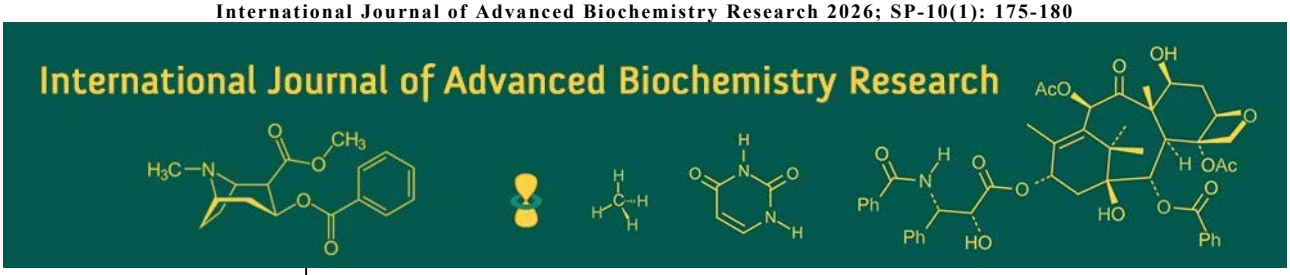

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Studies on standardization of frozen green pea and evaluation of its quality attributes

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Abstract
Green pea seeds are widely consumed as a fresh vegetable and are also extensively utilized after processing in various forms such as canning, freezing, and dehydration. Owing to their high moisture content and active metabolic processes, green peas are highly perishable and undergo rapid quality deterioration after harvest, which limits their storage life under ambient conditions. Significant post-harvest losses occur due to physiological changes, moisture loss, enzymatic reactions, and microbial spoilage, thereby affecting their nutritional quality, sensory attributes, and market value. To address these challenges, various storage and processing technologies have long been employed to transform perishable fruits and vegetables into safe, palatable, and shelf-stable products while preserving their nutritional and sensory characteristics. Among the available preservation methods, freezing is regarded as one of the most efficient techniques, as it effectively retards enzymatic activity and microbial growth, ensuring extended shelf life with minimal quality degradation. Hence, the production of frozen green peas is essential to reduce post-harvest losses, ensure year-round availability, enhance economic returns, and provide consumers with a convenient and nutritious vegetable product. The present investigation entitled "Studies on standardization of frozen green pea and evaluation of its quality attributes" was conducted to evaluate the effect of different pre-treatment combinations on the quality and storage behaviour of frozen green peas. The experiment consisted of eight treatments with three replications, involving blanching, salt, citric acid, acetic acid, and their combinations. Sensory evaluation indicated that treatment T_8 (blanching + acetic acid) was the most acceptable, recording the highest overall score (3.98), followed by T_6 (blanching + salt). TSS was highest in the control, while sugar, acidity, ascorbic acid, and protein contents varied significantly among treatments. The benefit cost ratio of 2.17 confirmed the economic feasibility of frozen green pea processing.

Keywords: Frozen peas, quality, preservation, sensory, processing

Introduction
Pea (*Pisum sativum* L.) is one of the most popular pulse crops of India. It ranks top ten among the vegetable crops and belongs to Fabaceae family. The fruit is a typical pod containing four to nine seeds. They are used for the human diet for a long time because it is an excellent source of protein, vitamins, minerals and other nutrients and low in fat, high in fiber and contains no cholesterol. Garden pea/sweet pea is a choice vegetable grown for its fresh shelled green seeds rich in protein (18-30%), slowly digestible starch (50%), soluble sugars (5%), fiber, minerals and vitamins. Garden pea generally has white flowers and their seed shapes may be round, dimpled or wrinkled, and their seed colour is green or yellow. The green seeds are used as vegetable or can be used after processing (canning, freezing and dehydration). Unfortunately, they are perishable and can't be stored for longer period. Storage and processing technologies have been utilised for centuries to transform these perishable fruits and vegetables into safe, delicious and stable products. So there is need for production of frozen green pea. Frozen product that obtained from pea cooked before freezing contained higher amounts of most amino acids than that obtained from traditionally frozen pea. Green pea prepared for consumption from the frozen product obtained using the modified technology (cooking before freezing) contained higher amounts of polyphenols and beta-carotene and had higher antioxidative activity than cooked pea obtained from the traditional frozen product (Gębczyński, 2006) [3]. Phenolic compounds are considered natural antioxidants that may help protect against diseases such as cancer and

various inflammatory-related diseases. Phenolic compounds are found to be present in the seed coat and cotyledon of peas.

Therefore, the study attempted to make the present investigation entitled of "Studies on standardization of frozen green pea and evaluation of its quality attributes" was conducted in light of the following objectives:

1. To assess the physio-chemical characteristics of green pea
2. To standardize the recipe for frozen green pea
3. To assess the quality of frozen green pea during storage period.
4. To find out the b/c ratio of frozen green peas.

Materials and Methods

The present research was conducted in the Laboratory of Horticulture, Department of Horticulture, NEHU Tura Campus, Meghalaya during 2020-2022 with a view to analyse the physio-chemical characteristics and sensory attributes of fresh and frozen product of green peas and to standardize along with the evaluation of nutritional values of stored peas. The overall experiment was done on the three replication and eight treatment combinations. Statistical analysis and test of significance were done following the method. The analysis of variance (ANOVA) of the data was carried out factorial randomised design. The storage study of standardized frozen green pea was done at monthly interval at-18 °C temperature. The meteorological data during the period of research experiment (2020-2022) are presented in Table 1 showed the average monthly temperature (°C) and Relative Humidity (%) during Research period.

Table 1: Meteorological data pertaining to period of experimentation

	Monthly Average temperature			Monthly Average RH			Rainfall
Months	**Max (°C)**	**Min (°C)**	**Average (°C)**	**Max (%)**	**Min (%)**	**Average (%)**	**(mm)**
Oct 2021	33	23	28	100	60	80.00	227.80
Nov 2021	27	19	28	96	59	77.50	0.00
Dec 2021	26	14	15	98	53	75.50	0.00
Jan 2021	24	12	18	100	47	73.50	12.20
Feb 2021	28	12	20	98	36	67.00	88.80
March 2022	35	20	27.50	100	28	64.00	29.20
April 2022	33	21	27	98	60	79.00	116.02
May 2022	33	23	28	98	60	79.00	208.10
	29.88	18	23.94	98.50	50.38	74.50	85.26

Sources: https://www.timeanddate.com and District Agricultural Office, Tura (2021-20)

Studies on physico-chemical characteristics of green pea

Part A: Physical parameters

Table 2: Physical characteristics of green pea

Sl. No.	Physical parameters	Methods used
1	Pod colour	By RHS chart and visual
2	Shelling percentage	By weighing balance

Physical characters of green pea

1) Pod colour

Colour was observed visually and with the help of RHS colour chart.

2) Shelling percentage

Shelling percentage was measured with the help of weighing machine.

Part B: Biochemical Parameters

Biochemical composition of fresh samples, stored frozen green peas were analysed with the following standard methods as mentioned below in Table 2.

Table 3: Biochemical parameters of fresh pea and stored frozen green peas.

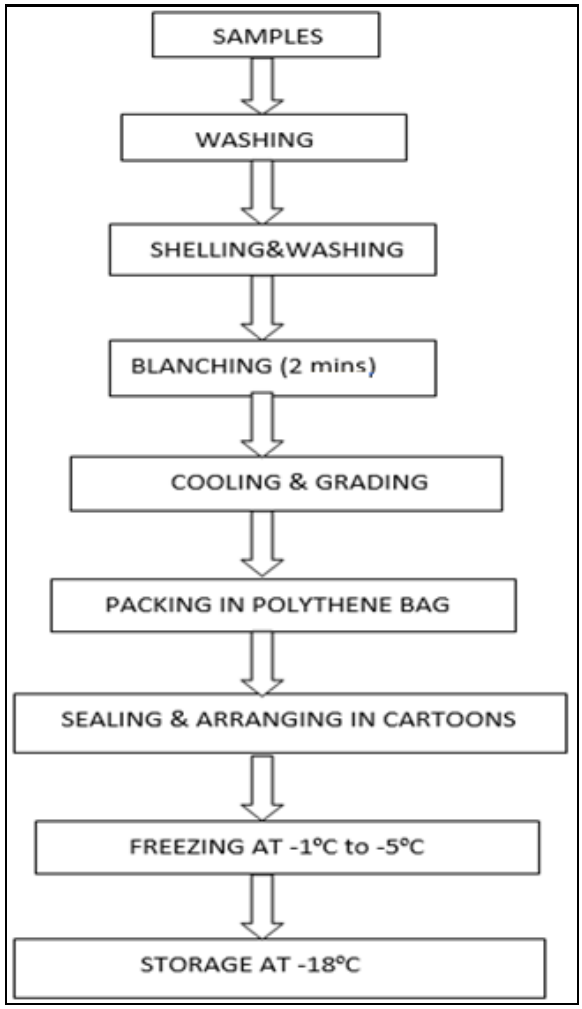
Sl. No.	Chemical parameters	Methods used
1	TSS (Degree Brix)	By Hand Refractometer
2	Total sugar (%)	By Lane and Eynon (1923) [5]
3	Reducing sugar (%)	By Lane and Eynon (1923) [5]
4	Non-reducing sugar (%)	By Lane and Eynon (1923) [5]
5	Ascorbic acid (mg/100 g)	By Ranganna (2004) [11]
6	Protein %	By Lowry's (1951)
7	Acidity%	By AOAC method (1984) [1]

Study on standardization of recipe for frozen green pea

Table 4: Standardization of recipes of frozen green pea

Treatment	Proportion of ingredient for frozen green pea (250 g/Replication = 750 g/Treatment)
T_1	Green pea (Control)
T_2	Blanched (80 °C) for 2 mins
T_3	1% salt for 5 mins
T_4	1% citric acid for 5 mins
T_5	1% acetic acid for 5 mins
T_6	Blanched (2 mins) + 1% salt (5 mins)
T_7	Blanched (2 mins) + 1% citric acid (5 mins)
T_8	Blanched (2 mins) + 1% acetic acid (5 mins)

Methodology used in standardization of frozen pea was (Singh *et al.* 2014). Post Harvest Handling and Processing of Fruits and Vegetables



Studies on quality assessment of frozen green pea during storage period

Table 5: Assessment of quality of frozen green pea during storage

Sl. No.	Chemical parameters	Methods used
1	TSS(Degree Brix)	By Hand Refractometer
2	Total sugar(%)	By Lane and Eynon (1923) [5]
3	Reducing sugar (%)	By Lane and Eynon(1923) [5]
4	Non-reducing sugar (%)	By Lane and Eynon(1923) [5]
5	Ascorbic acid(mg/100 g)	By Rangana, 2004
6	Protein%	By Lowry's method (1951) [7]
7	Acidity%	By AOAC method (1984) [1]

Estimation of Benefit: Cost ratio of standardized frozen green pea

The benefit cost ratio was calculated after estimation of total cost involved including the operational and 10% overhead charges incurred during the preparation of frozen green pea. The benefit: cost ratio was computed by the formula as given below:

$$\text{Net income Benefit: Cost ratio (b/c)} = \frac{\text{Net income}}{\text{Total cost of production}}$$

The gross income was estimated by average market price of similar products and total cost of production was estimated by addition of the fixed cost and variable cost with 10% overhead charges of fixed inputs.

Result and Discussion

Physical characteristics of fresh green pea

The physical parameters of fresh green pea values are presented in Table 6. The shelling percentage of green pea was found to be 44% and the colour was green.

Table 6: Physical characteristics of fresh green pea

Sl. No.	Physical parameters	Values
1	Pod colour	Green, 140B by RHS chart
2	Shelling percentage	44%

Biochemical characteristics of fresh pea

The biochemical compositions of fresh pea values are shown in Table 7. Fresh pea contained high amount of Protein (19.14%), Ascorbic acid (9.72 mg/100 g), TSS (8.33ºBrix), Total Sugars (2.34%), Reducing-sugar (1.92%), Non-reducing sugar (0.42%) and Acidity (0.13%) respectively. It was supported by Pal *et al.* (2018) in garden pea on biochemical characterization and its variability.

Table 7: Biochemical characteristics of fresh green pea

Sl. No.	Chemical parameters	Values
1	TSS	8.33ºBrix
2	Total sugar	2.34%
3	Reducing sugar	1.92%
4	Non-reducing sugar	0.42%
5	Ascorbic acid	9.72 mg/100 g
6	Protein	19.14%
7	Acidity	0.13%

Standardization of frozen green pea

The methods for standardization of frozen green pea were prepared according to the availability of raw materials with different concentrations and proportions along with the nutritive prospect. The proportions of ingredients required for frozen green pea in each treatment are presented in Table 3. Periodical panel tests of frozen peas were conducted at an interval of 0 month (freshly prepared), 1 month and 2 months(stored peas) by 15 panellists respectively. The acceptability of freshly and stored green peas on the basis of overall ratings ranged between 3.70 to 3.98, 3.68 to 3.88 and 3.60 to 3.80 respectively.

Treatments T_8 (3.98) showed highest acceptability score which was on par with T_6 (3.96) in freshly prepared peas while lowest value was noted in T_2 (3.70) and T_7 (3.72) respectively as shown in Table 3 and Fig 1. Similarly for 30 days the highest score was T_5 (3.88) which was on par with T_8 (3.86) and for lowest was in T_2 (3.68). For 60 daysthe highest was T_3 (3.80) followed by T_6 (3.74) and T_4 (3.72) while the lowest was in T_2 (3.60), T_7 (3.60) respectively. A similar observation was mentioned by Pukszta and Palich (2008) [10] on changes in stored frozen green peas and for sensory evaluation, a critical value was accepted at the level of 3.50 points and decreases during its 24 weeks of storage.

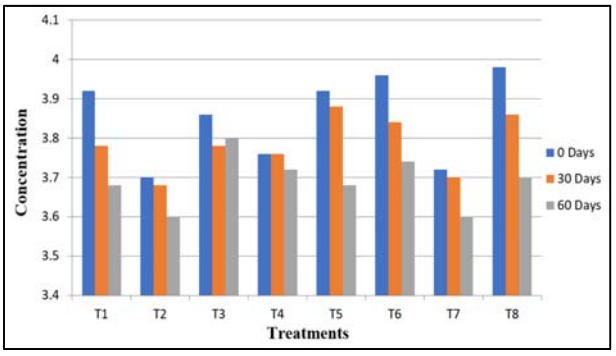


Fig 1: Standardization of frozen green pea during storage

Studies on quality assessment of frozen green pea during storage period

Total Soluble Solids (TSS)

The TSS content was found significantly difference ($p \leq 0.01$) among the treatments in fresh and 2 months stored frozen peas and values are presented in Table4.4 and Fig 2. The TSS content of fresh processed peas was observed highest in T_1 (9.13ºBrix) i.e, control which was on par with T_2 (8.80ºBrix) whereas the lowest was recorded in T_6 (6.80ºBrix) i.e, blanched + 1% salt followed by T_5 (7.47ºBrix) in the freshly prepared frozen peas(0 months). The peas were treated with different natural preservatives i.e, 1% salt, 1% citric acid, 1% acetic acid and stored in freezer. The TSS content was found continuously decreasing during the storage period upto 2 months at refrigerated temperature (-18º).The TSS content was highest in T_1 and T_3 i.e, 8.33ºBrix which was on par withT_3 (8.00ºBrix) and lowest was found in T_6 (6.47ºBrix).T_3 (7.80ºBrix) was highest which was on par with T_1 (7.67ºBrix) and lowest was T_6 (6.13ºBrix) after 2 months of storage. The decrease in TSS might be due to conversion into invert sugar during storage. A similar work was also done by in pea about blanching effect on quality and self-life of pea that TSS decreased with longer in storage period. It was supported by Martinez *et al.* (1995) [8] in turnip greens that unblanched one changed from 6 to 5 ºBrix during storage. The use of citric acid in blanching water for 2 mins stabilized the TSS during frozen storage.

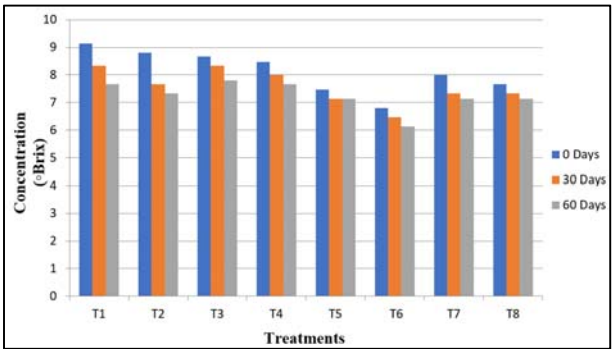


Fig 2: Change of levels of TSS during storage period

Total sugar

The data of frozen green pea illustrated in Table 4 and Fig 3 showed a significant difference ($p \leq 0.01$) among the 8 treatments in freezing conditions. Freshly prepared peas of total sugar content was found highest in T_8 (1.99%) which was on par with T_6 (1.96%) whereas the lowest was in T_4 (1.02%). After 2 months of storage there was reduction in total sugar content. For 30 days of storage, highest was recorded in T_8 (1.92%) followed by T_1 (1.88%) and lowest was recorded in T_4 (0.94%). Similarly, for 60 days, The highest was observed in T_8 (1.80%) which was on par with T_6 (1.60%) whereas, lowest was in T_4 (0.91%). The decrease in total sugar was due to solubilisation of sugars and absence of pods for protection from leaching out during water blanching. A similar research was made by Grzeszczuk *et al.* (2007) [4] on the effect of blanching, freezing and freeze storage on changes of some chemical compounds content in New Zealand spinach.

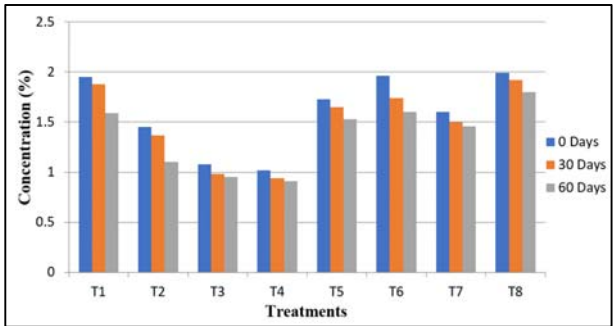


Fig 3: Change of levels of Total Sugar during storage period

Reducing sugar

The value of reducing sugar content in freshly and stored frozen peas were found significantly different ($p \leq 0.01$) within the treatments as data depicted from Table 5 and illustrated in Fig 4. Reducing sugar content in freshly prepared peas was found highest in T_8 (1.57%) which was on par with T_1 (1.54%) respectively whereas least amount was found in T_4 (0.62%). With the increase in storage period it showed a slight decrease in all the treatments. T_8 (1.50%) was highest which was on par with T_1 (1.46%) and lowest was recorded in T_4 (0.55%) for 30 days of storage. After 60 days of storage, T_8 (1.41%) which was on par with T_1 (1.22%) found the highest whereas lowest was found in T_4 (0.55%) respectively.

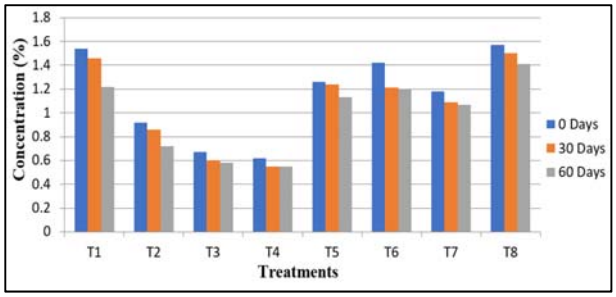


Fig 4: Change of levels of Reducing Sugar during storage period

Non-Reducing sugar

The value of non-reducing sugar content of freshly and stored frozen peas were found significantly different ($p \leq 0.01$) among the treatments and data are presented in Table 5 and illustrated in Fig 5. The non-reducing sugar was found highest in T_6 (0.51%) which was on par with T_2 (0.49%) and lowest was found in T_1 and T_4 i.e, 0.39% in freshly prepared green peas. For 30 days, T_6 (0.50%) was highest which was also on par with T_2 (0.48%) and lowest

was T_3 and T_4 i.e, 0.36%. There was a slight change in non-reducing content after 2 months of storage. The non-reducing sugar content was observed in decreasing trend with the increase in storage period. T_6 (0.38%) was recorded highest and lowest was observed in T_4 (0.34%) and T_3 (0.34%) after 2 months of storage.

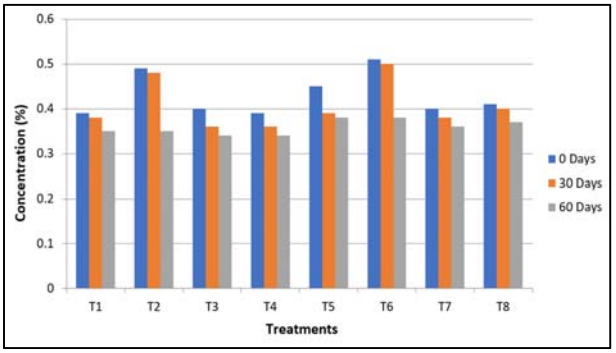


Fig 5: Change of levels of Reducing Sugar during storage period

Titratable acidity

The data in respect of acidity under different treatments is presented in Table 6 and illustrated in Fig 6: The highest amount of acidity was found in T_4, T_6, T_7, T_8 (0.38%) which was followed by T_6 (0.30%) and lowest was found in T_1 and T_2 with 0.13% for 0 month of storage. With the increase in storage period, it was found that acidity content decreased while T_1, T_2 and T_3 didn't change which has the lowest value and highest was recorded in T_4, T_5, T_7 and T_8 with 0.26% respectively. Acidity was decreased which might due to polymerization of organic acids with sugars and amino acids. It might be also due to modification of permeability of the cell membrane during frozen storage. A similar study was also done by Martinez *et al.* (2013) [8] who conducted a comparative study on effect of blanching and frozen storage on some quality parameters of turnip greens ('grelos') that highest titratable acidity was found in treatment treated with blanching + citric acid and decreases with storage period.

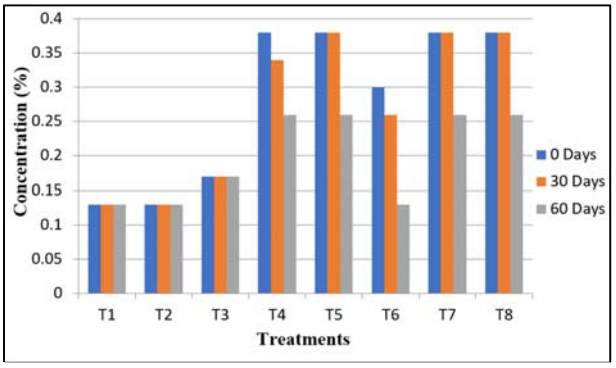


Fig 6: Change of levels of Titratable acidity during storage periods

Ascorbic acid

The ascorbic acid content of freshly and stored frozen green peas are presented in Table 6 and Fig 7. Ascorbic acid in freshly prepared frozen green peas was found highest in T_8 (6.48 mg/100 g) which was on par with T_7 (6.12 mg/100 g) while lowest was in T_2 (3.24 mg/100 g) respectively. The ascorbic acid content declined after 60 days of storage. For 30 days of storage, highest was observed in T_8, T_7 i.e, 5.28 mg/100 g and lowest was found in T_2 (2.64 mg/100 g). For 60 days, T_8, T_7 (4.80 mg/100 g) was highest and lowest in T_2 (2.40 mg/100 g). The declining of ascorbic acid content might be due to inactivation of oxidation enzymes and conversion of dehydro ascorbic into 2, 3-diketogluconic acid. Action of enzymes like AA oxidase, phenolase or peroxidise also directly or indirectly responsible for their losses. A similar study was observed by Jany *et al.* (2008) that when stored at freezing temperature and the lowest 12.1 mg/100 g was recorded in pea after 90 days of storage.

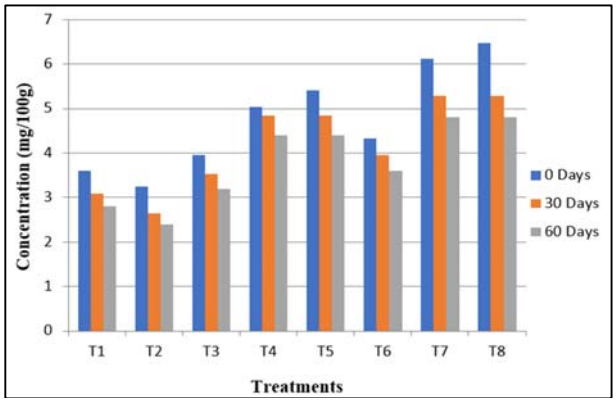


Fig 7: Change of levels of Ascorbic acid during storage periods

Protein

The protein values in freshly prepared and stored frozen green peas were found significantly superior ($p \leq 0.01$) within the treatments as shown in Table 7 and Fig 8. T_3 (17.42%) of freshly prepared green peas was found highest which was on par with T_1 (17.11%) and lowest was found in T_6 (11.47%). For 30 days T_1 (17.01%) was found highest followed by T_4 (13.56%) and lowest was T_5 (8.99%). Protein content was found declining with the increase in storage period. T_4 (12.65%) was recorded highest which was on par with T_8 (12.12%) for 60 days of storage and lowest was T_5 (6.11%).The declining in protein content comparing to the fresh one might be due to denaturation of protein during the storage condition for longer period. A similar finding was observed by Youling L. Xiong (1997) that protein denatured while stored in freezer.

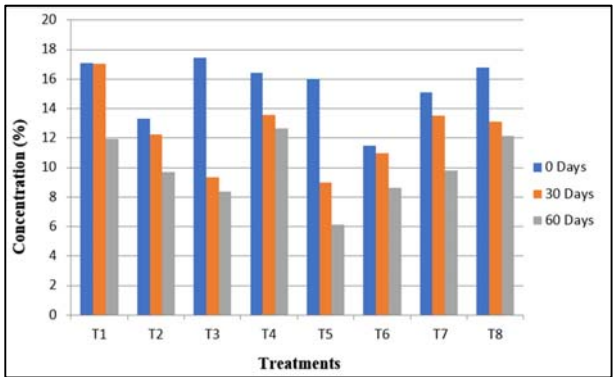


Fig 8: Change of levels of Protein during storage periods

Estimation of benefit/cost ratio of frozen green pea

The cost of ingredients and other expenses incurred for making of frozen green pea were estimated based on market price and benefit: cost ratio was calculated accordingly.

The benefit: cost ratio of standardized frozen green pea was calculated based on rated score by panellists according to

colour, flavour and taste in treatment. The data depicted from table 8 showed that calculated value of Benefit: Cost ratio of standardized frozen green peas based on sensory score, T_8 (2.17) got first grade among eight treatment whereas second grade was T_6 (2.04) and third grade was T_1 and T_5 (2.00) against 1 rupee investment of the product.

Table 8: Estimated benefit: cost ratio of frozen green pea

Sl. No.	Products	Cost (Rs./kg)	Gross Income (Rs./kg)	Net Income (Rs./kg)	Benefit: Cost ratio (b/c)	Rated scored out of 5.0
1	Frozen green pea (T_8)	75.64	240	164.36	2.17	3.98 Grade I
2	Frozen green pea (T_6)	75.64	230	154.36	2.04	3.96 Grade II
3	Frozen green pea (T_1/T_5)	75.64	220	144.36	2.00	3.92 Grade III

Summary and Conclusion

In the present investigation entitled "Studies on standardization of frozen green pea and evaluation of its quality attributes" was made with 8 treatments and 3 replications having different combinations of pre treatment methods. These combinations were formulated to evaluate the characteristics of frozen green pea and storage behaviours. With regards to the sensory evaluation of frozen green pea by panellists, the most acceptable treatment was T_8 (blanched + acetic acid) which scored 3.98 for colour, flavour/aroma and taste followed by T_6 (blanched + salt) which scored 3.96. TSS recorded was highest in T_1 (control) with 9.13ºBrix followed by T_2 (blanched) with 8.80ºBrix respectively. Total sugar was lowest in T_4 (citric acid) with 0.91% whereas highest was observed in T_8 (blanched + acetic acid) with 1.80% after 2 months of storage. Similarly, reducing sugar was lowest in T_4 (citric acid) with 0.55% and highest was recorded in T_8 (blanched + acetic acid) with 1.41% after 2 month of storage. Non-reducing content in T_4 (citric acid) and T_3 (salt) was 0.34% which was lowest and highest was recorded in T_6 (blanched + salt). Highest acidity was found in T_8 (blanched + acetic acid), T_7 (blanched + citric acid), T_5 (acetic acid), T_4 (citric acid) having 0.26% and lowest was recorded in T_1 (control), T_2 (blanched) with 0.13%.There were not many changes in acidity value. The ascorbic acid content was highest in T_8 (blanched + acetic acid) and T_7 (blanched + citric acid) having 4.80 mg/100 g and lowest in T_2 (blanched) having 2.40 mg/100 g after 2 month of storage. The protein content in T_5 (acetic acid), T_3 (salt), T_6 (blanched + salt) were 6.11%, 8.36% and 8.65% respectively while highest was found in T_4 (citric acid) with 12.65%. The benefit: cost ratio of frozen green pea was found 2.17. Hence, it is economically feasible.

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