypes HSC-I and Madhuri, were found to be highly acceptable and organoleptic scores were in the category of liked very much. Mean scores obtained for various attributes including colour, appearance, flavour, texture and taste were in ranges of 7.70 to 8.20 for cutlet, 7.90 to 8.20 for manchurian as well as for *pulav*. Among all the sensory attributes colour, appearance and taste of cutlet, manchurian and *pulav* were liked extremely by the judges as scores were above 8.00. Overall acceptability scores of all the three products prepared from both the genotypes were in the category of liked extremely. The data indicated that there were no significant varietal differences observed in mean scores of sensory characteristics of products prepared from both the genotypes.

Table 4.7 : Mean scores for sensory characteristics of Cutlet, Manchurian and Pulav prepared from sweet corn

Products Genotypes	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
CUTLET						
HSC-1	8.10±0.17	8.10±0.10	8.00±0.21	7.70±0.21	8.10±0.17	8.02±0.13
Madhuri	8.20±0.13	8.00±0.01	8.00±0.21	8.00±0.01	8.00±0.21	8.04±0.10
't' value	NS	NS	NS	NS	NS	NS
MANCHURIAN						
HSC-1	8.20±0.13	8.10±0.10	8.00±0.01	8.10±0.17	8.20±0.13	8.10±0.07
Madhuri	8.00±0.21	8.10±0.23	8.20±0.20	7.90±0.27	8.20±0.23	8.17±0.18
't' value	NS	NS	NS	NS	NS	NS
PULAV						
HSC-1	8.10±0.17	8.20±0.20	7.90±0.17	7.90±0.27	8.10±0.17	8.02±0.17
Madhuri	8.00±0.21	8.10±0.23	8.00±0.21	8.00±0.25	8.10±0.23	8.04±0.20
't' value	NS	NS	NS	NS	NS	NS

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.2.3 Dry Vegetable and *Kofta* Curry

Mean organoleptic scores of dry vegetable and *kofta* curry are depicted in Table 4.8. Mean scores for colour, appearance, flavour, texture and taste of dry vegetable prepared using HSC-I were 8.10, 8.10, 7.90, 7.90, 8.10 and for that prepared from Madhuri were 8.00, 8.20, 8.00, 8.10, and 8.10, respectively. *Kofta* curry scored above 8.00 for all the attributes i.e. colour, appearance, flavour, texture, and taste.

Table 4.8 : Mean scores for sensory characteristics of Dry Vegetable and *Kofta* Curry prepared from sweet corn.

Products Genotypes	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
DRY VEGETABLE						
HSC-1	8.10±0.73	8.10±0.17	7.90±0.10	7.90±0.10	8.10±0.17	8.00±0.12
Madhuri	8.00±0.66	8.20±0.20	8.00±0.25	8.10±0.23	8.10±0.23	8.08±0.16
't' value	NS	NS	NS	NS	NS	NS
KOFTA CURRY						
HSC-1	8.00±0.21	8.20±0.20	8.00±0.25	8.30±0.21	8.10±0.17	8.14±0.18
Madhuri	8.10±0.17	8.10±0.10	8.00±0.14	8.00±0.14	8.10±0.17	8.04±0.14
't' value	NS	NS	NS	NS	NS	NS

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

Data indicated that all the scores were in the category of liked extremely. Scores indicated that colour, appearance and taste of dry vegetable and *kofta* curry was liked extremely by the judges where as flavour and texture of dry vegetable prepared by HSC-I was liked very much. On comparing scores of organoleptic attributes obtained for dry vegetable and *kofta* curry prepared by HSC-I and Madhuri, it was found that there was no significant difference in between *kofta* and dry vegetable prepared from HSC-I and Madhuri.

4.2.4 Halwa and Kheer

Mean organoleptic scores of *halwa* and *kheer* prepared by both the sweet corn genotype are depicted in Table 4.9. Both *halwa* and *kheer* were organoleptically acceptable to judges. *Halwa* lied in the category of liked very much and *kheer* lied in the category of liked extremely in terms of all sensory attributes, respectively. Mean scores for colour, appearance, flavour, texture and taste of *kheer* prepared using HSC-1 were 8.20, 8.10, 8.10, 8.20, 7.90 and that of *kheer* prepared from madhuri were 8.30, 8.00, 8.00, 8.20, and 8.60, respectively. *Kheer* prepared using fresh kernels of Madhuri scored significantly higher for taste than that of *kheer* prepared from HSC-1. However, there were no significant varietal influence on the mean scores of overall acceptability of both *kheer* and *halwa*.

Table 4.9 : Mean scores for sensory characteristics of Halwa and Kheer prepared from sweet corn

Products Genotypes	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
HALWA						
HSC-1	7.20±0.13	7.20±0.20	7.40±0.16	7.10±0.27	7.30±0.21	7.24±0.13
Madhuri	7.40±0.16	7.60±0.16	7.10±0.10	7.20±0.24	7.00±0.25	7.28±0.09
't' value	NS	NS	NS	NS	NS	NS
KHEER						
HSC-1	8.20±0.13	8.10±0.10	8.10±0.10	8.20±0.13	7.90±0.23	8.10±0.10
Madhuri	8.30±0.21	8.00±0.29	8.00±0.25	8.20±0.24	8.60±0.16	8.20±0.15
't' value	NS	NS	NS	NS	2.45*	NS

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.2.5 Pickle

Mean organoleptic scores of pickle are presented in Table 4.10. Mean scores for all organoleptic attributes of pickle prepared from HSC-I and Madhuri were in the category of liked very much by the judges. Mean scores for colour, appearance, flavour, texture and taste of pickle prepared from HSC-I were 7.70, 7.50, 7.40, 7.30, 7.10 and that of pickle prepared from Madhuri were 7.70, 7.50, 7.30, 7.60 and 7.70, respectively. Pickle prepared

from Madhuri scored slightly higher in texture and taste than the pickle prepared from HSC-I but the difference was not significant. Overall, there was no significant varietal difference observed between the genotypes for organoleptic attributes of pickle.

Table 4.10 : Mean scores for sensory characteristics of Pickle prepared from sweet corn.

Genotype	Colour	Appearance	Flavour	Texture	Taste	Overall acceptability
HSC-1	7.70±0.15	7.50±0.23	7.40±0.16	7.30±0.21	7.10±0.10	7.42±0.10
Madhuri	7.70±0.16	7.50±0.22	7.30±0.15	7.60±0.16	7.70±0.15	7.56±0.14
't' value	NS	NS	NS	NS	NS	NS

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.3 Shelf life of dehydrated sweet corn

Sweet corn kernels were removed from the cob and dried in oven at 45⁰C for 26 hours. The dehydrated samples were cooled and packed in polyethylene packets and sealed and stored for 90 days at room temperature (25-30⁰C), and analyzed for nutritional composition and organoleptic evaluation at every 30 days interval up to 90 days.

4.3.1 Effect of storage on nutritional composition of dehydrated sweet corn

Dehydrated sweet corn was analyzed for proximate composition, available carbohydrate and mineral content on 0, 30, 60 and 90 days of storage.

4.3.1.1 Proximate composition

Data regarding proximate composition i.e. moisture, crude protein, ash, fat and fibre of dehydrated sweet corn of both the genotypes i.e. HSC-I and Madhuri has been depicted in Table 4.11.

Moisture : Moisture content of dehydrated sweet corn genotypes HSC-I and Madhuri on zero day of storage was 4.10 g/100g and 4.38 g/100g respectively. Moisture content increased slightly to 4.19 g/100g in HSC-1 and 4.46 g/100g in Madhuri by the end of storage period (Table 4.11). The moisture content of Madhuri was significantly higher than that of HSC-I at each storage interval.

Crude protein: The protein content of dehydrated HSC-I was 13.44, 13.19, 12.99, 12.79 and that of Madhuri was 15.30, 14.96, 14.68 and 14.62 per cent on 0, 30th, 60th and 90th day of storage, respectively. As indicated in the data, crude protein content of dehydrated sweet corn (hybrid and variety) decreased slightly with increase in storage period. Crude protein content of Madhuri was found to be significantly higher as compared to HSC-I throughout 90 days of storage period.

Table 4.11 : Effect of storage on proximate composition of dehydrated sweet corn (g/100g, dry matter basis)

	Days of storage				CD(P<0.05)
	0	30	60	90	
Moisture					
HSC-1	4.10±0.021	4.12±0.01 (0.48)	4.17±0.01 (1.70)	4.19±0.01 (2.19)	NS
Madhuri	4.38±0.03	4.39±0.04 (0.22)	4.41±0.04 (0.68)	4.46±0.03 (1.82)	NS
't' value	6.15**	6.22*	5.47*	6.96*	
Crude protein					
HSC-1	13.44±0.45	13.19±0.07 (1.86)	12.99±0.13 (3.48)	12.79±0.06 (4.83)	NS
Madhuri	15.30±0.04	14.96±0.27 (2.22)	14.68±0.31 (4.05)	14.62±0.34 (4.44)	NS
't' value	4.5*	6.34*	4.45*	5.57**	
Total ash					
HSC-1	4.42 ^a ±0.02	4.38 ^{ab} ±0.12 (0.90)	4.33 ^{bc} ±0.01 (2.03)	4.29 ^c ±0.01 (2.94)	0.04
Madhuri	4.70 ^a ±0.00	4.62 ^b ±0.00 (1.70)	4.58 ^c ±0.02 (2.55)	4.57 ^c ±0.01 (2.76)	0.04
't' value	13.57**	10.50**	10.26**	14.84**	
Crude fat					
HSC-1	2.26 ^a ±0.01	2.21 ^{ab} ±0.01 (2.21)	2.16 ^{bc} ±0.01 (4.42)	2.13 ^c ±0.03 (5.75)	0.07
Madhuri	2.58 ^a ±0.01	2.43 ^b ±0.03 (5.81)	2.41 ^b ±0.03 (6.58)	2.36 ^b ±0.01 (8.52)	0.08
't' value	13.43**	5.81*	6.70**	6.26**	
Crude fibre					
HSC-1	3.76±0.01	3.73±0.03 (0.79)	3.71±0.01 (1.32)	3.68±0.03 (2.12)	NS
Madhuri	3.13±0.01	3.08±0.09 (1.59)	3.06±0.06 (2.23)	3.01±0.08 (3.98)	NS
't' value	26.87**	17.44**	27.57**	17.88**	

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

Figures in parenthesis indicate percent change compared to zero day

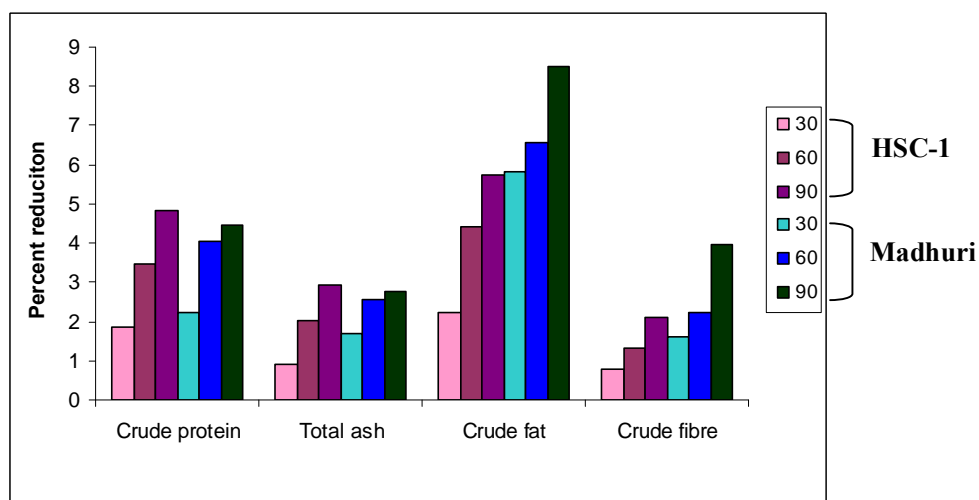


Fig 1: Percent reduction in proximate composition during storage of dehydrated sweet corn

Total ash : Total ash content of dehydrated HSC-I was 4.42 g/100g at zero day which decreased significantly to 4.38 g/100g at 60th day of storage. Ash content of Madhuri was 4.70 g/100g at zero day which decreased significantly to 4.58 g/100g at 60th day of storage. After 60 days of storage, the ash content of both the genotypes remained unchanged till further storage period of 90 days. On comparing ash content of both the varieties it was found that ash content of genotype Madhuri was significantly higher than that of HSC-I at each storage interval.

Crude fat : Results for fat content of HSC-I showed that fat content in dehydrated HSC-I decreased significantly from 2.26 g/100g at zero day to 2.13 g/10g at 90th day of storage period. Similarly, the fat content of Madhuri decreased significantly from zero day (2.58 g/100g) to 30th day of storage (2.43 g/100g). With further increase in storage period, non significant reduction was observed in the fat content of Madhuri from 30th day (2.43 g/100g) to 90th day (2.36 g/100g) of storage. However, fat content of Madhuri was significantly higher as compared to HSC-I and remained higher than HSC-I throughout the storage period.

Crude fibre : Crude fibre content of dehydrated sweet corn i.e. HSC-I was 3.76, 3.73, 3.71 and 3.68 and that of Madhuri was 3.13, 3.08, 3.06 and 3.01 g/100g on 0, 30th, 60th and 90th day of storage, respectively (Table 4.11). Crude fibre content of both the genotype i.e. HSC-I and Madhuri remained almost similar throughout the storage period. However, the crude fibre content of HSC-I was significantly higher than Madhuri and remained higher than Madhuri throughout the storage period.

4.3.1.2 Available Carbohydrates

Results for soluble sugar, reducing sugars, non-reducing sugars and starch have been depicted in Table 4.12.

Total soluble sugars : Total soluble sugar content of dehydrated HSC-I was 11.70g/100g at zero day of storage period which decreased negligibly to 11.02g/100g by the end of 90 days of storage. Similarly, non significant reduction was observed in the total sugar content of Madhuri from zero day (13.51 g/100g) to 90th day (13.03 g/100g) of storage period. However, total soluble sugar was found to be significantly higher in Madhuri than that of HSC-I at zero day and also at each interval of storage period.

Reducing sugars: Reducing sugar content of dehydrated sweet corn HSC-I and Madhuri was 2.81 and 3.40 g/100g, respectively, on dry matter basis. As indicated by the data, reducing sugars content of dehydrated sweet corn genotypes i.e. HSC-I decreased gradually from 2.81 g/100g on zero day to 2.51 g/100g on 90th day and in Madhuri reducing sugars decreased from 3.40 g/100g on zero day to 3.18 g/100g on 90th day, respectively. Reduction in reducing sugar content of dehydrated sweet corn was non significant upto 30th day of storage. Whereas with further increase in storage period to 60 and 90 days the, reduction in reducing sugar was significant. However, reducing sugars content of Madhuri was found to be significantly higher than reducing sugar content of HSC-I at each storage interval.

Table 4.12 : Effect of storage on available carbohydrates content of dehydrated sweet corn (g/100g, dry matter basis)

	Days of storage				CD(P<0.05)
	0	30	60	90	
Total soluble sugar					
HSC-1	11.70±0.11	11.45±0.23 (2.13)	11.26±0.14 (3.76)	11.02±0.09 (5.58)	NS
Madhuri	13.51±0.27	13.28±0.05 (1.70)	13.18±0.05 (2.44)	13.03±0.08 (3.55)	NS
't' value	6.02*	22.09**	30.05**	21.85**	
Reducing sugars					
HSC-1	2.81 ^a ±0.01	2.77 ^{ab} ±0.00 (1.42)	2.72 ^b ±0.03 (3.02)	2.51 ^c ±0.03 (10.67)	0.08
Madhuri	3.40 ^a ±0.02	3.31 ^{ab} ±0.04 (2.64)	3.26 ^{bc} ±0.04 (4.11)	3.18 ^c ±0.04 (6.47)	0.13
't' value	20.53**	12.08**	9.44**	11.64**	
Non reducing sugars					
HSC-1	8.89±0.10	8.67±0.23 (2.47)	8.54±0.22 (3.93)	8.50±0.12 (4.38)	NS
Madhuri	10.10±0.29	9.96±0.02 (1.38)	9.92±0.03 (1.78)	9.85±0.04 (2.47)	NS
't' value	3.91*	27.36**	34.21**	30.52**	
Starch					
HSC-1	57.98±0.14	57.85±0.17 (0.02)	57.65±0.26 (0.56)	57.57±0.26 (0.70)	NS
Madhuri	53.26±0.41	53.03±0.09 (0.43)	52.87±0.15 (0.73)	52.75±0.17 (0.95)	NS
't' value	10.79**	24.45**	15.78**	15.27**	

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

Figure in parenthesis indicate percent reduction compared to zero day

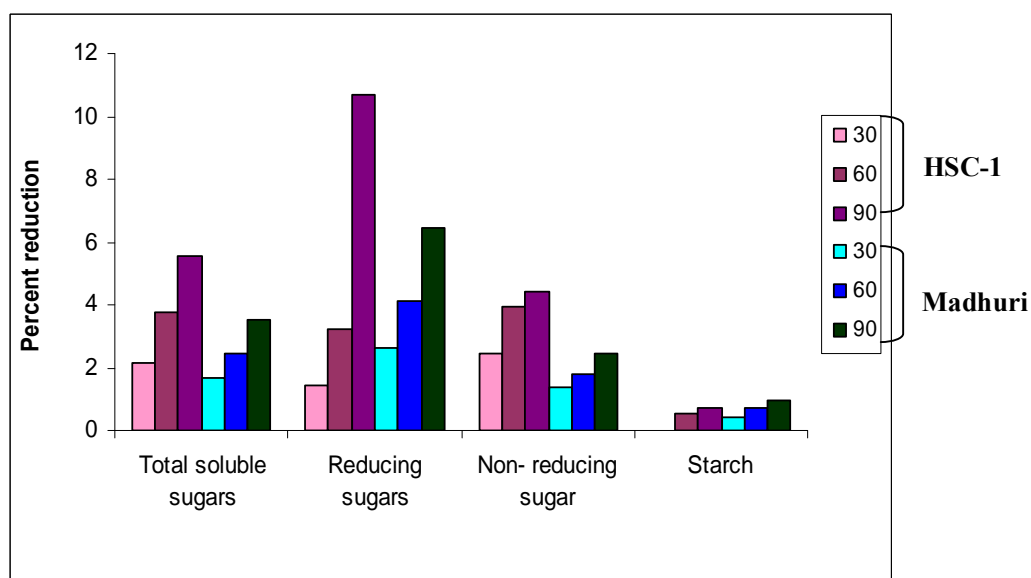


Fig II: Percent reduction of available carbohydrates during storage of dehydrated sweet corn

Non-reducing sugars : Non-reducing sugars content of dehydrated sweet corn genotypes on 0, 30th, 60th and 90th day of storage was 8.89, 8.67, 8.54 and 8.50 g/100g in HSC-I and 10.10, 9.96, 9.92 and 9.85 g/10g in Madhuri, respectively, on dry matter basis. Perusal of data indicated that the reduction in non-reducing sugars content of both the genotypes were not significant with increase in storage period. However, non-reducing sugars content of Madhuri was significantly higher than non-reducing sugars content of HSC-I throughout the storage period of 90 days.

Starch : Starch content of dehydrated HSC-I (hybrid) and Madhuri (variety) on zero day of storage was 57.98 and 53.26 g/100g, respectively, on dry matter basis. Starch content reduced almost negligibly in both the genotypes (HSC-I and Madhuri) i.e. by 0.02 and 0.42 per cent on 30th day, by 0.56 and 0.73 per cent on 60th day, by 0.70 and 0.95 per cent on 90th day (Fig. II), respectively, on dry matter basis. On comparing starch content of dehydrated corn kernels of both the genotypes, it was observed that the starch content of HSC-I was significantly higher than that of Madhuri and remained higher in HSC-I throughout the storage period.

4.3.1.3 Total minerals

The mean values for magnesium, zinc, iron and phosphorus of dehydrated sweet corn as observed at storage intervals of 0, 30, 60 and 90 days are presented in Table 4.13.

Magnesium : Results for magnesium content in both the dehydrated sweet corn (HSC-1 and Madhuri) indicated that magnesium content decreased slightly during storage in both the genotypes. Magnesium content of dehydrated HSC-I on zero day of storage was 253.66 mg/100g which reduced negligibly i.e. by 0.78 per cent on 30th day of storage, by 1.90 per cent on 60th day and by 3.54 per cent on 90th day (Fig. III). Similarly, magnesium content of Madhuri reduced slightly, by 0.95 per cent on 30th day by 2.21 per cent on 60th day and by 3.75 per cent on 90th day. Magnesium content of both the sweet corn was almost similar throughout the storage period.

Zinc : Result indicated that zinc content of dehydrated sweet corn genotypes HSC-1 and Madhuri was almost similar i.e. 5.03 and 5.10, respectively. As indicated that data, zinc content decreased significantly from 5.03 mg/100g at zero day to 4.70 mg/100g at 90 days of storage in dehydrated HSC-I. Reduction in zinc was significant on 30th day of storage whereas reduction after 30 days up to 90 days of storage was non significant. Zinc content of Madhuri was 5.10 mg/100g at zero day of storage period which decreased significantly to 4.73 mg/100g at 90th day of storage period. However, non significant difference was observed in the zinc content between both the genotypes (HSC-I and Madhuri) throughout the storage period.

Table 4.13 : Effect of storage on mineral content of dehydrated sweet corn (g/100g, dry matter basis)

	Days of storage				CD(P<0.05)
	0	30	60	90	
Magnesium					
HSC-1	253.66±1.96	251.66±1.54 (0.78)	248.83±1.51 (1.90)	244.66±0.64 (3.54)	NS
Madhuri	252.75±1.25	250.33±1.06 (0.95)	247.16±0.41 (2.21)	243.3±0.74 (3.75)	NS
't' value	NS	NS	NS	NS	
Zinc					
HSC-1	5.03 ^a ±0.01	4.81 ^b ±0.05 (0.95)	4.73 ^b ±0.02 (5.96)	4.70 ^b ±0.01 (6.56)	0.10
Madhuri	5.10 ^a ±0.00	4.85 ^b ±0.02 (4.90)	4.76 ^c ±0.02 (6.66)	4.73 ^c ±0.04 (7.25)	0.08
't' value	NS	NS	NS	NS	
Iron					
HSC-1	6.60±0.12	6.47±0.06 (1.66)	6.27±0.08 (5.00)	6.23±0.15 (5.60)	NS
Madhuri	6.51±0.08	6.47±0.01 (0.61)	6.29±0.04 (3.37)	6.22±0.02 (4.45)	NS
't' value	NS	NS	NS	NS	
Phosphorus					
HSC-1	357.19 ^a ±1.63	351.25 ^a ±1.08 (1.66)	333.66 ^b ±3.17 (6.58)	323 ^c ±4.77 (9.57)	9.88
Madhuri	366.98 ^a ±2.34	352.70 ^b ±4.93 (3.89)	340.24 ^c ±0.63 (7.28)	328.97 ^d ±1.28 (10.35)	9.20
't' value	NS	NS	NS	NS	

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

Figure in parenthesis indicate percent reduction compared to zero day

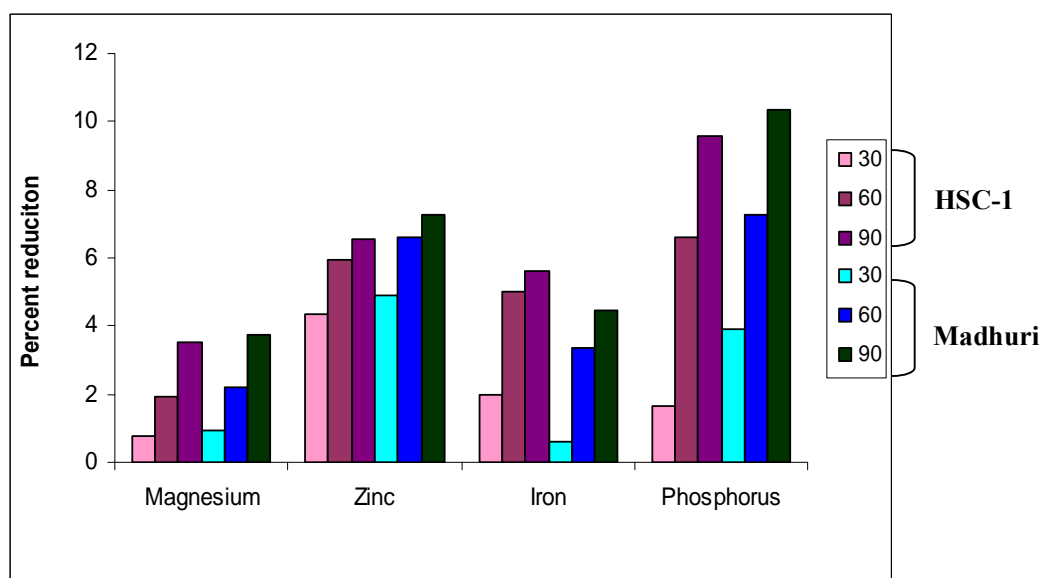


Fig III: Percent reduction of total minerals during storage of dehydrated sweet corn

Iron : Iron content of dehydrated sweet corn HSC-I was 6.60 mg/100g and that of Madhuri was 6.51 mg/100g on zero day of storage. Storage study indicated that iron content of dehydrated sweet corn HSC-I and Madhuri was reduced slightly i.e. by 1.66 and 0.61 per cent on 30th day, 5.00 and 3.37 per cent on 60th day and by 5.60 and 4.45 per cent on 90th day of storage (Fig. III). The observed reduction in iron content in both the genotype (HSC-I and Madhuri) was non significant at various periods of storage intervals. Iron content of both the genotypes i.e. HSC-I and Madhuri was almost similar to each other throughout the storage.

Phosphorus : Phosphorus content of dehydrated HSC-I was 357.19, 351.25, 333.66 and 323 mg/100g and that of Madhuri was 366.98, 352.70, 340.24 and 328.97 mg/100g on 0, 30th, 60th, and 90th day of storage, respectively. The reduction in phosphorus content of HSC-I and Madhuri was found to be significant throughout the storage period. However, there was non significant difference observed in phosphorus content between the genotypes of sweet corn at all storage intervals.

4.3.2 Effect of storage on acceptability of products developed from dehydrated sweet corn

Dehydrated sweet corn of both the genotypes were soaked in water for eight hours for rehydration at each storage intervals of 0, 30, 60 and 90 days. Rehydrated sweet corn were utilized for the preparation of various products including sweet corn soup, *kheer*, cutlet and dry vegetable. The prepared products were studied for their organoleptic acceptability by a panel of 10 judges using 9 point Hedonic Rating Scale.

4.3.2.1 Soup

Mean scores for all the sensory attributes of soup prepared using dehydrated HSC-I and dehydrated Madhuri at every 30 days storage interval upto three months are summarized in Table 4.14. Scores obtained for all the sensory attributes i.e. colour, appearance, flavour, texture and taste indicated that the soup prepared from stored rehydrated sweet corn was not liked extremely on zero day whereas soup prepared from rehydrated sweet corn of both the genotypes on 30th, 60th and 90th day of storage period was liked very much by the judges. There was slight reduction in mean score for colour, appearance, flavour and texture of sweet corn soup prepared from stored dehydrated corn of both the genotypes stored at 30th day as compared to zero day of storage. Although significant reduction in mean score for colour, appearance, taste and texture of soup prepared from dehydrated sweet corn was observed on 60th and 90th day of storage when compared to zero day but the scores were in category liked very much. Whereas mean score of flavour of soup prepared from dehydrated Madhuri and HSC-I at each interval of 30 day, remained same throughout the storage period. Mean scores for overall acceptability of soup prepared using stored rehydrated HSC-I on 0, 30th, 60th and 90th day of storage period were 8.06, 7.66, 7.46 and 7.38, respectively and that of soup prepared using rehydrated Madhuri were 8.02, 7.68, 7.46 and 7.39, respectively. As indicated

by the data there was no significant difference observed in mean scores of all the sensory attributes of soup prepared from both genotypes at every interval of storage which indicated that variety had no influence on acceptability of soup.

Table 4.14 : Organoleptic acceptability of “Soup” prepared from dehydrated sweet corn at different storage interval

Organoleptic characteristics	Days of storage				CD(P<0.05)
	0	30	60	90	
Colour					
HSC-1	8.10 ^a ±0.10	7.50 ^b ±0.16	7.40 ^b ±0.15	7.30 ^b ±0.16	0.42
Madhuri	8.10 ^a ±0.10	7.50 ^b ±0.16	7.40 ^b ±0.16	7.40 ^b ±0.16	0.43
‘t’ value	NS	NS	NS	NS	
Appearance					
HSC-1	8.00 ^a ±0.00	7.70 ^{ab} ±0.15	7.60 ^b ±0.16	7.40 ^b ±0.16	0.39
Madhuri	8.20 ^a ±0.13	7.50 ^b ±0.16	7.70 ^b ±0.15	7.40 ^b ±0.16	0.44
‘t’ value	NS	NS	NS	NS	
Flavour					
HSC-1	7.90±0.10	7.50±0.16	7.70±0.15	7.40±0.16	NS
Madhuri	7.80±0.13	7.80±0.13	7.80±0.16	7.50±0.16	NS
‘t’ value	NS	NS	NS	NS	
Texture					
HSC-1	8.00 ^a ±0.00	7.80 ^a ±0.13	7.40 ^b ±0.16	7.40 ^b ±0.16	0.38
Madhuri	8.00 ^a ±0.14	7.90 ^a ±0.10	7.30 ^b ±0.15	7.30 ^b ±0.15	0.40
‘t’ value	NS	NS	NS	NS	
Taste					
HSC-1	8.30 ^a ±0.15	7.80 ^b ±0.13	7.30 ^c ±0.15	7.30 ^c ±0.15	0.42
Madhuri	8.00 ^a ±0.00	7.70 ^a ±0.15	7.30 ^b ±0.15	7.30 ^b ±0.15	0.37
‘t’ value	NS	NS	NS	NS	
Overall acceptability					
HSC-1	8.06 ^a ±0.05	7.66 ^b ±0.09	7.46 ^b ±0.11	7.38 ^b ±0.12	0.29
Madhuri	8.02 ^a ±0.02	7.68 ^b ±0.10	7.46 ^{bc} ±0.09	7.39 ^c ±0.12	0.27
‘t’ value	NS	NS	NS	NS	

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.3.2.2 Cutlet

Mean scores of all the sensory attributes of cutlet prepared using stored rehydrated HSC-I and Madhuri on different storage intervals are depicted in Table 4.15. The mean scores obtained for all the sensory attributes of cutlet prepared using rehydrated HSC-I and Madhuri at different storage intervals fell in the category of liked very much. However, slight reduction in the score for colour, appearance, flavour, texture and taste of cutlet prepared from rehydrated HSC-I and Madhuri was observed on 30th day, whereas significant reduction

was observed in the score for colour, appearance, flavour, texture and taste of cutlet prepared from rehydrated HSC-I and Madhuri on 60th and 90th day when compared to zero day. Mean score of colour, appearance, flavour, texture and taste of cutlet prepared using rehydrated sweet corn of both the genotypes at 30th, 60th and 90th day of storage were in the category of -liked very much. Mean score for taste of cutlet prepared using rehydrated HSC-I stored for 0, 30, 60 and 90 days were 8.10, 7.70, 7.40 and 7.60 and of cutlet prepared using rehydrated Madhuri were 8.00, 7.60, 7.50 and 7.20. However, no significant varietal influence was observed in all sensory attributes of cutlets prepared using both dehydrated sweet corn genotype at each interval of storage.

Table 4.15 : Organoleptic acceptability of “Cutlet” prepared from dehydrated sweet corn at different storage interval

Organoleptic characteristics	Days of storage				CD(P<0.05)
	0	30	60	90	
Colour					
HSC-1	8.10 ^a ±0.17	7.90 ^a ±0.16	7.30 ^b ±0.15	7.40 ^b ±0.16	0.43
Madhuri	8.20 ^a ±0.13	7.70 ^b ±0.21	7.30 ^b ±0.15	7.40 ^b ±0.16	0.48
‘t’ value	NS	NS	NS	NS	
Appearance					
HSC-1	8.10 ^a ±0.10	7.80 ^{ab} ±0.13	7.60 ^b ±0.16	7.40 ^b ±0.16	0.40
Madhuri	8.00 ^a ±0.00	7.50 ^{ab} ±0.22	7.60 ^{ab} ±0.16	7.60 ^b ±0.16	0.46
‘t’ value	NS	NS	NS	NS	
Flavour					
HSC-1	8.00 ^a ±0.21	7.50 ^{ab} ±0.16	7.40 ^b ±0.16	7.40 ^b ±0.16	0.50
Madhuri	8.00 ^a ±0.21	7.50 ^{ab} ±0.22	7.80 ^{ab} ±0.15	7.60 ^b ±0.16	0.54
‘t’ value	NS	NS	NS	NS	
Texture					
HSC-1	7.70±0.21	7.40±0.16	7.40±0.16	7.30±0.15	NS
Madhuri	8.00±0.01	7.60±0.22	7.80±0.13	7.40±0.16	NS
‘t’ value	NS	NS	NS	NS	
Taste					
HSC-1	8.10 ^a ±0.17	7.70 ^{ab} ±0.15	7.40 ^b ±0.16	7.60 ^b ±0.16	0.47
Madhuri	8.00 ^a ±0.21	7.60 ^{ab} ±0.22	7.50 ^{ab} ±0.16	7.20 ^b ±0.20	0.57
‘t’ value	NS	NS	NS	NS	
Overall acceptability					
HSC-1	8.02 ^a ±0.13	7.66 ^b ±0.09	7.42 ^b ±0.05	7.44 ^b ±0.10	0.28
Madhuri	8.04 ^a ±0.10	7.58 ^b ±0.18	7.50 ^b ±0.08	7.45 ^b ±0.11	0.35
‘t’ value	NS	NS	NS	NS	

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.3.2.3 Dry vegetable

Data for organoleptic score of dry vegetables prepared from sweet corn genotypes (HSC-I and Madhuri) on different storage intervals is presented in Table 4.16. All the sensory attributes of dry vegetable were in category of liked extremely by the judges on zero day of storage and were in range of -liked very much when prepared from dehydrated stored corn on 30th, 60th and 90th day of storage. Mean score for colour, appearance, flavour and taste for dry vegetables prepared using stored dehydrated HSC-I and Madhuri, remained unchanged upto 30th day of storage. However, mean score for texture of dry vegetable prepared using dehydrated HSC-1 at 30th and 60th day of storage, as compared to zero day and lied in the category -liked very much by the judges throughout the storage period. Mean score for overall acceptability of dry vegetable prepared from dehydrated HSC-I were 8.00, 7.66, 7.32 and 7.28 and that of dry vegetable prepared from Madhuri were 8.08, 7.62, 7.34 and 7.26 on 0, 30th, 60th and 90th day of storage, respectively. There was no significant reduction observed in all the sensory attributes of dry vegetable prepared from both dehydrated sweet corn genotypes between 60th and 90th day of storage. However, there was no significant varietal influence observed on all sensory attributes of cutlet prepared using both genotypes throughout the storage period.

Table 4.16 :Organoleptic acceptability of “Dry Vegetable” prepared from dehydrated sweet corn at different storage interval

Organoleptic characteristics	Days of storage				CD(P<0.05)
	0	30	60	90	
Colour					
HSC-1	8.10 ^a ±0.73	7.80 ^{ab} ±0.13	7.60 ^{ab} ±0.16	7.40 ^b ±0.16	0.50
Madhuri	8.00 ^a ±0.66	7.70 ^{ab} ±0.15	7.60 ^{ab} ±0.16	7.40 ^b ±0.16	0.49
‘t’ value	NS	NS	NS	NS	
Appearance					
HSC-1	8.10 ^a ±0.17	7.60 ^b ±0.16	7.50 ^b ±0.16	7.40 ^b ±0.16	0.48
Madhuri	8.20 ^a ±0.20	7.80 ^a ±0.13	7.30 ^b ±0.15	7.30 ^b ±0.15	0.46
‘t’ value	NS	NS	NS	NS	
Flavour					
HSC-1	7.90 ^a ±0.10	7.70 ^a ±0.15	7.30 ^b ±0.15	7.20 ^b ±0.13	0.39
Madhuri	8.00 ^a ±0.25	7.40 ^b ±0.16	7.40 ^b ±0.16	7.40 ^b ±0.16	0.54
‘t’ value	NS	NS	NS	NS	
Texture					
HSC-1	7.90 ^a ±0.10	7.50 ^b ±0.16	7.10 ^{bc} ±0.10	7.40 ^c ±0.16	0.39
Madhuri	8.10 ^a ±0.23	7.30 ^b ±0.15	7.10 ^b ±0.10	7.10 ^b ±0.10	0.44
‘t’ value	NS	NS	NS	NS	
Taste					
HSC-1	8.10 ^a ±0.17	7.70 ^a ±0.21	7.10 ^b ±0.10	7.00 ^b ±0.01	0.42
Madhuri	8.10 ^a ±0.23	7.90 ^a ±0.81	7.30 ^b ±0.15	7.20 ^b ±0.13	0.51
‘t’ value	NS	NS	NS	NS	
Overall acceptability					
HSC-1	8.00 ^a ±0.12	7.66 ^b ±0.14	7.32 ^c ±0.08	7.28 ^c ±0.08	0.31
Madhuri	8.08 ^a ±0.16	7.62 ^b ±0.12	7.34 ^b ±0.09	7.26 ^b ±0.10	0.36
‘t’ value	NS	NS	NS	NS	

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.3.2.4 *Kheer*

Mean scores for all the sensory attributes of *kheer* prepared from tored dehydrated HSC-I and Madhuri at each storage interval are listed in Table 4.17. Mean scores for all the attributes i.e., colour, appearance, flavour, texture and taste of *kheer* prepared from dehydrated HSC-I and Madhuri at zero day of storage were in the category of 'liked extremely' by the judges. Although the acceptability scores of *kheer* prepared from both the genotype (Hybrid and Variety) at every 30 day interval reduced significantly with increase in storage period, but acceptability remained in the category of 'liked very much'. Acceptability scores for colour, flavour, texture and taste of *kheer* prepared using dehydrated HSC-I and Madhuri decreased significantly on 30th day of storage and then remained similar on 60th and 90th day of storage. However, all the attributes lied in the category of 'liked very much' throughout the storage period and there was no significant varietal difference was observed in all sensory attributes of *kheer* prepared by both the genotype at each interval of storage.

Table 4.17 : Organoleptic acceptability of “Kheer” prepared from dehydrated sweet corn at different storage interval

Organoleptic characteristics	Days of storage				CD(P<0.05)
	0	30	60	90	
Colour					
HSC-1	8.20 ^a ±0.13	7.70 ^b ±0.15	7.40 ^b ±0.16	7.50 ^b ±0.16	0.44
Madhuri	8.30 ^a ±0.21	7.60 ^b ±0.16	7.40 ^b ±0.16	7.40 ^b ±0.16	0.50
‘t’ value	NS	NS	NS	NS	
Appearance					
HSC-1	8.10±0.10	7.50±0.26	7.60±0.16	7.40±0.16	NS
Madhuri	8.00±0.29	7.80±0.13	7.70±0.15	7.50±0.16	NS
‘t’ value	NS	NS	NS	NS	
Flavour					
HSC-1	8.10 ^a ±0.10	7.60 ^b ±0.16	7.50 ^b ±0.16	7.40 ^b ±0.16	0.43
Madhuri	8.00 ^a ±0.25	7.60 ^{ab} ±0.16	7.70 ^{ab} ±0.15	7.40 ^b ±0.16	0.54
‘t’ value	NS	NS	NS	NS	
Texture					
HSC-1	8.20 ^a ±0.13	7.60 ^b ±0.16	7.40 ^b ±0.16	7.50 ^b ±0.16	0.45
Madhuri	8.20 ^a ±0.24	7.60 ^b ±0.16	7.40 ^b ±0.16	7.20 ^b ±0.13	0.52
‘t’ value	NS	NS	NS	NS	
Taste					
HSC-1	7.90±0.23	7.50±0.16	7.60±0.16	7.50±0.16	NS
Madhuri	8.60 ^a ±0.16	7.60 ^b ±0.16	7.40 ^b ±0.16	7.50 ^b ±0.16	0.47
‘t’ value	2.45*	NS	NS	NS	
Overall acceptability					
HSC-1	8.10 ^a ±0.10	7.88 ^{ab} ±0.19	7.50 ^b ±0.11	7.48 ^b ±0.13	0.40
Madhuri	8.20 ^a ±0.15	7.66 ^b ±0.99	7.52 ^b ±0.12	7.46 ^b ±0.12	0.36
‘t’ value	NS	NS	NS	NS	

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.4 Shelf life of frozen sweet corn

Sweet corn kernels were removed from the cob and packed in polyethylene packets and sealed and stored for 90 days in freezer at -20°C . Frozen sweet corn samples were analyzed for nutritional composition and organoleptic evaluation of products prepared from frozen sweet corn at every 30 days interval up to 90 days.

4.4.1 Effect of storage on nutritional composition of frozen sweet corn

Frozen sweet corn was analyzed for proximate composition, available carbohydrate and mineral content on 0, 30, 60 and 90 days of storage.

4.4.1.1 Proximate composition

Moisture, crude protein, crude fat, total ash and crude fibre content of frozen sweet corn as analyzed on regular intervals of 0, 30, 60 and 90 days is depicted in Table 4.18.

Moisture : Mean moisture content of frozen HSC-I (Hybrid) was 70.30, 70.33, 70.33 and 70.38 per cent and that of Madhuri (Variety) was 72.21, 72.21, 72.24 and 72.37 per cent on 0, 30th, 60th and 90th day of storage, respectively on fresh matter basis. As indicated in data slight increase in moisture content of both sweet corn and genotype was noticed with increase in storage. However, Madhuri has significantly higher moisture content than HSC-I at each storage interval.

Crude protein : Protein content of frozen sweet corn genotypes HSC-I and Madhuri on zero day of storage was 13.44 g/100g and 15.30 g/100g, respectively on dry matter basis which decreased to 12.92 g/100g and 14.34 g/100g, respectively by the end of storage period. However, reduction was not significant. On comparing both genotypes, it was observed that crude protein content of frozen Madhuri was found to be significantly higher as compared to protein content of frozen HSC-I throughout 90 days of storage period.

Total ash : Ash content of frozen HSC-I and Madhuri was 4.42 g/100g and 4.70 g/100g on zero day, 4.38g/100g and 4.64g/100g on 30th day, 4.31g/100g and 4.56g/100g on 60th day and 4.17 g/100g and 4.43 g/100g on 90th day of storage, respectively. Significant reduction of 0.90, 2.48 and 5.65 per cent was observed in ash content of frozen kernels of HSC-I and similarly, significant reduction of 1.27, 2.97 and 5.74 per cent was observed in ash content of frozen kernels of Madhuri on 30th, 60th and 90th day of storage period as compared to zero day (Fig. IV). However, ash content of frozen kernels of Madhuri was found to be significantly higher than that of HSC-I at each 0, 30th and 60th day of storage.

Crude fat : Results for fat content of HSC-I indicated that fat content of frozen kernels HSC-I (Hybrid) reduced significantly from 2.26 g/100g at zero day to 2.08 g/100g on dry matter basis at 90th day of storage period. Similarly, the fat content of Madhuri decreased significantly from zero day (2.58 g/10g) to 30th day of storage (2.46 g/100g). With further increase in storage period to 60 days, non significant reduction was observed in fat content of frozen kernels of Madhuri i.e. to 2.41 g/100g whereas significant reduction in fat content of

Madhuri observed at 90th day (2.38 g/100g) of storage. Fat content of Madhuri was significantly higher as compared to fat content of HSC-I and remained higher throughout the storage period.

Table 4.18: Effect of storage on proximate composition of frozen sweet corn (g/100g, dry matter basis)

	Days of storage				CD(P<0.05)
	0	30	60	90	
Moisture					
HSC-1	70.30±0.11	70.33±0.03 (0.04)	70.33±0.03 (0.04)	70.38±0.61 (0.11)	NS
Madhuri	72.21±0.02	72.21±0.01	72.24±0.02 (0.04)	72.37±0.06 (0.22)	NS
't' value	16.55**	54.64**	46.94**	3.2*	
Crude protein					
HSC-1	13.44±0.45	13.26±0.02 (1.33)	13.12±0.07 (2.38)	12.92±0.63 (3.86)	NS
Madhuri	15.30±0.04	14.89±0.20 (2.67)	14.75±0.27 (3.59)	14.34±0.06 (6.27)	NS
't' value	4.05*	8.03*	5.78*	15.47**	
Total ash					
HSC-1	4.42 ^a ±0.02	4.38 ^b ±0.01 (0.90)	4.31 ^b ±0.01 (2.48)	4.17 ^c ±0.02 (5.65)	0.07
Madhuri	4.70 ^a ±0.03	4.64 ^b ±0.01 (1.27)	4.56 ^c ±0.03 (2.97)	4.43 ^d ±0.03 (5.74)	0.06
't' value	13.57**	13.65**	14.51**	NS	
Crude fat					
HSC-1	2.26 ^a ±0.01	2.28 ^{ab} ±0.06 (3.53)	2.16 ^{ab} ±0.01 (4.42)	2.08 ^b ±0.01 (7.96)	0.10
Madhuri	2.58 ^a ±0.01	2.46 ^b ±0.03 (4.65)	2.41 ^{bc} ±0.01 (6.58)	2.38 ^c ±0.01 (7.75)	0.07
't' value	13.43**	4.12*	10.60**	12.72**	
Crude fibre					
HSC-1	3.76±0.01	3.73±0.09 (0.79)	3.65±0.24 (2.92)	3.62±0.22 (3.72)	NS
Madhuri	3.13±0.01	3.10±0.13 (0.95)	3.07±0.11 (1.91)	3.04±0.12 (2.87)	NS
't' value	26.87**	24.60**	17.32**	12.49**	

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

Figure in parenthesis indicate percent change compared to zero day

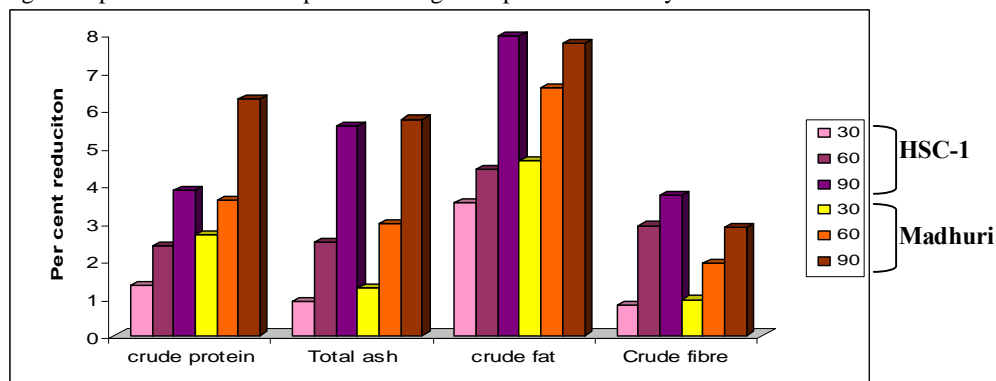


Fig IV : Percent reduction of proximate composition during storage of frozen sweet corn

Crude fibre : Crude fibre content of frozen sweet corn i.e. HSC-I was 3.76, 3.73, 3.65 and 3.62 g/100g and that of Madhuri was 3.13, 3.10, 3.07 and 3.04 g/100g on dry matter basis, on 0, 30th, 60th and 90th day of frozen storage, respectively (Table 4.18). Crude fibre content of both the genotypes remained almost similar throughout the frozen storage. Crude fibre content of HSC-I was significantly higher than crude fibre content of Madhuri and remained higher throughout the storage period.

4.4.1.2 Available carbohydrates

The data on total soluble sugars, reducing sugars, non-reducing sugars and starch of frozen sweet corn on regular storage intervals of 0, 30, 60 and 90 days are presented in Table 4.19.

Total soluble sugars : Total soluble sugars content of frozen HSC-I and Madhuri on zero day of storage was 11.70 and 13.51 per cent, respectively. Total soluble sugars content of frozen sweet corn decreased slightly by 2.30, 3.84 and 4.18 per cent in HSC-I and 1.77, 2.36 and 3.47 per cent in Madhuri on 30th, 60th and 90th day of storage, respectively. However, reducing sugars content of Madhuri was found to be significantly higher than that of HSC-I at each storage interval.

Reducing sugars : As presented in data reducing sugars content of frozen sweet corn i.e. HSC-I was 2.81, 2.76, 2.71 and 2.68 g/100g and that of Madhuri was 3.40, 3.30, 3.24 and 3.21 g/100g on dry matter basis, on 0, 30th, 60th and 90th day of storage, respectively (Table 4.19). The data indicated that reduction in reducing sugars content of both the genotypes (HSC-I and Madhuri) was significant upto 30th day of storage whereas reduction was non significant upto 60th and 90th day of storage. However, reducing sugars content of Madhuri was significantly higher than HSC-I and remained higher than Madhuri throughout the storage period.

Non-reducing sugars : Mean value of non-reducing sugars on zero day was 8.89 g/100g and 10.10 g/100g in frozen HSC-I and frozen Madhuri, respectively. The data indicated that there was a gradual decrease in non-reducing sugars content of both the genotype with increase in storage period. On comparing with zero day, reduction of 2.47, 3.93, 4.16 per cent in HSC-I and 1.28, 1.48 and 2.67 per cent in Madhuri was observed on 30th, 60th and 90th day of storage period, respectively. Values thus indicated that non-reducing sugars content of both sweet corn genotypes (HSC-I and Madhuri) unaffected by the storage period. Whereas, non-reducing sugars content of frozen kernels of madhuri was found to be significantly higher than HSC-I at each storage interval.

Table 4.19 : Effect of storage on available carbohydrates content of frozen sweet corn (g/100g, dry matter basis)

	Days of storage				CD(P<0.05)
	0	30	60	90	
Total soluble sugar					
HSC-1	11.70±0.11	11.43±0.27 (2.30)	11.25±0.14 (3.84)	11.21±0.21 (4.18)	NS
Madhuri	13.51±0.27	13.27±0.06 (1.77)	13.19±0.06 (2.36)	13.04±0.04 (3.47)	NS
't' value	6.02*	26.49**	26.54**	40.62**	
Reducing sugars					
HSC-1	2.81 ^a ±0.01	2.76 ^{ab} ±0.00 (1.72)	2.71 ^b ±0.03 (3.55)	2.68 ^b ±0.03 (4.62)	0.07
Madhuri	3.40 ^a ±0.02	3.30 ^{ab} ±0.05 (2.94)	3.24 ^b ±0.04 (4.70)	3.21 ^b ±0.03 (5.58)	0.13
't' value	20.53**	9.51*	9.73**	10.58*	
Non reducing sugars					
HSC-1	8.89±0.10	8.67±0.23 (2.47)	8.54±0.12 (3.93)	8.52±0.25 (4.16)	NS
Madhuri	10.10±0.29	9.97±0.03 (1.28)	9.95±0.05 (1.48)	9.83±0.01 (2.67)	NS
't' value	3.91*	27.92**	23.68**	44.51**	
Starch					
HSC-1	57.98±0.14	57.69±0.20 (0.50)	57.59±0.20 (0.67)	57.46±0.16 (0.89)	NS
Madhuri	53.26±0.41	53.14±0.42 (0.22)	53.01±0.31 (0.46)	52.83±0.10 (0.80)	NS
't' value	10.79**	7.63**	12.26**	23.37**	

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

Figure in parenthesis indicate percent reduction compared to zero day

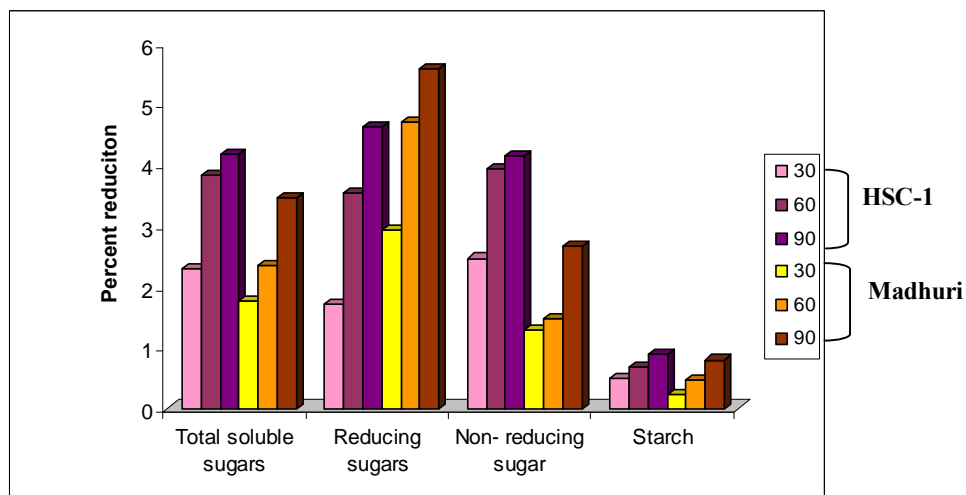


Fig V : Percent reduction of available carbohydrates during storage of frozen sweet corn

Starch : Starch content of frozen HSC-1 was 57.26g/100g which was significantly higher than that of Madhuri which was 53.26g/100g. During the storage of frozen sweet corn starch content of HSC-I was 57.26, 57.69, 57.59 and 57.46 g/100g and that of Madhuri was 53.26, 53.14, 53.01 and 52.83 g/100g on dry matter basis, respectively on 0, 30th, 60th and 90th day of storage. The observed reduction of starch content in both genotypes was non significant between different periods of storage interval. However, starch content of frozen HSC-I which was significantly higher than that of frozen kernels of Madhuri and remained higher in HSC-I throughout the storage period.

4.4.1.3 Total minerals

Mean value for magnesium, zinc, iron and phosphorus of frozen sweet corn genotypes (HSC-I and Madhuri) on regular intervals of 0, 30, 60 and 90 days are depicted in Table 4.20.

Magnesium : Results for magnesium content in both frozen sweet corn genotypes indicated that magnesium content was almost same in both the type of frozen kernels and decreased slightly during the storage in both the genotypes. Magnesium content of frozen HSC-I and Madhuri on zero day of storage was 253.66 and 252.75 mg/100g which decreased slightly to 245.00 and 243.66 mg/100g, respectively on 90th day of storage. However, non significant difference was observed in magnesium content between both genotypes of frozen sweet corn upto 90th day of storage period.

Zinc: Mean value for zinc content of frozen HSC-I (Hybrid) was 5.03 mg/100g and that of Madhuri was 5.10 mg/100g on zero day of storage. Significant reduction of 0.59, 1.59 and 4.77 per cent was observed in zinc content of frozen HSC-I and similarly, significant reduction of 1.37, 3.92 and 5.68 per cent was observed in zinc content of frozen kernels of Madhuri on 30th 60th and 90th day of storage period as compared to zero day (Fig. VI). However, non significant difference was observed in zinc content between both frozen sweet corn kernels at each interval of storage.

Iron : Iron content of frozen sweet corn i.e. HSC-I was 6.60, 6.55, 6.47 and 6.40 mg/100g and that of Madhuri was 6.51, 6.43, 6.42 and 6.32 mg/100g on 0, 30th, 60th and 90th day of storage, respectively (Table 4.20). As indicated by data of iron content of both the type of frozen kernels remained almost unchanged throughout the storage period. Iron content between both the genotypes remained similar upto 90th day of storage period. No varietal difference was observed on iron content.

Table 4.20 : Effect of storage on mineral content of frozen sweet corn (g/100g, dry matter basis)

	Days of storage				CD(P<0.05)
	0	30	60	90	
Magnesium					
HSC-1	253.66±1.96	251.18±0.94 (0.97)	247.25±1.09 (2.52)	245 ±11.30 (3.41)	NS
Madhuri	252.75±1.25	249.83±1.68 (1.15)	245.33±1.59 (2.93)	243.66±1.20 (3.59)	NS
't' value	NS	NS	NS	NS	
Zinc					
HSC-1	5.03 ^a ±0.01	5.00 ^a ±0.02 (0.59)	4.95 ^a ±0.02 (1.59)	4.79 ^b ±0.04 (4.77)	0.08
Madhuri	5.10 ^a ±0.00	5.03 ^a ±0.01 (1.37)	4.90 ^b ±0.02 (3.92)	4.81 ^b ±0.05 (5.68)	0.11
't' value	NS	NS	NS	NS	
Iron					
HSC-1	6.60±0.12	6.55±0.12 (0.75)	6.47±0.12 (1.96)	6.40±0.13 (3.03)	NS
Madhuri	6.51±0.08	6.43±0.14 (1.22)	6.42±0.23 (1.38)	6.32±0.12 (2.91)	NS
't' value	NS	NS	NS	NS	
Phosphorus					
HSC-1	357.19 ^a ±1.63	353.71 ^a ±2.48 (0.97)	337.84 ^a ±5.16 (5.41)	332.69 ^b ±1.98 (6.85)	10.21
Madhuri	366.98 ^a ±2.34	361.04 ^a ±1.82 (1.61)	342.68 ^b ±2.58 (6.62)	338.03 ^b ±3.16 (7.88)	8.22
't' value	NS	NS	NS	NS	

Values are mean ± SE of three independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

Figure in parenthesis indicate percent reduction compared to zero day

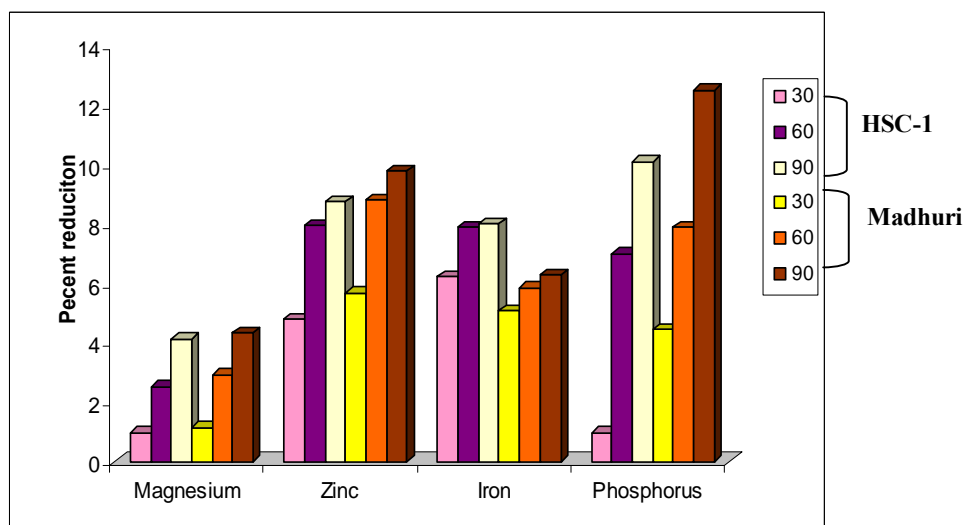


Fig VI : Percent reduction of total minerals during storage of frozen sweet corn

Phosphorus : Phosphorus content of frozen HSC-I on storage days of 0, 30th, 60th and 90th day was 357.19, 353.71, 337.84 and 332.69 mg/100g and that of Madhuri was 366.98, 351.04, 342.68 and 338.03 mg/100g, respectively. The data indicated non significant reduction of phosphorus content in frozen kernels of HSC-I on 30th, 60th day whereas significant reduction was observed on 90th day as compared to zero day. Similarly, phosphorus content of frozen Madhuri decreased slightly on 30th day of storage whereas significant decrease in phosphorus content of Madhuri was observed on 60th and 90th day of storage as compared to zero day. However, non significant differences in phosphorus were observed between both the genotypes throughout the storage period.

4.4.2 Effect of storage on acceptability of products developed from frozen sweet corn

Frozen sweet corn of both the genotypes at storage interval of 0, 30, 60 and 90 days was utilized for preparation of various products including sweet corn soup, cutlet, dry vegetable and *kheer*. The products were studied for their organoleptic acceptability by a panel of 10 judges using 9 point Hedonic Rating Scale.

4.4.2.1 Soup

Mean scores for all the sensory attributes and overall acceptability of sweet corn soup prepared from frozen kernels at different storage intervals is depicted in Table 4.21. All the sensory attributes i.e. colour, appearance, flavour, texture and taste of soup prepared from frozen HSC-I and Madhuri was liked extremely by the judges on zero day. Although the acceptability scores of soup prepared from both the genotype decreased significantly with increase in storage period but the acceptability remained in the category of 'liked very much'. Acceptability scores for flavour of soup prepared using frozen kernels of both the genotypes were almost similar on 30, 60, and 90 day of storage and 'liked very much'. Acceptability scores for colour, appearance, texture and taste of soup prepared using frozen HSC-I and Madhuri remained similar on 30th day and reduced gradually on 60th and 90th day, when compared to zero day. However, all the attributes fell in the category of 'liked very much' throughout the storage period. As indicated by data there was no significant difference observed between mean score for all the sensory attributes of soup prepared using both genotype at every interval of storage, which indicted that variety had no influence on acceptability of soup.

Table 4.21 : Organoleptic acceptability of “Soup” prepared from frozen sweet corn at different storage interval.

Organoleptic characteristics	Days of storage				CD(P<0.05)
	0	30	60	90	
Colour					
HSC-1	8.10 ^a ±0.10	7.70 ^{ab} ±0.15	7.40 ^b ±0.16	7.40 ^b ±0.16	0.42
Madhuri	8.10 ^a ±0.10	7.50 ^b ±0.16	7.40 ^b ±0.16	7.50 ^b ±0.16	0.43
‘t’ value	NS	NS	NS	NS	
Appearance					
HSC-1	8.00 ^a ±0.01	7.50 ^{ab} ±0.16	7.60 ^{ab} ±0.16	7.50 ^b ±0.16	0.41
Madhuri	8.20 ^a ±0.13	7.60 ^b ±0.16	7.70 ^b ±0.15	7.50 ^b ±0.16	0.44
‘t’ value	NS	NS	NS	NS	
Flavour					
HSC-1	7.90±0.10	7.80±0.13	7.70±0.15	7.60±0.16	NS
Madhuri	7.80±0.13	7.80±0.13	7.80±0.13	7.50±0.16	NS
‘t’ value	NS	NS	NS	NS	
Texture					
HSC-1	8.00 ^a ±0.01	7.80 ^{ab} ±0.13	7.60 ^{bc} ±0.16	7.30 ^c ±0.15	0.37
Madhuri	8.00 ^a ±0.14	7.90 ^{ab} ±0.10	7.50 ^{bc} ±0.16	7.40 ^c ±0.16	0.42
‘t’ value	NS	NS	NS	NS	
Taste					
HSC-1	8.30 ^a ±0.15	7.60 ^b ±0.16	7.40 ^b ±0.16	7.20 ^b ±0.11	0.44
Madhuri	8.00 ^a ±0.01	7.60 ^{ab} ±0.16	7.40 ^b ±0.16	7.40 ^b ±0.16	0.40
‘t’ value	NS	NS	NS	NS	
Overall Acceptability					
HSC-1	8.06 ^a ±0.05	7.68 ^b ±0.07	7.54 ^{bc} ±0.09	7.40 ^c ±0.11	0.26
Madhuri	8.02 ^a ±0.02	7.70 ^b ±0.08	7.56 ^b ±0.08	7.48 ^b ±0.12	0.24
‘t’ value	NS	NS	NS	NS	

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.4.2.2 Cutlet

Mean scores for all the sensory attributes of cutlet prepared using frozen HSC-I (Hybrid) and frozen Madhuri (Variety) at every 30 days storage interval upto three months are summarized in Table 4.22. Scores obtained for all the sensory attributes i.e. colour, appearance, flavour, texture and taste indicated that cutlet prepared from the both sweet corn genotypes lied in category -liked extremelyø on zero day. Mean scores for colour, appearance, flavour and texture of sweet corn cutlet prepared from frozen corn of both the genotype remained almost same at 30 day as compared to zero day. On further increase in storage period of the cutlet prepared from frozen corn stored for 60 and 90 day of storage indicated significant reduction in mean scores for colour, appearance, flavour and texture. However there was no significant reduction observed in mean score of all sensory attributes of cutlet

prepared from frozen kernels of sweet corn between 60th and 90th day. Scores for all the sensory attributes i.e. colour, appearance, flavour, texture and taste was in the category of -liked extremely on zero day and fell in the category of -liked very much on in cutlet prepared from frozen sweet corn on 30th, 60th and 90th day of storage in both the genotypes. Mean scores for overall acceptability of cutlet prepared using frozen HSC-I on 0, 30th, 60th and 90th day of storage period were 8.02, 7.88, 7.48 and 7.36, respectively and that of cutlet prepared using Madhuri were 8.04, 7.90, 7.52 and 7.42, respectively. Varietal difference was not observed in mean scores of all the sensory attributes of cutlet prepared by both genotypes at every interval of storage.

Table 4.22 : Organoleptic acceptability of “Cutlet” prepared from frozen sweet corn at different storage interval

Organoleptic characteristics	Days of storage				CD(P<0.05)
	0	30	60	90	
Colour					
HSC-1	8.10 ^a ±0.17	7.90 ^a ±0.10	7.40 ^b ±0.16	7.40 ^b ±0.16	0.44
Madhuri	8.20 ^a ±0.13	7.90 ^{ab} ±0.10	7.40 ^{bc} ±0.16	7.70 ^c ±0.15	0.39
‘t’ value	NS	NS	NS	NS	
Appearance					
HSC-1	8.10 ^a ±0.10	8.00 ^a ±0.01	7.40 ^b ±0.16	7.40 ^b ±0.16	0.36
Madhuri	8.00 ^a ±0.01	8.00 ^a ±0.01	7.50 ^b ±0.16	7.50 ^b ±0.16	0.33
‘t’ value	NS	NS	NS	NS	
Flavour					
HSC-1	8.00 ^a ±0.21	8.00 ^a ±0.01	7.50 ^b ±0.16	7.30 ^b ±0.15	0.44
Madhuri	8.00 ^a ±0.21	7.80 ^{ab} ±0.13	7.50 ^{bc} ±0.16	7.30 ^c ±0.15	0.48
‘t’ value	NS	NS	NS	NS	
Texture					
HSC-1	7.70 ^a ±0.21	7.40 ^{ab} ±0.16	7.40 ^{ab} ±0.16	7.20 ^b ±0.13	0.48
Madhuri	8.00 ^a ±0.01	7.60 ^b ±0.16	7.30 ^{bc} ±0.15	7.10 ^c ±0.10	0.35
‘t’ value	NS	NS	NS	NS	
Taste					
HSC-1	8.10 ^a ±0.17	8.10 ^a ±0.23	7.70 ^{ab} ±0.15	7.50 ^b ±0.16	0.53
Madhuri	8.00 ^a ±0.21	8.20 ^{ab} ±0.20	7.70 ^{ab} ±0.15	7.50 ^b ±0.16	0.52
‘t’ value	NS	NS	NS	NS	
Overall Acceptability					
HSC-1	8.02 ^a ±0.13	7.88 ^a ±0.07	7.48 ^b ±0.12	7.36 ^b ±0.12	0.33
Madhuri	8.04 ^a ±0.10	7.90 ^b ±0.09	7.52 ^b ±0.11	7.42 ^b ±0.08	0.28
‘t’ value	NS	NS	NS	NS	

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

4.4.2.3 Dry vegetable

Mean scores of all the sensory attributes of dry vegetable prepared using frozen kernels of sweet corn i.e. HSC-I (Hybrid) and Madhuri (Variety) on different

storage intervals are depicted in Table 4.23. The mean scores for all the sensory attributes of dry vegetable prepared using stored frozen kernels of HSC-I and Madhuri at 30th, 60th and 90th day storage intervals lied in the category of δ liked very much \emptyset

Table 4.23 : Organoleptic acceptability of “Dry Vegetable” prepared from frozen sweet corn at different storage interval.

Organoleptic characteristics	Days of storage				CD(P<0.05)
	0	30	60	90	
Colour					
HSC-1	8.10 ^a ±0.73	7.90 ^{ab} ±0.10	7.50 ^{bc} ±0.16	7.30 ^c ±0.15	0.48
Madhuri	8.00 ^a ±0.66	7.90 ^{ab} ±0.10	7.60 ^{ab} ±0.16	7.50 ^b ±0.16	0.47
‘t’ value	NS	NS	NS	NS	
Appearance					
HSC-1	8.10 ^a ±0.17	7.70 ^a ±0.15	7.70 ^a ±0.15	7.20 ^b ±0.13	0.44
Madhuri	8.20 ^a ±0.20	7.90 ^{ab} ±0.10	7.70 ^{bc} ±0.15	7.40 ^c ±0.16	0.45
‘t’ value	NS	NS	NS	NS	
Flavour					
HSC-1	7.90 ^a ±0.10	7.50 ^{ab} ±0.16	7.50 ^{ab} ±0.16	7.30 ^b ±0.15	0.42
Madhuri	8.00 ^a ±0.25	7.60 ^{ab} ±0.16	7.30 ^b ±0.15	7.30 ^b ±0.15	0.53
‘t’ value	NS	NS	NS	NS	
Texture					
HSC-1	7.90 ^a ±0.10	7.60 ^{ab} ±0.16	7.40 ^b ±0.16	7.30 ^b ±0.15	0.42
Madhuri	8.10 ^a ±0.23	7.70 ^{ab} ±0.15	7.40 ^b ±0.16	7.20 ^b ±0.13	0.53
‘t’ value	NS	NS	NS	NS	
Taste					
HSC-1	8.10 ^a ±0.17	8.10 ^a ±0.23	7.30 ^b ±0.15	7.50 ^b ±0.16	0.53
Madhuri	8.10 ^a ±0.23	8.30 ^a ±0.21	7.30 ^b ±0.15	7.40 ^b ±0.16	0.55
‘t’ value	NS	NS	NS	NS	
Overall Acceptability					
HSC-1	8.00 ^a ±0.12	7.76 ^{ab} ±0.10	7.48 ^{bc} ±0.07	7.32 ^c ±0.10	0.29
Madhuri	8.08 ^a ±0.16	7.88 ^a ±0.10	7.46 ^b ±0.07	7.36 ^b ±0.11	0.36
‘t’ value	NS	NS	NS	NS	

Values are mean \pm SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS δ Non significant

However, slight reduction in the mean score for colour, appearance, flavour, texture, taste and overall acceptability of dry vegetable prepared from stored frozen kernels of HSC-I and Madhuri were observed on 30th day, whereas significant reduction was observed on 60th and 90th day when compared to zero day. Mean score for colour, appearance, flavour, texture and taste were in the category of δ liked very much \emptyset and remained unchanged during the 30th, 60th and 90th day of storage interval. Mean scores for taste of dry vegetable prepared using frozen HSC-I were 8.10, 8.10, 7.30 and 7.50 and that of prepared using frozen Madhuri were 8.10, 8.30, 7.30 and

7.40 on 0, 30th, 60th and 90th day of storage, respectively. However, no significant varietal difference was observed in all sensory attributes of dry vegetable prepared using both frozen sweet corn genotype at each interval of storage.

4.4.2.4 *Kheer*

Data for organoleptic score of *kheer* prepared from sweet corn genotypes (HSC-I and Madhuri) on different storage intervals is presented in Table 4.24.

Table 4.24 : Organoleptic acceptability of “*kheer*” prepared from frozen sweet corn at different storage interval

Organoleptic characteristics	Days of storage				CD(P<0.05)
	0	30	60	90	
Colour					
HSC-1	8.20 ^a ±0.13	7.50 ^{ab} ±0.16	7.50 ^{bc} ±0.16	7.50 ^c ±0.16	0.45
Madhuri	8.30 ^a ±0.21	7.50 ^{ab} ±0.16	7.50 ^{ab} ±0.16	7.40 ^b ±0.16	0.51
‘t’ value	NS	NS	NS	NS	
Appearance					
HSC-1	8.10 ^a ±0.10	7.60 ^a ±0.16	7.70 ^a ±0.15	7.70 ^b ±0.15	0.41
Madhuri	8.00 ^a ±0.29	7.60 ^{ab} ±0.16	7.80 ^{bc} ±0.13	7.60 ^c ±0.16	0.57
‘t’ value	NS	NS	NS	NS	
Flavour					
HSC-1	8.10 ^a ±0.10	7.80 ^{ab} ±0.13	7.70 ^{ab} ±0.15	7.70 ^b ±0.15	0.39
Madhuri	8.00 ^a ±0.25	7.80 ^{ab} ±0.13	7.80 ^b ±0.13	7.60 ^b ±0.16	0.51
‘t’ value	NS	NS	NS	NS	
Texture					
HSC-1	8.20 ^a ±0.13	7.60 ^{ab} ±0.16	7.20 ^b ±0.13	7.20 ^b ±0.13	0.40
Madhuri	8.20 ^a ±0.24	7.70 ^{ab} ±0.15	7.30 ^b ±0.15	7.30 ^b ±0.15	0.52
‘t’ value	NS	NS	NS	NS	
Taste					
HSC-1	7.90 ^a ±0.23	7.60 ^a ±0.16	7.50 ^b ±0.16	7.30 ^b ±0.15	0.52
Madhuri	8.60 ^a ±0.16	7.80 ^a ±0.13	7.50 ^b ±0.16	7.40 ^b ±0.16	0.45
‘t’ value	2.45*	NS	NS	NS	
Overall Acceptability					
HSC-1	8.10 ^a ±0.10	7.64 ^{ab} ±0.07	7.52 ^{bc} ±0.10	7.48 ^c ±0.11	0.28
Madhuri	8.20 ^a ±0.15	7.68 ^a ±0.07	7.58 ^b ±0.10	7.48 ^b ±0.09	0.31
‘t’ value	NS	NS	NS	NS	

Values are mean ± SE of ten independent observations

*Significant at 5% level of significance

**Significant at 1% level of significance

NS ó Non significant

All the sensory attributes of *kheer* prepared using frozen kernels of both the genotypes were liked extremely by the judges on zero day of storage and were in range of -liked very muchó by the judges on 30th, 60th and 90th day of storage. Mean score for appearance, flavour, texture and taste of *kheer* prepared using frozen HSC-I and Madhuri, remained unchanged upto 30th day of storage. Significant reduction was observed in scores for colour, appearance, texture and taste on 60th and 90th day of

storage as compared to zero day. In spite of reduction in scores, the acceptability remained in the category -liked very much at 60th and 90th day of storage. Mean score for overall acceptability of *kheer* prepared from stored frozen kernels of HSC-I at 0, 30th, 60th, 90th day of storage were 8.10, 7.64, 7.52 and 7.48, respectively and that of *kheer* prepared using frozen kernels of Madhuri were 8.20, 7.68, 7.58 and 7.48, respectively. As indicated by the data, there was no significant varietal differences was observed in all sensory attributes of *kheer* prepared using with sweet corn genotypes throughout the storage period.

Two genotypes of sweet corn HSC-1 (hybrid) and Madhuri (variety) were analyzed for their chemical composition and utilized for formulation of food products. Both the sweet corn genotypes were stored under dehydrated and frozen conditions to increase the shelf-life. The effect of storage was studied on its chemical composition and organoleptic acceptability. The results of the present study have been discussed under the following heads and subheads:

5.1 Nutritional evaluation of sweet corn

- 5.1.1 Proximate composition
- 5.1.2 Available carbohydrates
- 5.1.3 *In vitro* protein and starch digestibility
- 5.1.4 Vitamins
- 5.1.5 Total minerals

5.2 Organoleptic evaluation of developed products

- 5.2.1 Salad and Soup
- 5.2.2 Cutlet, Manchurian and *Pulav*
- 5.2.3 Dry vegetable and *Kofta* curry
- 5.2.4 *Halwa* and *Kheer*
- 5.2.5 Pickle

5.3 Shelf life of dehydrated sweet corn**5.3.1 Effect of storage on nutritional composition of dehydrated sweet corn**

- 5.3.1.1 Proximate composition
- 5.3.1.2 Available carbohydrates
- 5.3.1.3 Total minerals

5.3.2 Effect of storage on acceptability of products developed from dehydrated sweet corn**5.4 Shelf life of frozen sweet corn****5.4.1 Effect of storage on nutritional composition of frozen sweet corn**

- 5.4.1.1 Proximate composition
- 5.4.1.2 Available carbohydrates
- 5.4.1.3 Total minerals

5.4.2 Effect of storage on acceptability of products developed from frozen sweet corn**5.1 Nutritional evaluation of sweet corn**

5.1.1 Proximate Composition

Moisture content of HSC-I (Hybrid) and Madhuri (variety) was 70.30 and 72.21 per cent, respectively (Table 4.1). The moisture content was almost similar in both the genotypes. The moisture content of these genotypes of sweet corn was close to the values reported by earlier workers, Felex *et al.* (1982), they reported moisture content to range 71.5 to 80.5 per cent. Similar results have been reported by various workers in sweet corn, Collins and Taylor (1976) reported 70.44 to 74.94 per cent, and Makhlof *et al.* (1995) reported 75.5 per cent moisture in sweet corn. Sanderson *et al.* (1979) reported 73.3 to 87.7 per cent moisture in different sweet corn varieties. The higher upper limit reported may be due to different harvesting period of sweet corn.

The crude protein content was 13.44 g/100g in HSC-I and 15.30 g/100g in Madhuri, on dry matter basis. Significantly ($P < 0.05$) higher amount of protein content was found in Madhuri than in HSC-I. The protein content obtained is in agreement with that reported in LII Annual Progress Report (2008), where 15.79 per cent protein was reported in genotype Madhuri. Protein content in different genotypes of sweet corn on dry matter basis was reported to range from 9.31 to 18.67 per cent Sweet corn was reported to have 14.5 g/100g protein (Gopalan *et al.*, 1989). Awasthi *et al.* (2002) in their study on nutrition composition of normal maize reported its crude protein to range 9.60 to 12.10 per cent. On the other hand, Yadav and Yadav (2002) reported a wide variation in protein content of maize ranging from 4.10 to 12.98 per cent.

Crude fat was observed to be significantly higher in Madhuri (2.58%), than in HSC-I (2.26%) on dry matter basis. The value of fat content obtained in sweet corn genotypes are in close agreement with those reported earlier by Sanderson *et al.* (1979) who reported fat content in sweet corn varieties to range from 1.7 to 4.2 per cent.

The ash content in HSC-I and Madhuri was determined as 4.42 and 4.70 per cent, respectively, on dry matter basis. Significant difference was observed in ash content of both the genotypes. Results obtained are in close conformity to those obtained by Sanderson *et al.* (1979) who reported 2.4 to 5.5 per cent ash content in sweet corn varieties on dry matter basis. Sweet corn was found to contain comparatively less ash content than baby corn (Santosh, 2005) and high ash content than maize, dry (1.50 g/100g) and commonly used vegetables like brinjal (0.30 g/100g), cucumber (0.30 g/100g), French beans (0.50 g/100g) and green papaya (0.50 g/100g) (Gopalan *et al.*, 1989).

Sweet corn contained 3.76 and 3.13 per cent crude fibre in HSC-I (Hybrid) and Madhuri (Variety), respectively, on dry matter basis. Values were significantly ($P < 0.01$) higher in HSC-I than that of Madhuri. Sanderson *et al.* (1979) reported almost similar value for crude fibre in sweet corn varieties. Sweet corn contain higher crude fibre content than

most of the commonly used vegetables like lettuce, radish, spinach, bottlegourd, colacasia stem and ridge gourd (Goplan *et al.*, 1989).

5.1.2 Available carbohydrates

The total soluble sugar content was found to be 11.70 and 13.51 per cent in HSC-I and Madhuri on dry matter basis, respectively. Madhuri contained significantly ($P < 0.05$) higher amount of total soluble sugar content than HSC-I. The result obtained for total soluble sugars are in agreement to the values reported earlier in LII Annual Progress Report (2008). In different sweet corn genotypes, total soluble sugar was reported to range from 5.39 to 17.50 per cent (LII Annual Progress Report, 2008). Meena *et al.*, (2005) reported 10.14 per cent of total soluble sugar content in Madhuri. Sweet corn was found to contain comparatively high total soluble sugar content that of normal maize, Khadar and Phani (1997) reported a range of 2.07-3.70 per cent of total soluble sugars in normal maize because sweet corn is the result of a naturally occurring recessive mutation in the genes which control conversion of sugar to starch inside the endosperm of the corn kernel (Schultheis, 1994).

The reducing sugar content was 2.81 per cent in HSC-I and 3.40 per cent in Madhuri on dry matter basis (Table 4.2). Data indicated significant varietal influence on the reducing sugar content of selected sweet corn genotypes. The findings of the present study are in agreement with that reported earlier by Meena *et al.* (2005), who reported 2.19 to 2.70 per cent reducing sugar in different sweet corn varieties. The results observed for reducing sugars content was higher than the reducing sugar content of maize, which range from 0.07-0.24 per cent in normal maize (Park *et al.*, 2000).

The non-reducing sugar content in HSC-I and Madhuri was 8.89 and 10.10 per cent respectively. Significantly ($P < 0.05$) higher amount of non-reducing sugar content was found in Madhuri than in HSC-I (Hybrid). Findings of the present study are supported by results of earlier study conducted by Meena *et al.* (2005) who reported non-reducing sugar content to vary from 6.25 to 7.44 per cent in sweet corn genotypes. The difference in reducing sugars content of sweet corn genotypes under investigation with earlier reported values might be due to the difference in varieties selected for investigation.

The starch content was found significantly higher in HSC-I i.e. 57.98 per cent, than in Madhuri, in which it was 53.26 per cent on dry matter basis. Meena *et al.* (2005) also reported similar values of starch content in sweet corn. The results obtained for starch content are in agreement to the values reported earlier in LII Annual Progress Report (2008) in which starch was reported to range from 37.61-72.10 per cent in different sweet corn cultivars.

5.1.3 In vitro protein and starch digestibility

In vitro protein digestibility of sweet corn was found to be 67.38 per cent in HSC-I and 71.25 per cent in Madhuri on dry matter basis. Non-significant difference in the *in vitro* protein digestibility was observed in both the genotype. The findings of the present study are

in agreement with those reported by Singh (2002), who reported a higher protein digestibility (70.81 to 82.75%) in maize cultivars. Santosh (2005) reported similar values in baby corn.

Starch digestibility (*in vitro*) of HSC-I was 36.13 mg maltose release per gram, which found to be significantly higher than that of Madhuri (31.83 mg maltose released per gram). The results obtained are consistent with those reported earlier by Khader and Phani (1997) who found *in vitro* starch digestibility of maize in the range of 34.86-36.20 mg maltose released per gram.

5.1.4 Vitamins

The ascorbic acid content of both the sweet corn genotypes was almost similar i.e. 6.13 mg/100g in HSC-I and 5.86 mg/100g in Madhuri, on fresh matter basis. The obtained values for ascorbic acid content of selected sweet corn genotypes are in close agreement with earlier studies conducted by Makhlof *et al.* (1995) who reported 6.8 mg/100g ascorbic acid in raw corn. Sweet corn thus can supply ascorbic acid higher than and most of the common vegetables like carrot, calocasia stem, pumpkin and ridge gourd which supply 3.00, 3.00, 2.00 and 5.00 mg ascorbic acid/100g, respectively (Gopalan *et al.*, 1989).

The β -carotene content was found to be significantly higher in Madhuri (48.41 μ g/100g) than in HSC-I (46.34 μ g/100g), on fresh matter basis. The level of β -carotene in selected sweet corn is comparable to the values reported by (Gopalan *et al.*, 1989) in maize tender.

5.1.5 Total minerals

The magnesium content was 253.66 and 252.75 mg/100g in HSC-I and Madhuri, respectively, on the dry matter basis. Sweet corn was found to contain comparatively high magnesium content than maize dry (Gopalan *et al.*, 1989) and less than baby corn (Santosh, 2005).

The zinc content of HSC-I and Madhuri was almost similar and was 5.03 and 5.10 mg/100g on dry matter basis, respectively. Sweet corn was found to contain comparatively less zinc content than baby corn (Santosh, 2005) and high zinc content than maize, dry (2.8 mg/100g) and commonly used vegetables like bringal (0.22 mg/100g), beet root (0.91 mg/100g), bitter gourd (0.46 mg/100g), cauliflower (0.40 mg/100g) and french beans (0.42 mg/100g) (Gopalan *et al.*, 1989).

The iron content was 6.60 and 6.51 mg/100g in HSC-I and Madhuri respectively, on dry matter basis. Non-significant difference was observed between iron content of both the sweet corn genotypes. The values obtained for iron in the present study are consistent with values reported earlier by Santosh (2005) who reported 6.91 mg/100g of iron in baby corn. Iron content of sweet corn was observed to be higher than a number of common vegetables like bitter gourd (0.61 mg/100g), brinjal (0.38 mg/100g), french beans (0.61 mg/100g) and ladies finger (0.35 mg/100g) as reported by Gopalan *et al.* (1989).

The phosphorus content of Madhuri (366.98 mg/100g) was found to be significantly higher than phosphorus content of HSC-I (357.19 mg/100g). As indicated by phosphorus content, sweet corn was found to be the rich source of phosphorus and was several times higher than the phosphorus content of other common vegetables like cabbage, lettuce, spinach, bitter gourd, brinjal, cauliflower, french beans and ladies finger which are reported to have 44.00, 28.00, 26.00, 10.00, 47.00, 57.00, 28.00 and 56.00 mg phosphorus per 100g, respectively (Gopalan *et al.*, 1989).

5.2 Organoleptic evaluation of developed products

Various food products including salad, soup, cutlet, manchurian, *pulav*, dry vegetable, *kofta* curry, *halwa*, *kheer* and pickle were developed utilizing sweet corn. The organoleptic acceptability of the products was adjudged by a panel of ten judges using nine point Hedonic Rating Scale, and acceptability of products was as under.

5.2.1 Salad and Soup

Mean scores for sensory characteristics of salad and soup depicts that both were liked very much by the judges. The mean scores for colour, appearance, flavour, texture and taste of soup and salad using fresh sweet corn ranged from 7.80 to 8.30 (soup) and 7.90 to 8.20 (salad). Santosh (2005) also prepared soup and baby corn chat, using baby corn which were found acceptable in terms of all sensory attributes.

5.2.2 Cutlet, manchurian and *pulav*

Sensory attributes i.e. colour, appearance, flavour, texture, taste and overall acceptability of Cutlet, manchurian and *pulav* prepared using the fresh kernels of hybrid (HSC-I) and variety (Madhuri) of sweet corn were liked very much by the judges. Non-significant difference was observed between the mean scores of sensory attributes of cutlet, manchurian and *pulav* developed from both the genotypes. Santosh (2005) reported that cutlet and manchurian prepared using fresh baby corn, were acceptable highly in terms of all sensory attributes.

5.2.3 Dry vegetable and *kofta* curry

Mean scores of dry vegetable prepared using HSC-I (Hybrid) and Madhuri (Variety) showed that dry vegetable was liked very much in terms colour, appearance, flavour, texture, taste and overall acceptability. And data indicated (Table 4.8) that variety had no influence on acceptability of dry vegetable. Results of organoleptic acceptability of sweet corn dry vegetables are in close agreement to those reported by Santosh (2005), and Gupta (2008). The acceptability scores of *kofta* curry prepared using sweet corn genotypes indicated that the *kofta* curry was liked very much in the terms of all sensory attributes. The results are in close conformity with the study of Santosh (2005), who reported that *kofta* curry developed using baby corn was organoleptically acceptable.

5.2.4 Halwa and Kheer

Mean scores of sweet products, i.e. *halwa* and *kheer* developed using HSC-I (Hybrid) and Madhuri (Variety) indicated that sweet products i.e. *halwa* was liked very much by the judges in terms of colour, appearance, flavour, texture and overall acceptability whereas *kheer* lied in the category liked extremely. The results are in close agreement with the study of Anitha and Rajyalakshmi (2005), and Santosh (2005) who reported that *halwa* and *kheer* developed using baby corn were organoleptically acceptable.

5.2.5 Pickle

Sweet corn pickle was developed using sweet corn genotypes HSC-I and Madhuri. The mean scores of pickle developed using both the sweet corn genotypes lied in the category of liked moderately as indicated by mean scores of organoleptic characteristics. The results of sensory scores of pickle are in close agreement to that of reported by Anitha and Rajyalakshmi (2005) and Santosh (2005) used baby corn for development of pickle, on the other hand Dwivedi *et al.* (2005) found vegetable pickle and mixed pickle organoleptically more acceptable (8.70) as compared to sweet corn pickle.

5.3 Shelf life of dehydrated sweet corn

Sweet corn kernels were removed from the cob and dried in oven at 45⁰C for 26 hours. The dehydrated samples were cooled and packed in polyethylene packets and sealed and stored for 90 days at room temperature (25-30⁰C), and analyzed for nutritional composition and organoleptic evaluation at every 30 days interval up to 90 days.

5.3.1 Effect of storage on nutritional composition of dehydrated sweet corn

Dehydrated sweet corn was analyzed for proximate composition, available carbohydrate and mineral content on of 0, 30, 60 and 90 days of storage.

5.3.1.1 Proximate composition

Moisture:

Moisture content of dehydrated sweet corn genotypes HSC-I and Madhuri on zero day of storage was 4.10 g/100g and 4.38 g/100g, respectively. Non-significant increase i.e. 0.48 to 2.19 per cent in HSC-I and 0.22 to 1.82 per cent in Madhuri was observed during zero, 30th, 60th and 90th day of storage. Varietal difference in moisture content remained significant during storage between both the genotypes. The results are in conformity with the published literature (Arora and Bakshi, 1994, Pawar *et al.*, 1994). Sheriful (2002) reported a range of 5.92 to 7.53 per cent moisture content during storage of various dehydrated pea varieties. Santosh (2005) observed the same trend and reported non-significant increase of 8.19 per cent in moisture content of baby corn by the end of storage of 90 days.

Crude protein:

Results (Table 4.11) for protein content indicated that crude protein content of HSC-I (hybrid) and Madhuri decreased by 1.86 and 2.22 per cent on 30th day, by 4.83 and 4.44 per

cent on 90th day respectively as compared to zero day. Similar decrease in protein content of dried peas during storage was observed by Kulesza and Gertig (1976). Sheriful (2002) noticed a decline of 0.19 to 0.31 per cent protein in various pea cultivars during storage of dehydrated peas for 6 months. Non-significant reduction of 3.12 per cent by the end of storage of 90 days in protein content of dehydrated baby corn was reported by Santosh (2005). Tandon (2006) observed a reduction of ranged 2.00 to 2.04 per cent in protein content in different pea cultivars.

Total ash: Total ash content of HSC-I and Madhuri was 4.42 and 4.70 g/100g on zero day and 4.29 and 4.57 g/100g on 90th day of storage. There was a reduction of 2.94 and 2.76 per cent in HSC-I and Madhuri, respectively at the end of storage period. Significant varietal differences were observed in the ash content between both the genotypes. Similar trend in reduction of ash content in baby corn was noticed after the storage period of 90th day. Santosh (2005) and Tandon (2006) observed significant reduction in ash content of pea cultivars ranges 5.97 to 7.62 per cent on the 90th day of storage.

Crude fat:

Crude fat content of HSC-I and Madhuri was 2.26 and 2.58 g/100g on zero day. Reduction in fat content was observed in both the genotypes by 2.21 and 5.81 per cent on 30th day, by 4.42 and 6.58 per cent on 60th day and 5.75 and 8.52 per cent in HSC-I and Madhuri, respectively at end of storage interval. Santosh (2005) reported that fat content declined from 6.57 to 8.45 per cent during storage of 3 months in dehydrated baby corn. Similar trend of reduction in fat content during storage of 3 months was observed by Tandon (2006) who reported significant reduction in fat content, ranged from 6.92 to 14.86 per cent in different peas cultivars at the end of storage period.

Crude fibre:

Fibre content in oven dried HSC-I and Madhuri was 3.76 and 3.13 g/100g on zero day. A slight reduction of 0.79 and 1.59 per cent by 30th day, 1.32 and 2.23 per cent by 60th day and 2.12 and 3.98 per cent by 90th day were observed in fibre content of HSC-I and Madhuri, respectively. Santosh (2005) in earlier study also indicated that fibre content declined by 1.19 per cent in dehydrated baby corn on storage for three months and Tandon (2006) indicated that fibre content declined significantly by 3.12 to 3.80 per cent in dehydrated peas, during the storage of 3 months.

5.3.1.2 Available carbohydrate

Total soluble sugar :

Total soluble sugar content of HSC-I and Madhuri was 11.70 and 13.51 g/100g at zero day and reduced slightly by the end of storage period of 90 days. Similarly, Tandon (2006) reported a decline of 6.04 to 19.0 per cent in total soluble sugar content of various dehydrated cultivars of peas throughout the storage of 6 months.

The value of total soluble sugar ranged from 4.60 to 10.14 per cent in dehydrated peas during the storage of 2 months (Ruchika, 2004).

Reducing sugars:

As indicated by the data (Table 4.12) reducing sugar content of dehydrated sweet corn genotypes i.e. HSC-I and Madhuri decreased gradually from 2.81 and 3.40 g/100g on zero day to 2.51 and 3.18 g/100 g on 90th day respectively. A reduction of 10.67 and 6.47 per cent in reducing sugar of HSC-I and Madhuri was observed on 90th day of storage, respectively. Similarly, reducing sugar content as reported by Tandon (2006) declined significantly by 5.84 to 23.72 per cent in dehydrated peas during storage of 90 days.

Non-reducing sugars:

Non-reducing sugar content of HSC-I was 8.89 g/100g and madhuri was 10.10 g/100g, on zero day. A slight reduction in non-reducing sugar content of both the genotypes was observed up to the end of storage period. However, in a study, Tandon (2006) indicated higher reduction in non-reducing sugar content i.e. by 17.90 to 20.12 per cent during the storage of dehydrated pea cultivars for 3 months.

Starch:

Starch content of both the sweet corn genotype (HSC-I and Madhuri) remained almost same throughout the storage period. However, loss of 2.05 per cent in starch content of pea cultivars was observed during dehydrated storage for 3 months by Tandon (2006).

5.3.1.3 Total minerals

Magnesium:

Results for magnesium content in both dehydrated sweet corn genotypes indicated that magnesium content decreased slightly during storage in both the genotypes. Magnesium content of HSC-I and Madhuri reduced slightly i.e. by 0.78 and 0.95 per cent on 30th day, by 1.90 and 2.21 per cent on 60th day and by 3.54 and 3.75 per cent on 90th day (Fig. III), respectively. Santosh (2005) reported lower loss of 2.61 per cent during storage of dehydrated baby corn.

Zinc:

Zinc content of dehydrated HSC-I and Madhuri were 5.03 and 5.10 mg/100g respectively on zero day. Zinc content reduced significantly by 0.95 and 4.90 per cent on 30th day, by 5.96 and 6.66 per cent on 60th day and by 6.56 and 7.25 per cent on 90th day in HSC-I and Madhuri, respectively. Santosh (2005) reported similar loss of 7.74 per cent in zinc content during storage of dehydrated baby corn for about three months. Similarly, Tandon (2006) also reported that storage of dehydrated peas for three months resulted in 7.74 to 10.05 per cent loss of zinc content.

Iron:

Iron content in oven dried sweet corn genotypes i.e. HSC-I and Madhuri was 6.60 and 6.51 mg/100, respectively, on zero day. Decline of 1.66 to 5.60 per cent was observed in HSC-I and 0.61 to 4.45 per cent was observed in Madhuri during 30th to 90th day of storage. The reduction was statistically non-significant. Iron content declined from 6.97 to 6.57 mg/100g during the storage of baby corn for duration of 3 months as reported by Santosh (2005). In another study reduction of 0.75 to 3.00 per cent in iron content was reported during the storage of dried pea cultivars for a period of 3 months (Tandon, 2006).

Phosphorus:

Phosphorus content in oven dried sweet corn was 357.19 and 366.98 mg/100g in HSC-I and Madhuri on zero day. Significant decline of 9.57 and 10.35 per cent in HSC-I and Madhuri was observed by the end of storage period. Whereas, 6.70 per cent loss in phosphorus was observed, in dehydrated baby corn after three months of storage (Santosh, 2005).

5.3.2 Effect of storage on acceptability of products developed from dehydrated sweet corn

Dehydrated sweet corn genotypes i.e. HSC-I and Madhuri were utilized for the preparation of various products including sweet corn soup, *kheer*, cutlet and dry vegetable at each storage period of 30, 60 and 90 day. Mean scores for all the sensory attributes of soup, *kheer*, cutlet and dry vegetable prepared using dehydrated HSC-I and dehydrated Madhuri (Variety) indicated that all the products were found to be acceptable at 0, 30, 60 and 90th day of storage in term of all sensory attributes viz., colour, appearance, flavour, texture, taste and overall acceptability. The mean sensory scores of soup, *kheer*, cutlet and dry vegetable although declined slightly by 90th day but acceptability lied in the category -liked very much throughout the storage period. The storage period did not affect the acceptability of soup, cutlet, dry vegetable and *kheer*. Santosh (2005) also prepared baby corn soup and mixed vegetable using dehydrated baby corn and found them acceptable throughout the storage. On the other hand, Tandon (2006) prepared dry vegetable from dehydrated peas at each interval of 30 days upto 3 months and found it acceptable in terms of all sensory attributes. Dehydrated sweet corn can be stored safe up to three months and can be utilized in various food preparations. The acceptability of the products prepared from dehydrated and stored sweet corn indicates that sweet corn can be dehydrated during gult season and used in various food products, during period of non availability.

5.4 Shelf life of frozen sweet corn

Sweet corn kernels was removed from the cob and packed in polyethylene packets and sealed and stored for 90 days in freezer at -20^oC. Frozen sweet corn samples were

analyzed for nutritional composition and organoleptic evaluation of products prepared from frozen sweet corn at every 30 days interval up to 90 days.

5.4.1 Effect of storage on nutritional composition of frozen sweet corn

Frozen sweet corn was analyzed for proximate composition, available carbohydrate and mineral content on of 0, 30, 60 and 90 days of storage.

5.4.1.1 Proximate composition

Moisture:

Moisture content of frozen sweet corn genotypes HSC-I and Madhuri on zero day of storage was 70.38 g/100g and 72.21 g/100g, respectively. Non-significant increase i.e. 0.04 to 0.11 per cent in HSC-I and 0.04 to 0.22 per cent in Madhuri was estimated during 0, 30th, 60th and 90th day of storage. Similar findings have been reported by Santosh (2005).

Crude protein:

Protein content in dehydrated HSC-I and Madhuri was 13.44 and 15.30 g/100g on zero day. A slight reduction in protein content i.e. 1.33 and 2.67 per cent on 30th day, 2.38 and 3.59 per cent on 60th day and 3.86 and 6.27 per cent on 90th day were observed in HSC-I and madhuri, respectively. Dhaliwal (2002) also reported slight but non-significant reduction in protein content of frozen stored vegetables similarly, Jaswinder (2003) reported non-significant reduction in protein content of frozen stored vegetables i.e. beans, okra and capsicum. Santosh (2005) indicated 1.5 per cent decline in protein content in frozen baby corn and Tandon (2006) indicated 2.04 per cent reduction in protein content in frozen peas, during the storage of three months.

Total Ash:

Ash content of HSC-I and Madhuri was 4.42 and 4.70 g/100g on zero day (Table 4.8). Slight reduction of ash content was observed in both the genotypes by 0.90 and 1.27 per cent on 30th day, by 2.48 and 2.97 per cent on 60th day and by 5.65 and 5.74 per cent by the end of storage period. The observed reduction in ash content of frozen sweet corn may be due to leaching of minerals during thawing done during drying of sweet corn for analysis of ash. Similarly, in earlier study on frozen foods, Pawar *et al.* (1994) also observed significant reduction in ash content of peas during 4½ months of frozen storage and Santosh (2005) observed higher reduction of 11.32 per cent in ash content of frozen baby corn.

Crude fat:

Crude fat content of HSC-I (Hybrid) was 2.26 and Madhuri (Variety) was 2.58 g/100g on zero day. Crude fat content of both the genotype reduced significantly by 7.96 and 7.75 per cent on 90th day of storage. Non-significant decline of 9.39 per cent by the end of storage of 90th day in fat content of frozen baby corn was reported by Santosh (2005) on the other hand decline of 7.56 to 9.03 per cent by the end of storage of 3 months was reported in fat content of frozen peas by Tandon (2006).

Crude fibre :

Results (Table 4.18) for fibre content indicated that crude fibre content of HSC-I and Madhuri decreased slightly by 0.79 and 0.95 per cent on 30th day and by 3.72 and 2.87 per cent on 90th day, respectively. Similar trend of slight reduction of crude fibre content of frozen vegetables was observed by Dhaliwal (2002) and Jaswinder (2003). Similar reduction in fibre content in frozen peas was reported by Tandon (2006) in frozen baby corn Santosh (2005).

5.4.1.2 Available carbohydrates**Total soluble sugars :**

Total soluble sugar content of HSC-I was 11.70 g/100g and Madhuri was 13.51 g/100g, on zero day. A slight reduction in total sugar content of both the genotype were observed up to the end of storage period. Similar to findings of present study, Tandon (2006) also indicated that total soluble sugar content declined by 3.92 to 4.38 per cent during the storage of frozen pea cultivars for three months. In another study, Dhaliwal (2002) and Jaswinder (2003) reported non-significant reduction in total soluble sugar content of frozen vegetables i.e. beans, okra and capsicum.

Reducing sugars:

Results indicated that (Table 4.19) reducing sugar content of frozen sweet corn genotypes i.e. HSC-I and Madhuri decreased slightly from 2.81 and 3.40 g/100g on zero day to 2.68 and 3.21 g/100g on 90th day respectively. A reduction of 4.62 and 5.58 per cent of reducing sugar in HSC-I and Madhuri, respectively was observed after 90th days of storage. Reducing sugar content as reported by Tandon (2006) declined by 3.63 to 21.73 per cent in frozen peas during storage of 90 days.

Non-reducing sugars:

Non-reducing sugar content of HSC-I and Madhuri was 8.89 and 10.10 g/100g at zero day and reduced slightly upto the end of storage period. The value of non-reducing sugars declined, by 4.16 and 2.67 per cent, on 90th day of storage. A slight reduction in non-reducing sugar content during the storage of frozen vegetables has also been reported by various workers (Dhaliwal, 2002; Jaswinder, 2003). On the other hand, Tandon (2006) reported significant reduction of non-reducing sugar content in frozen peas for the storage period of three months.

Starch :

Starch content of both the sweet corn genotype (HSC-I and Madhuri) remained almost similar throughout the storage period. No significant reduction was observed in starch content of both the genotypes at the end of storage of 3 months. Dhaliwal (2002) also reported slight but non-significant reduction in starch content of frozen stored vegetables. Similarly,

Tandon (2006) indicated slight reduction of starch (0.76 to 0.94%) in frozen pea cultivars during the storage period of 3 months.

5.4.1.3 Total minerals

Magnesium:

Magnesium content in frozen sweet corn genotypes i.e. HSC-I and Madhuri was 253.66 and 252.75 mg/100g, respectively on zero day. Decline of 0.97 to 3.41 per cent was observed in HSC-I and 1.15 to 3.59 per cent in Madhuri during 30th to 90th day of storage. The reduction in magnesium content was statistically non-significant. Santosh (2005) reported higher loss of 6.96 per cent during frozen storage of baby corn.

Zinc:

Zinc content in frozen sweet corn was 5.03 and 5.10 mg/100g in HSC-I and Madhuri on zero day, respectively. Significant reduction of 4.77 and 5.68 per cent in zinc content in HSC-I and Madhuri was observed by the end of storage period. Santosh (2005) reported higher loss of 12.09 per cent during storage of frozen baby corn for about three months. Similarly, Tandon (2006) also reported that storage of frozen peas for three months resulted in 4.19 to 5.66 per cent loss of zinc content.

Iron:

Results for iron content of both frozen sweet corn (Hybrid and Variety) indicated that iron content decreased slightly during storage in both the genotypes. The iron content decline from, 6.91 to 6.12 mg/100g during, the storage of baby corn for duration of three months as reported by Santosh (2005).

Phosphorus:

Phosphorus content of frozen HSC- and Madhuri was 357.19 and 366.98 mg/100g, respectively on zero day. Phosphorus content declined significantly by 0.97 and 1.61 per cent on 30th day, by 5.41 and 6.62 per cent on 60th day, and by 6.85 and 7.88 per cent on 90th day in HSC-I and Madhuri, respectively. Higher losses (7.03%) in phosphorus were observed in baby corn during storage of three months (Santosh, 2005).

The observed reduction in magnesium, zinc, iron and phosphorus content of frozen sweet corn during three months storage period may be due to leaching of minerals during thawing process.

5.4.2 Effect of storage on acceptability of products developed from frozen sweet corn

Frozen sweet corn of both the genotypes at storage interval of 0, 30, 60 and 90 days was utilized for preparation of various products including sweet corn soup, cutlet, dry vegetable and *kheer*. Mean scores for all the sensory attributes of soup, cutlet, dry vegetable and *kheer* prepared using frozen sweet corn genotypes i.e. HSC-I and Madhuri (Table 4.21 to 4.24) at different storage intervals depicted that products were in the category -liked very much. A slight reduction in the mean scores for colour, appearance, flavour, texture and taste

for soup, cutlet, dry vegetable and *kheer* were observed when prepared from stored frozen corn up to 90 days. However, mean scores for colour, appearance, flavour, taste and texture of all the developed products prepared at each interval of 30 day of storage were in the category of -liked very much. The storage period did not affect the acceptability of soup, cutlet, dry vegetable and *kheer* prepared from frozen kernels of HSC-I and Madhuri. Dhaliwal (2002) also prepared dry vegetable using frozen vegetables at each storage interval of 30 days and reported to be acceptable. Non-significant differences in colour, flavour, appearance, texture and taste of dry vegetable were reported throughout the storage period. Similarly, Santosh (2005) used frozen baby corn for development of products i.e. soup, mixed vegetable, *masala* baby corn and found all the products acceptable when prepared using frozen baby corn stored for 90 days. Tandon (2006) also found dry vegetable prepared from frozen peas acceptable at each interval of a month up to three months. The products prepared from frozen corn stored for 90 days were acceptable, thus sweet corn can conveniently be frozen for utilization in product development.

The present study was undertaken for the nutritional evaluation, utilization of sweet corn for product development and increasing its shelf life by dehydration and freezing. Samples of sweet corn cultivar i.e. HSC-I (Hybrid) and Madhuri (Variety) were obtained from Regional Research Station, CCS Haryana Agricultural University, Uchani, Karnal. Sweet corn were nutritionally analyzed for proximate composition, available carbohydrates, mineral content, *in vitro* protein and starch digestibility and vitamins. Fresh sweet corn genotypes were utilized for the development of various products including soup, salad, dry vegetable, *kofta* curry, *pulav*, cutlet, manchurian, *kheer*, *halwa* and pickle and these products were studied for organoleptic acceptability. Sweet corn genotypes were subjected to two processing method i.e. dehydration and freezing for extending their shelf-life. The dehydrated and frozen samples were nutritionally analyzed for proximate composition, available carbohydrate and mineral content at 0, 30th, 60th and 90th day of storage. At each storage interval frozen and dried sweet corn genotypes were used for development of soup, dry vegetable, cutlet and *kheer* and evaluated organoleptically.

The result of nutritional evaluation of sweet corn indicated that HSC-I contained 70.30, 13.44, 4.42, 2.26 and 3.76 per cent moisture (on fresh matter basis), protein, fat, ash and crude fibre, respectively where as Madhuri contained 72.21, 15.30, 4.70, 2.58 and 3.31 per cent moisture (on fresh matter basis), protein, fat, ash and crude fibre, respectively on dry matter basis. The amount of crude protein, total ash and crude fat was significantly higher in Madhuri than in HSC-I.

Sweet corn contained 11.70 and 13.51 per cent total soluble sugar, 2.81 and 3.40 g/100g reducing sugars, 8.89 and 10.10 g/100g non-reducing sugars, 57.98 and 53.26 g/100g starch in HSC-I and Madhuri on dry matter basis, respectively. *In vitro* protein digestibility of sweet corn genotypes was 67.38 and 71.25 per cent whereas *in vitro* starch digestibility was 36.13 and 31.83 mg maltose released per gram in HSC-I and Madhuri respectively. The amount of ascorbic acid and β -carotene was found 6.13 and 5.86 mg/100g, 46.34 and 48.41 g/100g in HSC-I and Madhuri on fresh matter basis, respectively. The sweet corn genotypes HSC-I and Madhuri contained 253.66 and 252.75 mg/100g magnesium, 5.03 and 5.10 mg/100g zinc, 6.60 and 6.51 mg/100g iron, 357.19 and 366.98 mg/100g phosphorus, respectively, on dry matter basis. Magnesium, zinc and iron content of both the sweet corn genotype were almost similar.

The results of organoleptic evaluation of products from fresh sweet corn genotypes (Hybrid and Variety) indicated that all the products viz. salad, soup, cutlet, manchurian,

pulav, dry vegetable, *kofta* curry, *halwa*, *kheer* and sweet corn pickle were highly acceptable and were liked very much by the judges. The scores for all the sensory attributes were in the category of 'liked extremely' except flavour of soup prepared using both genotypes, texture of salad prepared using fresh Madhuri (Variety), texture of dry vegetable prepared using fresh kernels of HSC-I (Hybrid), flavour and texture of pulav prepared using fresh kernels of HSC-I, were 'liked very much' by the judges. All the sensory attributes viz., colour, appearance, flavour, texture, taste and overall acceptability of *kheer* prepared using both sweet corn genotype (HSC-1 and Madhuri) were in category 'liked extremely' whereas scores of all the sensory attributes of *halwa* and pickle prepared by using HSC-I and Madhuri were in the category 'liked very much' by the judges.

The result of nutritional evaluation of dehydrated sweet corn stored for 90 days indicated that moisture content of dehydrated sweet corn genotypes (HSC-I and Madhuri) increased slightly from 0.48 to 2.19 per cent in HSC-I and from 0.22 to 1.82 per cent in Madhuri on 90th day of storage, respectively. Crude protein content of HSC-I and Madhuri remained almost unchanged throughout the storage period of three months. Ash content decreased significantly by 0.90 per cent on zero day to 2.94 per cent of 90th day of storage in HSC-I and by 1.70 per cent on zero day to 2.76 per cent of 90th day of storage in Madhuri. Crude fat content of both the genotypes HSC-I and Madhuri decreased significantly by 5.75 and 8.52 per cent, respectively till end of storage as compared to zero day. Crude fibre content of dehydrated HSC-I and dehydrated Madhuri remained almost unchanged during the entire storage period. Crude protein, ash and fat content of Madhuri was significantly higher than HSC-1 at each storage interval and fibre content of HSC-1 was significantly higher than Madhuri and remained higher in HSC-1 throughout the storage period.

During the dehydrated storage of sweet corn, total soluble sugar content of HSC-I and Madhuri decreased by 5.58 and 3.55 per cent at the end of storage as compared to total soluble sugar content of HSC-I and Madhuri on zero day. On storage of dehydrated kernels for three months, significant reduction of 10.67 and 6.47 per cent in reducing sugars content was observed in HSC-1 and Madhuri, respectively. Non-reducing sugars content of HSC-I and Madhuri on zero day was 8.89 and 10.10 g/100g, respectively which reduced by 4.38 and 2.47 per cent, respectively by the end of storage. Non significant changes were observed in starch content of both the dehydrated genotypes (HSC-I and Madhuri) throughout the storage period. Total soluble sugar, reducing sugars, non-reducing sugars content of Madhuri was significantly higher than HSC-1 at each storage interval and starch content of HSC-1 was significantly higher than Madhuri and remained higher in HSC-1 throughout the storage period.

Magnesium showed a non significant reduction of 3.54 and 3.75 per cent in HSC-I and Madhuri, respectively till the end of storage study. Zinc content of dehydrated sweet corn

genotypes i.e. HSC-I and Madhuri decreased gradually from 5.03 and 5.10 mg/100g on zero day to 4.70 and 4.73 mg/100g on 90th day of storage. Iron content showed a non significant reduction of 5.60 and 4.45 per cent HSC-I and Madhuri, respectively. Phosphorus content of HSC-I and Madhuri decreased significantly by 9.57 and 10.35 per cent till the end of storage interval, respectively. Inter genotype difference in total minerals of both the genotypes during storage period were found to be non significant.

The results obtained for organoleptic acceptability of products developed from stored dehydrated sweet corn indicated that soup, cutlet, dry vegetable and *kheer* prepared from dehydrated kernels of HSC-I (Hybrid) and Madhuri (Variety) at zero day was liked extremely and mean scores for all the sensory attributes were in the category of liked very much of all the products prepared on 30th, 60th and 90th day from dehydrated HSC-I and dehydrated Madhuri. A slight reduction in the scores for all the sensory attributes of all four product were observed till the end of the storage period. However, all the products lied in the category of liked very much throughout the storage period. There were no significant difference observed between mean scores of all the sensory attributes of soup, cutlet, dry vegetable and *kheer* prepared by both genotypes at every interval of storage which indicated that variety had no influence on acceptability of developed products.

The results obtained for nutritional evaluation of frozen sweet corn indicated that there was non significant increase of 0.11 and 0.22 per cent in moisture content of frozen HSC-I and Madhuri, respectively. Crude protein and crude fibre content of frozen sweet corn genotypes (Hybrid and Variety) showed non significant reduction during storage period. Ash content decreased significantly by 0.90 per cent on 30th day to 5.65 per cent of 90th day of storage in HSC-I and by 1.27 per cent on 30th day to 5.74 per cent of 90th day of storage in Madhuri. Fat content of frozen sweet corn i.e. HSC-I and Madhuri decreased significantly by 7.96 and 7.75 per cent till the end of storage period. However, moisture, crude protein, total ash, fat content of Madhuri were found to be significantly higher in Madhuri as compared to HSC-I and remained higher throughout the storage period and fibre content of HSC-I was significantly higher than Madhuri and remained higher in HSC-I at each storage interval of 30 days upto three months.

Total soluble sugars content of frozen sweet corn reduced non significantly by 4.18 and 3.47 per cent in HSC-I and Madhuri, respectively till the end of storage study. Reducing sugars content of frozen HSC-I and Madhuri reflected significant reduction of 4.62 and 5.58 per cent, respectively till the end of storage period of three months. Non-reducing sugars did not show any significant reduction in both the genotypes similarly, starch content of both the genotype remained almost unchanged during the storage interval of three months. Total soluble sugar, reducing sugars, non-reducing sugars content of Madhuri was significantly

higher than HSC-1 at each storage interval and starch content of HSC-1 was significantly higher than Madhuri and remained higher in HSC-1 throughout the storage period.

Magnesium content of frozen HSC-I and Madhuri decreased slightly from 253.66 and 252.75 mg/100g to 245.00 and 243.66 mg/100g on 90th day of storage, respectively. Zinc content showed a significant reduction of 4.77 and 5.68 per cent in HSC-I and Madhuri, respectively by the end of storage period. Iron content of frozen sweet corn showed non significant decline from 6.60 and 6.51 mg/100g on zero day to 6.40 and 6.32 mg/100g on 90th day of storage in HSC-I and Madhuri, respectively. Phosphorus content of HSC-I and Madhuri showed a significant reduction of 6.85 and 7.88 per cent till the end of storage study. There were no significant inter genotype difference in mineral content of selected sweet corn genotypes at each storage interval, during storage.

The results obtained for organoleptic acceptability of products developed from stored frozen sweet corn indicated that soup, cutlet, dry vegetable and *kheer* prepared from frozen HSC-I and Madhuri were $\bar{\Delta}$ liked extremely on zero day. Acceptability scores of these products when prepared from frozen corn at 30, 60 and 90 days was in category of $\bar{\Delta}$ liked very much. A gradual reduction in the scores of all the sensory attributes viz. colour, appearance, flavour, texture, taste and overall acceptability of all products was noticed till the end of storage interval, but the scores of all sensory attributes of developed products were in the category $\bar{\Delta}$ liked very much and the category remained unchanged after 30 day of storage for all sensory attributes of developed products. There were no significant difference observed between the mean scores of all the sensory attributes of soup, cutlet, dry vegetable and *kheer* prepared by both genotypes at every interval of storage which indicated that variety had no influence on acceptability of developed products.

Thus, it can be concluded from the present study that sweet corn has a nutrient composition comparable to or even better than many common vegetable like cucumber, tomato, brinjal, cabbage, cauliflower etc. During the glut season sweet corn can be stored for a long period in dried and frozen conditions without much loss of nutrients and can be reutilized for product development during period of scarcity. Dehydration and freezing can be taken up as entrepreneurial activity of household level. Further studies are required to evaluate the microbiological safety of frozen and dried sweet corn and also on efficacy of pre-treatments like blanching, use of chemicals before drying and freezing of sweet corn.

LITERATURE CITED

- Aharoni, A., Azica, C., Gil, M. And Falik, E. 1996. Polyolefin stretch films maintain quality of sweet corn during storage and shelf-life. *Postharvest Biol. Technol.* **12**: 109-125.
- Amaro, M.A., Moreno, R. and Zurera, G. 1988. Nutritional estimation of changes in mineral content during frozen storage of white asparagus. *J. Food. Qual.* **21** (6): 445-458.
- Anitha, G. and Rajyalakshimi, P. 2005. Baby corn (*Zea mays*. L.): Physico-chemical characteristics and use in product development. *J. Food Sci. Technol.* **42** (3): 234-238.
- Annual progress Report. 2007. Directorate of Maize Research, Pusa Campus, New Delhi.
- AOAC. 2000. Official methods of analysis of the association of official Agricultural Chemists, Association of Analytical Chemists. Washington D.C.
- Aparicio, M.P., Rivas, J.C., Santos, C. and Garcia, C. 1989. Influence of storage conditions on quality of frozen green beans (var checkmate). *Revista-de-Agroquimicay-Tecnologia-de Alimentos.* **29** (2): 255-65. (Original not seen. Abstr. In: *FSTA*, AN: 1990-05-J0130, 1990-2001/05).
- Arora, S. and Bakshi, R. 1994. Effect of storage of physical characteristics and cooking quality of dehydrated peas and carrot. *J. Res. Punjab Agric. Uni.* **31** (1): 69-75.
- Awasthi, C.P., Singh, A.B., Sharma, B.K. and Singh, N. 2002. Biochemical evaluation of promising maize genotypes of Himachal Pradesh. In: Advance MAIZE production technology and quality improvement. Proc. Proceeding of National Seminar on Science Industry Interface in Maize Production, Processing and Utilization, HPKV, Palampur, Nov. 3-4. pp. 174-177.
- Bhobe, A.M. and Pai, J.S. 1986. Frozen storage of some Indian Green Vegetables. *J. Food Sci. Technol.* **23** (3): 133-135.
- Brewbaker, J.L., Banafunzi, N. 1975. 'Hawaiian super-sweet 6' corn. *Hort Science.* **10** (4): 427-428.
- Cartaya, G. L., Ortiz de, B. L., Bejarano, M. A. 1991. Physical and chemical characteristics of the grains of sweetcorn cultivars Pajimaca and Riqueza during maturation. *Agronomia Tropical Maracay.* **41** (5-6): 205-214.
- Cerning, J. and Guilhot, J., 1973. Changes in carbohydrate composition during maturation of wheat and barley kernel. *Cereal Chem.*, **50**: 220-222.
- Chen, P.S., Tosibara, T.Y. and Warner, H. 1956. Micro determination of phosphorus. *Anal. Chem.* **28**: 1756-1759.
- Clegg, K.M. 1956. The application of anthrone reagent of the estimation of starch in cereals. *J. Sci. Food Chem. Agric.* **7**: 40-44.
- Collins, J. L. and TAYLOR, J.C. 1976. Relationship between soluble solids level of raw sweet corn and sensory evaluation of deep fried corn-on the cob. *J. Food Sci.* **41**: 123-124.
- Coskun, M.B., Yalcin, I. and Ozarslan, C. 2006. Physical properties of sweet corn seed (*Zea mays saccharata* sturt). *J. Food Eng.* **74** (4): 523-528.
- Creech, R.G. 1965. Genetic control of carbohydrate synthesis in maize. *Genetics* **52** : 1175-1186.
- Das, N., Saini, S.P.S. and Bains, G.S. 1993. Effect of variety and maturity on quality and dehydrated peas. *Indian Food Packer* **43** (3): 17-24.
- Dass, S., Yadav, V.K., Kawatra, A., Rakshit, S., Kaul, J., Prakash, O., Singh, I., Singh, K.P. and Sekhar, J.C. 2008. Baby corn in India: DMR Technical Bulletin 2008/6. Directorate of Maize Research, Pusa Campus, New Delhi. pp. 1-45.
- Dayanand 1978. Market for dehydrated fruits and vegetables in India and Abroad. *Ind. Food Packer* **32** (1): 51-52.
- Deak, T., Heaton, F.K., Hung, Y.C. and Benchat, I.R. 1987. Extending the shelf-life of fresh sweet corn by shrink-wrapping, refrigeration and irradiation. *J. Food Sci.* **52**: 1625-1631.

- Dewanto, V., Wu, X. and Liu, R.H. 2002. Processed sweet corn has higher antioxidant activity. *J. Agric. Food Chem.* **50** (17): 4959-4964.
- Dewanto, V., Wu, X. and Liu, R.H. 2002. Processed sweet corn has higher antioxidant activity. *J. Agric. Food Chem.* **50** (17): 4959-4964.
- Dhaliwal, M. 2002. Nutritional and organoleptic evaluation of selected frozen vegetables. Ph.D. Thesis, Punjab Agricultural University, Ludhiana, India.
- Duffy, M. and Calvert, J. 2010. Sweet corn. ISU Department of Economics, Extension Economics, Iowa State University.
- Dwivedi, R., Shukla, P., Singh, G. and Bhattacharya, L. 2005. Development and quality evaluation of mushroom pickle, vegetable pickle and mixed mushroom-vegetable pickle. *Beverages and Food World*. **10** : 56-58.
- Evensen, K.B. and Boyer, C.D. 1986. Carbohydrate composition and sensory quality of fresh and stored sweet corn. *J. Amer. Soc. Hort. Sci.* **111** : 734-738
- Favell, D.J. 1997. A comparison of the vitamin C content of fresh and frozen vegetables. *Food Chem.* **62** (1): 59-64.
- Felix, G.R.R., George, W.V. and Martha, C.K. 1982. Sugar composition and flavour quality of high sugar (Shrunken) and normal sweet corn. *J. Food Sci.* **47** : 753-755.
- Flora, L.F. and Wiley, R.C. 1974. Sweet corn aroma, chemical components and relative importance in the overall flavour response. *J. Food Sci.* **39** : 770-773.
- Fuentes, Z. J. and Ciudad, B.C. 1974. Lysine and protein contents of some Chilean sweet corns (*Zea mays*). *Agricultura-Tecnica,-Chile*. **34** (1): 36-38.
- Garwood, D.L., Mc Ardle, F.J., Vanderslice, S.F. and Shannon, J.C. 1976. Post harvest carbohydrate transformations and processed quality of high sugar maize genotypes. *J. American Soci. Hort. Sci.* **101**: 400-404.
- Gauhar, A., Khan, A. and Jawaid, M. 1973. Losses of ascorbic acid in different varieties of sweet corn during processing. *Pakistan-J.-Scientific-Res.* **25** (1/2): 197-199.
- Gebhardt, S.D. and Matthews, R.H. 1981. Nutritive value of foods. USDA Human Nutrition Information service. Home and Garden bulletin 72. Washington, D.C.
- George, F. S. 1955. Corn and corn improvement. Academic Press Inc. Publishers. New york. pp. 441-446. .
- Goldman, I. L. and Tracy, W. F. 1994. Kernel protein concentration in sugary-1 and shrunken-2 sweet corn. *HortScience*. **29** (3): 209-210.
- Gopalan, C., Rama Sastri, B.V., Balasubramanian, S.C., Narasinga Rao, B.S., Doesthale, Y.G. and Pant, K.C. 1989. *Nutritive value of Indian Foods*. National Institute of Nutrition, ICMR, Hyderabad, India.
- Gupta, R.G. and Nath, N. 1984. Drying of tomatoes. *J. Food. Sci. Technol.* **21** (66) : 372-376.
- Gupta. 2008. Nutritional evaluation shelf-life and utilization of tomato powder and puree. M.Sc. Thesis, CCSHAU, Hsiar, India.
- Henard, M.C. 2003. USDA Foreign Agricultural Service. Global Agriculture Information Network Report Number : FR 3054. pp. 5.
- Howard, L., Wong, A., Perry, A. and Klein, B.P. 1996. The stability of nutrients in fresh and processed vegetables. pp 96. In : *IFT Annual Meeting : Book of Abstracts* (Original not seen. Abstr. in FSTA, AN : 1997-01-J0283, 1990-2001/05).
- <http://www.mdidea.com/products/new/new072b.html>
- Hugo, L.T., Marcial, S.J. and Eea, O.R. 1989 .Effect of blanching on the quality of frozen storage of green beans. In : Trends in Food science. Institute of Food. Sci. and Technol., Singapore (original not seen. Abstr. In FSTA, AN: 1990-06-J0095, 1990-2001/05).
- ICAR. 2006. *Hand Book of Agriculture*. ICAR Publication. pp. 886. .

- Jaswinder. 2003. Organoleptic and nutrition quality of selected frozen summer vegetables. Ph.D. Thesis, Punjab Agricultural University, Ludhiana, India.
- Kadam, D.M., Lata, Samuel, D.V.K. and Pandey, A.K. 2005. Influence of different treatments on dehydrated cauliflower quality. *J. Food. Sci. Technol.* **41** (2): 110-112.
- Kalra, C.L., Beerh, O.P., Mann, J.K., Teotia, M.S. and Sharma, T.C. 1986. Studies on screening of new pea cultivars for dehydration. *Indian Food Packer* **40** (6): 16-22.
- Khader, V. and Phani, V. 1997. Nutritive value and *in vitro* digestibility characteristics of maize (*Zeamays L.*). *Indian Food Packer* pp. 30-35.
- Kulesza, C. and Gertig, H. 1976. Influence of blanching freezing, and sterilization on the contents of protein and amino acids in the green pea. *Nahrung*, **20**: 369.
- Lal, G., Meena, M. L. and Dhaka, R. S. 2004. Shelf-life and physico-chemical composition of dehydrated slices of *kachri* (*Cucumis callosus*) as affected by different treatments. *J. Food. Sci. Technol.* **41** (6) : 661-665.
- Lee, S. S., Lee, S. J. and Kim, D.Y. 1987. Quality of sweet corn stored at different temperatures and duration. *Korean Journal of Crop Science*. **32**(2): 137-143.
- Leprat, K. and Pulam, T. 2007. Breeding for increased sweetness in sweet corn. *Int.J. Pl. Breeding*. **1** (1): 27-30.
- LII Annual Progress Report. 2008. Directorate of Maize Research, New Delhi.
- Lindsey, W.L. and Norwell, M.A. 1969. A new DATA-TEA soil test for zinc and iron. *Agron. Abst.* **61**: 48.
- Lisiewska, Z. and Kmiecik, W. 1996. Effects of level of nitrogen fertilizer, processing conditions and period of storage of frozen broccoli and cauliflower on vitamin C retention. *Food. Chem.* **57** (2): 267-270.
- Lisiewska, Z. and Kmiecik, W. 2000. Effects of storage period of temperature on the chemistry, composition and organoleptic quality of frozen tomato cubes. *Food. Chem.* **70** (2): 167-173.
- Makhlouf, J., Zee, J., Tremblay, N., Belanger, A., Michhaud, M.M. and Gosselin, A. 1995. Some nutritional characteristics of beans, sweet corn and peas (raw, canned and frozen) produced in the province of Quebec. *Food Res. International*. **28** (3): 253-259.
- Manimegali, G. and Ramah, S. 1998. Effect of pretreatments on the quality characteristics of dehydrated bitter gourd rings. *Indian Food Packer*. **52** (4): 7-11.
- McNeil, E. Castelnovo, G. 1997. Processed sweet corn situation in selected countries. *World-Horticultural-Trade-and-US-Export-Opportunities*. (11): 37-44.
- Meena, C., Gadag, R., Singh, B. and Singh, R.D. 2005. Analysis of productivity and kernal composition in India maize local cultivars and land races. *MNL*. **29**: 25.
- Mertz, E.T., Kirleis, A.W. and Sxtell, J.D. 1983. In vitro digestibility of proteins in major food cereals. *Fed. Proc.* **42** (5): 6026.
- Michalik, H. and Halla, M. 1991. Evaluation of processing quality in some carrot varieties. *Biuletyn Warzy Wniczy*. **37**: 219-225 (Original not seen. Abstr. of CAB Abstracts, AN : 941603014, 1993-94.
- Nakhasi, S.D., Schlimme and Solomos, T. 1991. Storage potential to tomato harvested at breaker stage using modified atmosphere packing. *J. Food Sci.* **56**: 55-59.
- Oliveira, S .P., Reyes, F. G. R., Sgarbieri, V. C., Areas, M. A. and Ramalho, A. C. 1991. Nutritional attributes of a sweet corn fibrous residue. *Journal of agricultural and food chemistry (USA)*. **39** (4): 740-743.
- Oruna-Concha, M. J., Gonzalez, M.J., Lopez Herandez, J. and Simal Lozano, J. 1996. Evaluation of sugar, starch, pectin and insoluble fibre contents in frozen green beans and pardon peppers. *Deutsche Lebensmittel Randschau*. **92** (9) : 278-281. (Original not seen. Abstr. in FSTA, AN : 1997-05-J0096, 2001/05).

- Pajic, Z., Rodosavlevic, M. and Eric, U. 2004. The utilisable value of sweet corn and popcorn hybrids. *Agroznanje Agroknowledge Journal*. **5** (4): 53-60
- Panse, Y.G. and Sukhatme, P.V. 1961. Statistical methods of agricultural workers. 2nd ed. Indian Council of Agricultural Research. New Delhi, pp. 12-87
- Park, D., Kenneth, G.D.A., Stermitz, F.R. and Maga, J.A. 2000. Chemical composition and physical characteristics of unpopped popcorn hybrids. *J. Food Composition Analysis*. **13** : 921-934.
- Pawar, D., Patil, D.A., Khedkar, D.M. and Ingle, U.M. 1985. Study on drying and dehydration of pumpkin. *Indian Food Packer* **39** (4): 58-66.
- Pawar, V.N., Gunjal, B.B., Ingle, U.M. and Ghatge, U.M. 1994. Studies on the varietal differences in some physico-chemical characteristics and quality of frozen peas (*Pisum sativum* L.). *Indian Food Packer* (July-August) : 5-13.
- Polo, M.V., Lagara, M.J. and Farre, R. 1991. The effect of freezing on mineral element content of vegetables. *J. Food. Sci.* **59** (1): 77-83.
- Prabhavat, S.; Kanchanapakornchai, U., Boonyaratanakornkit, M., Tiengpook, C. and Boonvisut, S., 1999. Canned corn beverage from sweet corn kernel and its cob. *Witthayasan Kasetsart* **33** (3) pp. 430-443
- Premavalli, K.S., Majumdar, T.K. and Madhora, C.V. 2001. Processing effects on colour and vitamins of green leafy vegetables. *J. Food Sci. Technol.* **38** (1): 79-81.
- Ramachandrappa, B.K., Nanjappa, H.V. 2006. Speciality corns. pop corn, sweet corn, baby corn. Kalyani Publication. pp. 32. .
- Ranganath, D. R. and Dubash, P.J. 1981. Loss of colour and vitamins on dehydration of vegetables. *Indian Food Packer* **35** (4) : 4-10.
- Riad, G.S., Brecht, J.K. and Talcott, S.T. 2003. Browning of fresh-cut sweet corn kernels after cooking is prevented by controlled atmosphere storage. *ISHS Acta Horticulture* **628**: XXVI *International Horticultural Congress: Issues and Advances in Postharvest Horticulture*.
- Risse, L.A. and McDonald, R.E. 1990. Quality of super sweet corn film-over-wrapped in trays. *Hort. Sci.* **25**: 322-324.
- Rosenthal, A., Sgarbieri, V. C. and Deliza R. 1991. Shelf-life of a drum-dried high lysine sweet corn pulp. *Food control*. **2**: 176-180.
- Ruchika. 2004. Evaluation of pretreatments for dehydration of peas (*Pisum sativum* L.) M.Sc. Thesis, Hisar Agricultural University, Haryana.
- Santosh. 2005. Nutritional evaluation and utilization of baby corn for product development. M.Sc. Thesis, CCS Haryana Agricultural University, Hisar, India.
- Sarswat, B.L., Chauhan, K.P.S. and Kumari, R. 2001. Baby corn *utpadan taking avam upyog*, (NHRDF). Krishi Vigyan Kendra, New Delhi.
- Schouten, S.P. 1993. Effect of temperature and CA storage on visual quality aspects, sugar and ethanol content of sweet corn. In : *Proc. 6th Intl. CA Res. Conf.* Cornell Univ., Ithaca, N.Y. **12** : 18-76.
- Schultheis, R.J. 1994. Sweet corn production. North Carolina Cooperative Extension Service, North Carolina State university.
- Sanderson, J.E., Paulis, J.W., Porcuna, F.N. and Wall, J.S. 1979. Sweet corn : varietal and development differences in amino acid content of composition of grain. *J. Food Sci.* **44** : 836-838.
- Sevov, A, Mitev, S., Ruskova, K. 1974. The inheritance of carbohydrates in the hybridization of sweet corn. *Genetika-i-Seleksiya*. **7** (6): 434-438.
- Sheriful, A. 2002. Drying behaviour and storage stability of promising genotypes of garden peas (*Pisum sativum* L.) PhD. Thesis, Punjab Agricultural University, Ludhiana, India.

- Shmaraev, G. E., Luk'yanenko, E. K., Govorov, N. V. 1976. Biochemical characteristics of super-sugar corn and the possibility of its utilization. *Trudy-po-Prikladnoi-Botanike,-Genetike-i-Selektsii*. **57** (3): 133-137.
- Shnitzler, S. 1994. U.S. processed sweet corn strong performer in overseas markets. *World Horticultural Trade and US Export-Opportunities*.(8): 20-22.
- Singh, U., Khedekar, M.S. and Jambuanathan, R. 1982. Studies on *desi*, *kabuli* chickpea cultivars. The level of amylase inhibitors, levels of oligosaccharides and *in vitro* starch digestibility. *J. Food. Sci.* **47**: 510.
- Singh, V. 2002. Development and nutritional evaluation of value added products from quality proteinmaize (*Zeamays* L.). Ph.D. Thesis, CCS Haryana Agricultural University, Hisar, India.
- Somogyi, M. 1945. A new reagent for the determination of sugar. *J. Biol. Chem.* **160** : 61-66.
- Son, Y. K., Kim, S. Y., Kim, S. L. And Hwang, J. J. (1997). Effects of ice cooling storage on chemical components in vegetable corn. *Korean Journal of Crop Science*. **42** (1): 95-103.
- Suman, M. and Kumari, K. K. 2002. A study on sensory evaluation, β -carotene retention and shelf-life of dehydrated carrot products. *J. Food Sci. Technol.* **39** (6): 677-681.
- Tandon, D.K., Kalra, S.K. and Chadha, K.L. 1981. Chlorophyll degradation of green peas in solar dryers. *Indian Journal of Hort.* **38** (3/8): 211-27.
- Tandon, S. 2006. Nutritional evaluation and processing of pea (*Pisum sativum* var. *sativum*) varieties. M.Sc. Thesis, CCS Haryana Agricultural University, Hisar, India.
- Trongpanich, K. Aekatasanawan, C.Teangpook,C. 1996. Effect of harvesting period on yield and quality of canned whole kernel sweet corn. *Inst. of Food Research and Product Development. IFRPD Research report 1992-1995. Raingan phonngan wichai pracham pi 2535-2538*. Bangkok (Thailand). 1996. 246 pp. 159-166.
- Turk, R., Turgut, I., Aydincioglu, S., Ben, Arie, R. and Philosoph H., S. 2001. Quality changes of sweet corn cultivars during cold storage. Processing of the fourth International Conference on Post-harvest Science, Jerusalem, Israel, 26-31. *Acta, Horticulture*. **553** (2): 756-760.
- U.S. per capita food availability, ERS, USDA, 2008 - This dataset facilitates the creation of custom reports about dairy, fruits, grains, meat, vegetables, etc.
- Vegetables 2009 Summary, NASS, USDA, 2010.
- Vliet,W. F. and Hertog, S. E. 1972. The sugar content of sweet corn. *Mededelingen,-Instituut-voor-Bewaring-en-Verwerking-van-Landbouwprodukten*. **406**: 8.
- Wiley, R.C. 1985. Sweet corn aroma : studies of its chemical components and influence on flavour. In : H.E. Pattee (Ed.), *Evaluation of crudity of fruits and vegetables*. AVI Publication, Co. Wstport. Conn. pp. 346-366.
- Williams, M.P. and Nelson, P.E. 1973. Effect of hybrids and processing on the dimethyl sulfide potential of sweet corn. *J. Food Sci.* **38**: 1136-1138.
- Yadav, S.S. and Yadav, R.P. 2002. Studies on some quality traits of maize genotypes. In : *Advance MAIZE production technology and quality improvement*. Proc. Proceeding of National Seminar on Science Industry Interface in Maize Production, Processing and Utilization, HPKV, Palampur, Nov. 3-4. pp. 181-183.
- Yemm, E.W. and Willis, A.J. 1954. The estimation of carbohydrates in plant extracts by anthrone. *Biochem. J.* **57**: 508-514.
- Yodpetch, C. 1979. Studies on sweet corn as potential young cob corn (*Zea mays* L.). Ph.D. Thesis, Philippines.
- Yue, S., Liu, H., Zhang, B. And Wang, X.M. 2003. Changes of carbohydrate and taste quality in the kernels of super sweet corn in the milky maturity stage. *J. South China Agricultural University*. **24** (2): 9-11.

- Zagory, D. and Kader, A.A. 1988. Modified atmosphere packing of fresh produce. *Food Technol.* **21** (9): 70-77.
- Zhu, S., Mount, J. R. and Collins, J. L. 1992. Sugar and soluble solids changes in refrigerated sweet corn (*Zea mays* L). *Journal of food science.* **57** (2): 454-457.

APPENDIX- I

Nine Point Hedonic Rating Scale

Name -----

Dated -----

Products -----

Test these samples and check how much you like or dislike each one. Use appropriate scale to show your attitude by assigning points that best describe your feelings about the sample. An honest expression of your feelings will help us.

Sr. No.	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability	Remarks
---------	--------	------------	-------	---------	-------	-----------------------	---------

Rate	Organoleptic score
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

ABSTRACT

Title of thesis	: Nutritional Evaluation and Utilization of Sweet Corn for Product Development
Full name of the degree holder	: RENU PANDEY
Admission No.	: 2008HS70M
Title of degree	: Masters of Science in Foods and Nutrition
Name and address of Major Advisor	: Dr.(Mrs.) Asha Kawatra Professor & Head Deptt. of Foods and Nutrition CCSHAU, Hisar ó 125004
Degree awarding university	: CCS Haryana Agriculture University Hisar
Year of award of degree	: 2011
Major subject	: Foods and Nutrition
Total number of pages in thesis	: 82+vi
Number of words in abstract	: Approx. 300

Key word : Sweet corn, nutritional evaluation, processing, dehydrated sweet corn, frozen sweet corn, sweet corn recipes, organoleptic acceptability

The present investigation was conducted to study nutritional composition of two sweet corn genotypes (HSC-I and Madhuri), to utilize sweet corn for product development and to standardize process like dehydration and freezing for extending shelf-life of sweet corn.

Sweet corn genotypes HSC-I (Hybrid) and Madhuri (Variety) were found to contain 70.30 and 72.21 per cent of moisture, 13.44 and 15.30 per cent of crude protein, 4.42 and 4.70 per cent of total ash, 2.26 and 2.58 per cent of fat, 3.76 and 3.31 per cent of crude fibre, respectively. Total soluble sugars, reducing sugars, non-reducing sugars and starch content was 11.70 and 13.51, 2.81 and 3.40, 8.89 and 10.10, 57.98 and 53.26 g/100g, on dry matter basis in HSC-I and Madhuri, respectively.

In vitro starch digestibility of HSC-I and Madhuri was 36.13 and 31.83 mg maltose released per gram and *in vitro* protein digestibility was 67.38 and 71.25 per cent, respectively. Hundred gram of edible HSC-I and Madhuri contained 6.13 and 5.86 mg of ascorbic acid and 46.34 and 48.41 µg of β -carotene, respectively. Magnesium, zinc, iron and phosphorus content of HSC-I was 253.66, 5.03, 6.60 and 357.19 and that of Madhuri was 252.75, 5.10, 6.51, and 366.98 mg/100g, respectively. Both the genotype of sweet corn were utilized for preparation of various products including ó salad, soup, cutlet, manchurian, *pulav*, dry vegetable, *kofia* curry, *halwa*, *kheer* and pickle which were acceptable organoleptically.

Dehydration and freezing was found effective in extending shelf-life of sweet corn kernels upto 90 days. Both the processes did not produce any significant change in moisture, crude protein and crude fibre content of both the genotypes of sweet corn. In both the genotypes total soluble sugars, non-reducing sugars and starch did not showed any significant change during storage except reducing sugars which declined significantly in both the genotypes. Magnesium and iron content of dehydrated and frozen sweet corn genotypes did not showed any significant change on storage whereas zinc and phosphorus declined significantly by the end of storage period.. Sweet corn soup, cutlet, dry vegetable and *kheer* made from stored dehydrated as well as frozen sweet corn were liked very much throughout the storage. Sweet corn thus can be utilized in preparation of wide variety of recipes and can be successfully stored in frozen and dehydrated form.

MAJOR ADVISOR

DEGREE HOLDER

HEAD OF THE DEPARTMENT

CURRICULUM VITAE



- a) Name of the Student : Renu Pandey
b) Date of Birth : 13th February 1987
c) Place of Birth : Baldao (Mathura)
d) Mother's Name : Mrs. Meena Pandey
e) Father's Name : Mr. Nand Kishore Pandey
f) Permanent Address : 251/31 Ashok Vihar, Gohana Road, Sonapat (HR)131001
g) Telephone : 0130-2222378
h) Mobile : 09467575907
i) E-mail : pndy.rnu@gmail.com
j) Academic qualifications :

Degree	University/Board	Year of passing	Percentage of marks	Subjects
Matric	Haryana Board (B.S.E.H.)	2002	77.3	Sci., Math, Eng., Sanskrit, S.S., Hindi
10+2	C.B.S.E.	2005	73.4	Political Science, Economics, Music, Hindi, English
B.Sc. (Home Sci.)	G.V.M. College, Sonapat (Affiliated to M.D.U. Rohtak)	2008	79.9	FN, HDFS, FRM, CT, HSEE
M.Sc. (Home Sci.)	CCSHAU, Hisar	2011	81.2	Foods and Nutrition

- k) Co-curricular activities :
- Participated in YOUTH FEST, held at Maharaja Agrasen College Jhajjar, and secured 1st position in Poster Making in 2005.
 - Participated in YOUTH FEST, held at Govt. P.G. College Jhajjar, and secured 2nd position in Spot Panting in 2006.
 - Participated in YOUTH FEST, held at Hindu Girls College Sonapat, and secured 1st position in Poster Making in 2007.
 - Participated in UTSAV-2010, held at CCSHAU, Hisar and secured 1st position in Spot Panting, collage making and 2st position in Poster Making .
 - Participated in other cultural activities, held at CCSHAU, Hisar and got served prizes on Nutrition Week, World Food Day, Talent Search, World Veterinary Day.
- l) Medals/Honours received :
- 7th Rank in M.D. University in B.Sc. 1st year.
 - 3th Rank in M.D. University in B.Sc. 2nd year.
 - 3th Rank in M.D. University in B.Sc. 3rd year.
- m) List of publications : Nil

RENU PANDEY