# Shelf-life Evaluation Using Accelerated Stability Testing (AST) and Transit Trial Testing in Selected Confectionery Products

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***Abstract***

*The shelf life of confectionery products can be changed commonly during storage and transportation. In this study, accelerated shelf life estimation (AST) and transit trial (TT) in selected confectionery products (hard candy, center filled chewing gum and jelly) were focused and the properties of confectionery samples were compared with the commercial products. Test sample and control sample were stored in climate chamber at 35/40ºC and 50/80% RH and test reference sample and control reference samples stored at finished good ware house <30 ºC. The samples were evaluated once a week along 21 days period. For TT, the samples were transported to the distance and returned back (850Km). Product's physical and packaging properties were evaluated by visual methods and moreover, organoleptic parameters were checked according to 5-point hedonic scale. The data were analyzed using analysis of variances (ANOVA) followed by Friedman Test at 0.05 significance level. Comparative test was done by test sample comparing with the other three of samples. According to the results, all of the quality properties were decreased with the storage period. Hard candy and center filled chewing gum specifically showed the textural changes but jelly samples had no changes in AST. Moreover, hard candy and jelly samples showed no significant differences in TT but chewing gum samples were showed somewhat differences. The overall qualities of the sample showed the more or less exact quality properties with the commercial products.*

***Keywords: Keywords: Accelerated Stability Test (AST), Transit Trial Test (TT), Center Filled Chewing Gum, Hard Candy, Jelly, Sugar confectionery***

## I. INTRODUCTION

The confectionery industry can be categorized into three main classes: chocolate, flour, and sugar confectioneries. Chocolate and flour confectioneries made from chocolate and flour and their shelf life can be short or long period (Edwards, 2018). Another confectionery industry can be identified as sugar confectioneries. Sugar is a generic term used to refer to any form of carbohydrate suitable for use as a sweetener, including sucrose, a chemical term for sugar extracted from sugar cane or beet (Lees, 2012). A broad range of sweet varieties of soft candy, hard candy and chewing gum are being marketed in the country (SLSI, 2017). This study aimed to predict the shelf life of selected confectionary products using Accelerated Stability Testing (AST) and the Transit trial method and to compare the properties of confectionery samples with commercial confectionery products.

## II. LITERATURE REVIEW

### *A. Quality Properties of Sugar Confectioneries*

The texture of candy is impacted by the concentration of sugar and boiling temperature, wherein lower temperatures yield softer candies, while higher temperatures result in harder ones. Texture analysis, conducted with a Texture Analyzer, quantifies firmness, fracturability, and fracture quantity. Color intensity contributes to the appetizing value and consumer acceptance of candies (Dilrukshi et al., 2019). Proper packaging and storage conditions prevent undesirable sugar crystallization, influencing food taste perception.

Chemical properties: Maillard reactions, caramelization and lipid peroxidation, create brown compounds in confectionery items. These reactions occur at higher temperatures, oxidize unsaturated fatty acids, and degrade ascorbic acid (Cheung and Mehta, 2015).

Organoleptic parameters: Flavor enhances food taste, with sweetness determined by sugars' chemical formula and tongue interaction. Storage changes flavor, texture, moisture content, and water activity, affecting product freshness (Arturo


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and Paredes, 2000; Hartel, von Elbe and Hofberger, 2018).

*B. Ingredients*

Sugar substitutes are compounds used for sweetening without insulin, such as sugar alcohols, sorbitol, xylitol, and mannitol. Dairy ingredients like condensed milk, milk powder, whey, and butter fat are used in the confectionery industry. Emulsifiers help form or stabilize emulsions, altering droplet size and texture. Flavors improve product appearance or are essential. Colors enhance product appearance or add flavor, with synthetic colors being more stable and pure (Schieberle and Grosch, 1988).

*C. Preparation Methods and Techniques*

In the preparation of confectionery, techniques such as vacuum cooking, steam injection cooking, and continuous plant utilization are employed. Within continuous vacuum conditions, sugar undergoes cooking and can be discharged at reduced temperatures, facilitated by a vacuum of 10 inches (25 cm) of mercury, thereby decreasing the boiling temperature by 20°C. The incorporation of a first stage cooker enhances production capacity, and evaporated syrup moisture is eliminated through a designated pipe. The cooking chamber is equipped with a sight glass outlet for real-time monitoring of the sugar stream, allowing the continuous addition of buffered lactic and citric acid, colors, and flavors. Furthermore, a discharge pump facilitates the extraction of the cooked sugar.

*D. Common Types of Sugar Confectioneries*

Hard candies are liquid mixtures of sucrose and corn syrup, maintained by high-temperature cooking (Spanemberg, 2019). They can be plain, modified, or lozenges. Chewing gum is a gum base with nutrients and flavorings, released through chewing. Soft candies include chewy products with sugar syrup, fats, coloring, and flavorings, and jelly-based candies like jelly beans and fruit paste (SLSI, 2017). Soft candies include plain toffee, milk toffee, modified toffee, and center filled toffee. They are made from sugar, edible vegetable fat, and may contain coloring, flavorings, fruits, nuts, modified toffee, and optional ingredients. These candies are similar to milk toffee or modified toffee but have distinct coatings (SLSI, 2017). Gelatin jellies have a soft, rubbery texture, often enhanced with gelling agents like thin boiling starch. Agar jellies are low-boiled, soft, and short-eating, while pectin jellies are excellent fruit-flavored bases, with acidic pH (E.B.Jackson, 1992).

*E. Packaging of Sugar Confectioneries*

Polypropylene film, oriented films, Polyvinyl Chloride (PVC), Polyvinylidene Chloride (PVDC), metalized films, shrink, and stretch films are suitable for confectionery packaging in humid conditions (Board, 2013).

*F. Shelf Life of Sugar Confectioneries*

Product characteristics, packaging, and transportation and storage factors include composition, raw material quality, structure, moisture content, water activity, fat content, pH, and oxygen susceptibility (Subramaniam, 2009). External conditions like temperature, humidity, oxygen, and light also affect shelf life. Estimation of shelf life involves real-time stability tests and accelerated stability tests (Calligaris et al., 2019).

## III. METHODOLOGY

The confectionery samples were manufactured in the same way as commercial products. Hard Candies and gum/jelly were manufactured according to the company recipe. Liquid glucose, water, sugar, acid, flavor mixed together and cooking under vacuum pressure. Then kneaded, cooled and rope sized and finally foamed candy. Sugar, gum base, liquid glucose, flavors and colors mixed together and pre extruded the batch and then rope sized and foaming gums. Jellies were prepared using sugar, liquid glucose, and water, and acid, fruit pulp with pectin, flavors and colors. All together added to collecting chambers and then passed through the depositors. For the depositor used depth increased depositing plates. The final product was packaged in a sealed package and collected from commercial samples and trial samples. The samples run in a temperature and humidity climate chamber with temperatures of
35/40°C and 50/80% relative humidity for 12 cycles.

Accelerated Stability Test (AST) product is kept under conditions of increased stress (such as pH, humidity, and temperature) (Calligaris et al., 2019). AST is a test designed to increase the rate of chemical degradation or physical change of a sample by using exaggerated storage conditions. AST is relatively quick test and therefore compatible with an often-limited project timeline.


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Transit Trial Test (TT) done by transportation of products may deteriorate the quality of product and/or pack. A TT is a test to evaluate the effect that transportation has on product and pack quality. Data collection was done once a week for a minimum 21 days weekly testing for AST and before and after transportation for transit trial. For the sensory evaluation follow up the 5-point Hedonic scale as low to high comparability of products with trained panel. Collected data were analyzed using SPSS software 26.0 using analysis of variances (ANOVA) followed by Friedman Test at 0.05 significance level on Tukey's test.

## IV. RESULTS AND DISCUSSION

### *A. Accelerated Stability Test*

#### *1) Visual Parameters of Samples*

The visual property of hard candy, chewing gum and jelly was reduced with the accelerated climate conditions. There were significant differences ($p<0.05$) observed in color intensity, smoothness, wrinkle and overall appearance of hard candy (Table 01), Color intensity, smoothness, shininess, deformation, syrup leakage, and overall appearance of chewing gum (Table 02) and color intensity, deformation, overall appearance of jelly (Table 03) while AST period those parameters changed may be due to the accelerated climatic conditions. When using low temperatures and high relative humidity, the composition of sweets can alter because citric and sucrose are quickly affected by moisture content. (Netramai et al., 2018). Newly introduced hard candy had no any significant difference in shininess and deformation within 21 days but it can be change if more time stay in climate chamber like more than month. Size reduced center filled chewing gum and new consumer packaging material used jelly samples' all properties had significant differences. Size reduced gum had the changes it may be due to the graining or high moisture intake during climate conditions (Arturo and Paredes, 2000). Smoothness and shininess of jelly had no any significant difference when comparing the commercial samples.

Table 01: Visual Properties of Hard Candy

| **Visual properties** | **Storage in days** | | | |
|---|---|---|---|---|
| | **Day 01** | **Day 07** | **Day 14** | **Day 21** |
| Color Int. | $5.00\pm0.00^{c}$ | $4.93\pm0.07^{c}$ | $4.40\pm0.16^{b}$ | $3.93\pm0.06^{a}$ |
| Smooth. | $4.93\pm0.06^{c}$ | $4.67\pm0.49^{bc}$ | $4.33\pm0.82^{b}$ | $3.67\pm0.13^{a}$ |
| Shini. | $4.80\pm0.11^{a}$ | $4.67\pm0.13^{a}$ | $4.53\pm0.19^{a}$ | $4.33\pm0.19^{a}$ |
| Deform. | $5.00\pm0.00^{a}$ | $5.00\pm0.00^{a}$ | $4.93\pm0.06^{a}$ | $4.87\pm0.09^{a}$ |
| Wrink. | $4.80\pm0.11^{b}$ | $4.73\pm0.12^{b}$ | $4.40\pm0.19^{ab}$ | $3.93\pm0.18^{a}$ |
| Overall appear. | $5.00\pm0.00^{b}$ | $4.73\pm0.12^{b}$ | $5.00\pm0.00^{b}$ | $4.06\pm0.21^{a}$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 02: Visual Properties of Chewing Gum

| **Visual properties** | **Storage in days** | | | |
|---|---|---|---|---|
| | **Day 01** | **Day 07** | **Day 14** | **Day 21** |
| Color Intensity | $5.00\pm0.00^{c}$ | $5.00\pm0.00^{c}$ | $4.13\pm0.35^{b}$ | $3.53\pm0.74^{a}$ |
| Smoothness | $5.00\pm0.00^{c}$ | $4.80\pm0.41^{c}$ | $4.00\pm0.00^{b}$ | $2.87\pm0.83^{a}$ |
| Shininess | $5.00\pm0.00^{c}$ | $4.73\pm0.46^{c}$ | $3.67\pm0.49^{b}$ | $1.93\pm0.70^{a}$ |
| Deformation | $5.00\pm0.00^{c}$ | $4.87\pm0.35^{bc}$ | $4.47\pm0.64^{b}$ | $3.53\pm0.52^{a}$ |
| Syrup leakage | $5.00\pm0.00^{c}$ | $4.87\pm0.35^{c}$ | $4.00.\pm0.65^{b}$ | $1.53\pm0.52^{a}$ |
| Overall appearance | $5.00\pm0.00^{c}$ | $5.00\pm0.00^{c}$ | $3.93\pm0.59^{b}$ | $1.80\pm0.77^{a}$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test


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Table 03: Visual Properties of Jelly

| | Storage in days | | | |
|---|---|---|---|---|
| Visual properties | **Day 01** | **Day 07** | **Day 14** | **Day 21** |
| Smoothness | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ |
| Shininess | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ |
| Deformation | 5.00±0.00$^{b}$ | 4.80±0.11$^{ab}$ | 4.80±0.11$^{ab}$ | 4.60±0.13$^{a}$ |
| Overall appearance | 5.00±0.00$^{b}$ | 5.00±0.00$^{b}$ | 5.00±0.00$^{b}$ | 4.60±0.13$^{a}$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test

*2) Organoleptic Parameters of Samples*

Organoleptic parameters including flavor, smoothness, sweetness, freshness and overall texture were evaluated. There was no any significant difference in flavor and sweetness (Figure 01) Accelerated climate condition period affect to the freshness, smoothness and overall texture of the hard candy. Moisture migration often causes the end of the shelf life for hard candies. Variations of moisture content can cause significant changes in product quality (Hartel et al., 2018b; Ergun et al., 2010). While in accelerated conditions loss or gain depends on relative humidity and water activity/ moisture content of the product. There was no any significant difference in flavor and sweetness. According to the research, confectioneries' flavor being lost in 10% over months of storage but there are no any significant differences between commercial products and testing samples (Figure 02). But bother parameters had the significant differences. The Freshness and overall texture of chewing gum showed the most difference in accelerated climate conditions within the 21-day period. In accelerated climate conditions of jelly there was no any significant difference observed according to new consumer packaging material. Permeability is impacted by the material's degree of symmetry and crystallinity. A molecule's capacity to penetrate the packaging material is decreased by a higher degree of order and structure. This may be due to that thickness does not directly correlate with permeability when comparing various packing materials, adding thickness usually reduces permeability for any given package (Ergun, Lietha and Hartel, 2010).

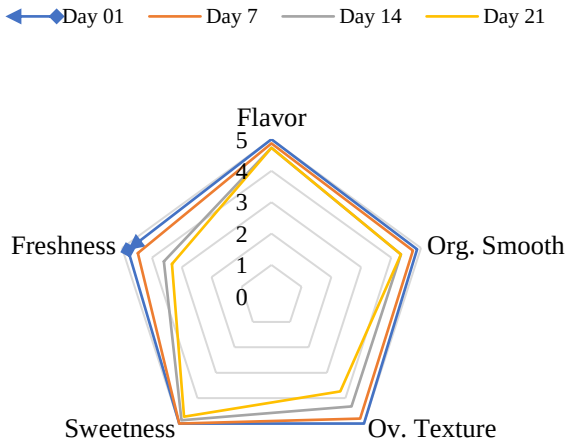


Figure 01: Sensory attributes in Hard Candy

The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test

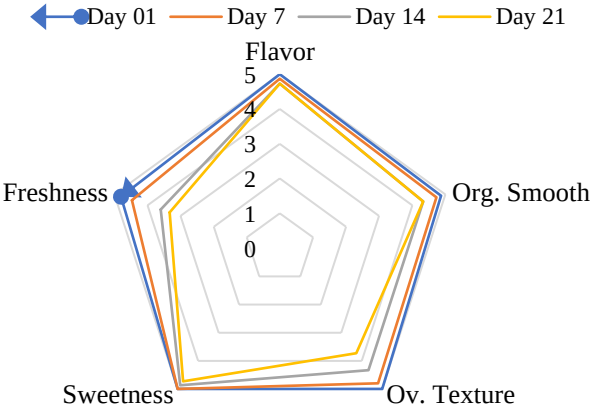


Figure 02: Sensory attributes in chewing gum

The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test


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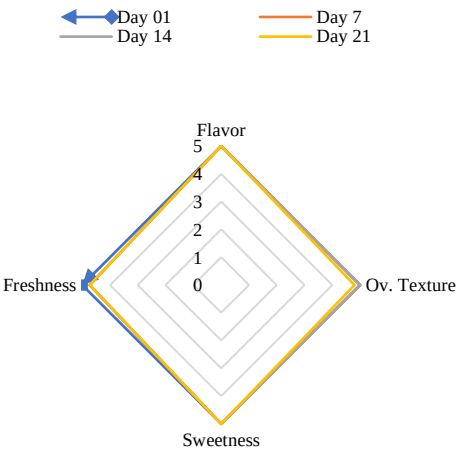


Figure 03: Sensory attributes in jelly

The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test

*3) Packaging Visual Properties*

There was significant difference ($p<0.05$) in stickiness between product to wrapper (primary package) and stickiness between products (primary package) to secondary package. The product becomes stickier and sticks to the wrapper as the moisture content rises. Surface moisture reduces viscosity and dilutes sugar concentration, which encourages sucrose crystallization and causes graining (Arturo and Paredes, 2000). Color stability of ink had no any significant difference ($p>0.05$) among all three products (Table 04, 05 and 06). If there is a volatile compositions it can be affect to packaging material color stability of ink without these compositions no harm for the ink of package (Arturo and Paredes, 2000).

Table 04: Visual Packaging Properties of Hard Candy

| **Visual properties** | **Storage in days** | | | |
|---|---|---|---|---|
| | **Day 01** | **Day 07** | **Day 14** | **Day 21** |
| Stickiness (pro: Pack) | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 4.87±0.09$^{a}$ | 4.73±0.12$^{a}$ |
| Stickiness (pro: Wrapper) | 5.00±0.00$^{b}$ | 4.80±0.11$^{b}$ | 4.53±0.17$^{b}$ | 4.00±0.20$^{a}$ |
| Color stability. Ink | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 4.87±0.09$^{a}$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 05: Visual Packaging Properties of Chewing Gum

| **Visual properties** | **Storage in days** | | | |
|---|---|---|---|---|
| | **Day 01** | **Day 07** | **Day 14** | **Day 21** |
| Stickiness (pro: Pack) | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 4.87±0.09$^{a}$ | 4.70±0.12$^{a}$ |
| Stickiness (pro: Wrapper) | 5.00±0.00$^{b}$ | 4.80±0.11$^{b}$ | 4.53±0.16$^{b}$ | 4.00±0.19$^{a}$ |
| Color stability of Ink | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 5.00±0.00$^{a}$ | 4.87±0.91$^{a}$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test


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Table 06: Visual Packaging Properties of Jelly

| Visual properties | Storage in days | | | |
|---|---|---|---|---|
| | Day 01 | Day 07 | Day 14 | Day 21 |
| Stickiness (pro: Pack) | $5.00\pm0.00^{c}$ | $4.80\pm0.11^{bc}$ | $4.60\pm0.13^{b}$ | $3.80\pm0.11^{a}$ |
| Stickiness (pro: Wrapper) | $5.00\pm0.00^{b}$ | $4.13\pm0.09^{a}$ | $4.33\pm0.21^{a}$ | $4.20\pm0.22^{a}$ |
| Color stability of Ink | $5.00\pm0.00^{a}$ | $5.00\pm0.00^{a}$ | $5.00\pm0.00^{a}$ | $4.73\pm0.18^{a}$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 07: Comparative Analysis of Hard Candy

| Sample | Test Sample | Control Sample |
|---|---|---|
| Physical quality | Yes | Yes |
| Taste and Flavor | Yes | Yes |
| Texture | Yes | Yes |
| Stickiness | Yes | No |

Table 08: Comparative Analysis of Chewing Gum

| Sample | Physical quality | Taste and Flavor | Texture | Syrup Leakage | Stickiness |
|---|---|---|---|---|---|
| Test | Yes | Yes | Yes | Yes | Yes |
| T.Ref | Yes | Yes | Yes | No | No |
| Control | Yes | Yes | Yes | Yes | Yes |
| Co.Ref | Yes | Yes | Yes | No | No |

Table 09: Comparative Analysis of Jelly

| Sample | Physical quality | Taste and flavor | Texture | Stickiness |
|---|---|---|---|---|
| Test | Yes | Yes | Yes | Yes |
| Test Ref. | Yes | Yes | Yes | Yes |
| Control | Yes | Yes | Yes | Yes |
| Con.Ref. | Yes | Yes | Yes | Yes |

*B. Transit Trial*

1) Physical parameters checked by visual inspections

There was no any significant difference ($p>0.05$) in shininess, deformation, wrinkle, cracks and overall appearance. Color intensity and smoothness of the hard candy had significant deference ($p<0.05$) (Table 10). The visual properties: color intensity, smoothness, shininess, deformation, overall appearance, syrup leakage was significant difference (Table 11). There was no any significant difference in any parameter of jelly samples while comparing the commercial samples (Table 12). All visual properties of the products decrease within the transportation period. When long distance transporting products hold different situations like different climatic conditions, weather conditions, different elevations, transportation methods and time affect for the product deterioration (Arturo and Paredes, 2000).


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Table 10: Visual Properties of Hard Candy

| Properties | Before transportation | After transportation |
|---|---|---|
| Color Intensity | 5.00±0.00* | 4.40±0.16* |
| Smoothness | 4.93±0.07* | 4.53±0.21* |
| Shininess | 4.80±0.11 | 4.53±0.19 |
| Deformation | 5.00±0.00 | 4.93±0.07 |
| Wrinkle | 4.80±0.11 | 4.40±0.19 |
| Cracks | 5.00±0.00 | 5.00±0.00 |
| Overall appearance | 5.00±0.00 | 5.00±0.00 |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 11: Visual Properties of Chewing Gum

| Properties | Before transportation | After transportation |
|---|---|---|
| Color Intensity | 5.00±0.00* | 3.53±0.19* |
| Smoothness | 5.00±0.00* | 2.87±0.22* |
| Shininess | 5.00±0.00* | 1.93±0.18* |
| Deformation | 5.00±0.00* | 3.53±0.13* |
| Overall appearance | 5.00±0.00* | 1.80±0.20* |
| Syrup leakage | 5.00±0.00* | 1.53±0.13* |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 12: Visual Properties of Jelly

| Properties | Before transportation | After transportation |
|---|---|---|
| Color intensity | 4.67±0.13 | 4.60±0.13 |
| Smoothness | 5.00±0.00 | 5.00±0.00 |
| Shininess | 5.00±0.00 | 5.00±0.00 |
| Deformation | 5.00±0.00 | 4.80±0.11 |
| Overall appearance | 5.00±0.00 | 5.00±0.00 |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

2) *Organoleptic parameters*

According to 5 point hedonic scale, during the transit trial period there was significant difference in freshness and other parameters like flavor, smoothness, texture, and sweetness were no any significant difference observed (Figure 04) in hard candy. Flavor and overall texture was changed in the transit trial period because of fluctuation of storage conditions (Arturo and Paredes, 2000). There was no any significant difference in freshness and sweetness (Figure 05) when comparing the commercial samples. There was no any significant difference in new consumer package used jelly samples (Figure 06) it may be due to thickness of the packaging material not much decreased (Ergun, Lietha and Hartel, 2010).

*3) Packaging Visual Propertie* All three products had a significant difference ($p<0.05$) in stickiness between primary package, wrapper and stickiness, with primary package being the most significant. Color stability of ink was no significant difference ($p<0.05$) between the two, and all visual packaging properties were reduced during transit trial period (Table 13, Table 14 and Table 15) (Calligaris *et al.*, 2019).


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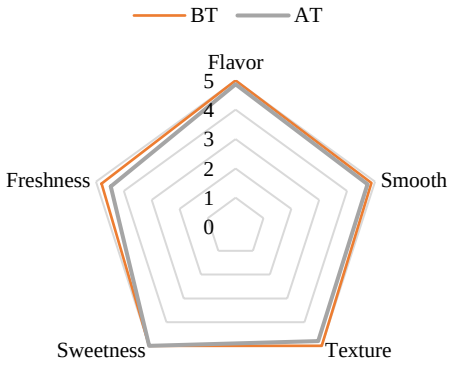


Figure 04: Sensory Attributes in Hard Candy
The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test

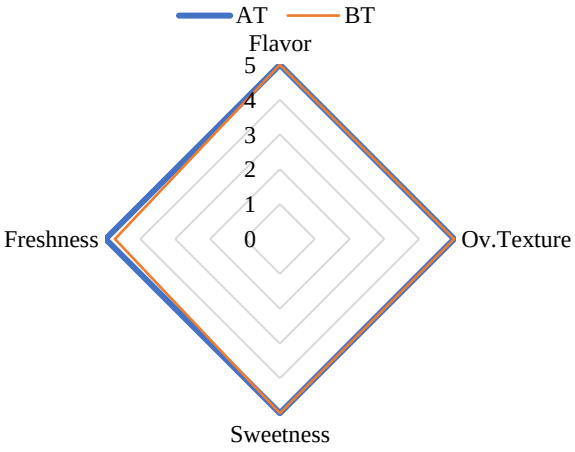


Figure 06: Sensory attributes in jelly
The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test
BT – Before Transportation
AT – After Transportation

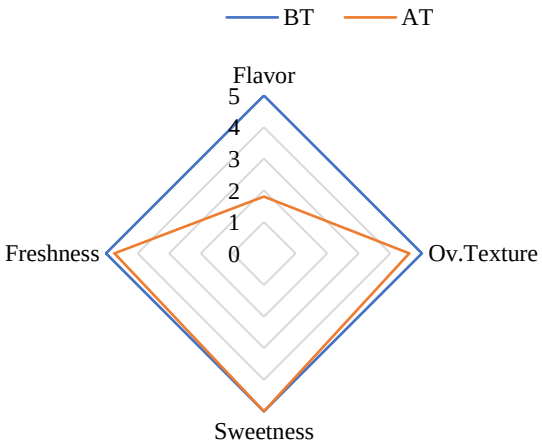


Figure 05: Sensory attributes in chewing gum
The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test
BT – Before Transportation
AT – After Transportation

Table 13: Visual Packaging Properties of Hard Candy

| **Properties** | **Before transportation** | **After transportation** |
|---|---|---|
| Stickiness product to package | 5.00±0.00* | 4.73±0.12* |
| Stickiness product to wrapper | 5.00±0.00* | 4.00±0.90* |
| Color stability ink package ink | 5.00±0.00 | 4.87±0.90 |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 14: Visual Packaging Properties of Chewing Gum

| **Properties** | **Before transportation** | **After transportation** |
|---|---|---|
| Stickiness product to package | 5.00±0.00* | 2.47±0.13* |
| Stickiness product to wrapper | 5.00±0.00* | 1.73±0.15* |
| Color stability of package ink | 5.00±0.00* | 4.47±0.13* |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test


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Table 15: Visual Packaging Properties of Jelly

| Properties | Before transportation | After transportation |
|---|---|---|
| Stickiness product to package | 5.00±0.00* | 3.80±0.11* |
| Stickiness product to wrapper | 5.00±0.00* | 4.20±0.22* |
| Color stability of package ink | 5.00±0.00 | 4.73±0.18 |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

## V. CONCLUSION

The results indicated that size, texture, quality of packaging material of confectioneries was affected by storage and transportation as well as temperature, moisture migration, relative humidity. Three production processes were conducted, revealing variations in commercial products such as new hard candy, decreased chewing gum size, and reduced thickness packaging for jelly. All confectionery samples deteriorate within the period due to moisture migration, low temperature, and high relative humidity in the climate chamber (35/40ºC and50/80% RH). Overall appearance of confectioneries can be affected by sucrose and citric acid content. However commercial chewing gum samples and hard candy samples showed better quality compared to size reduced samples due to their sensitivity to humidity and temperature. Further, the overall quality of all the samples closes to commercial products.

## REFERENCES


Arturo, L. and Paredes, A. (2000) "The stability and shelf-life of foo, The stability and shelf-life of food", *Woodhead Publishing Limited and CRC Press LLC*, 6(4), pp. 97–80.

Board, N. (2013*)* "Confectionery Products Handbook (Chocolate, Toffees, Chewing Gum \& Sugar Free Confectionery): Food Processing \& Agro Based Profitable Projects, Food Processing Industry in India, bread manufacturing project, candy manufacturing process", *asia pacific business press inc*, 11(4), pp. 17–29.

Calligaris, S., Manzocco, L., Anese, M. and Nicoli, M.C. (2019) "Accelerated Shelf-Life Testing. Food Quality and Shelf-Life", *Elsevier Inc*, 8(11), pp 89-92.

Cheung, P.C.K. and Mehta, B.M. eds. (2015) "Handbook of food chemistry", *Springer Berlin Heidelberg*, 11(2), pp. 19-25.

Dilrukshi, P.G.T., Munasinghe, H., Silva, A.B.G. and De Silva, P.G.S.M. (2019) "Identification of synthetic food colours in selected confectioneries and beverages in Jaffna District", *Journal of Food Quality*, 19(2), pp.1-8.

E.B.Jackson, R. L. (1992) "Sugar Confectionery and Chocolate Manufacture", *Springerlinc*, 9(2), pp.11-18.

Edwards, W. P. (2018) "The Science of Sugar Confectionery", *Royal Society of Chemistry*, 5(10), pp. 220-225.

Ergun, R., Lietha, R. and Hartel, R. W. (2010) "Moisture and shelf life in sugar confections", *Critical Reviews in Food Science and Nutrition*, 50(2), pp.162–192.

Hartel, R. W., von Elbe, J. H. and Hofberger, R. (2018) "Confectionery Science and Technology", *Confectionery Science and Technology*, 7(11), pp. 530-539.

Lees, R. (2012) "*Sugar Confectionery and Chocolate Manufacture", Springer US*, 5(1), pp. 32-39.

Netramai, S., Kijchavengkul, T., Sompoo, P. and Kungnimit, W. (2018) "The effect of intrinsic and extrinsic factors on moisture sorption characteristics of hard candy", *Journal of Food Processing and Preservation*, 42(5), pp. 135-148.

Schieberle, P. and Grosch, W. (1988) "Identification of potent flavor compounds formed in an aqueous lemon oil/citric acid emulsion", *Journal of Agricultural and Food Chemistry*, 36(4), pp. 797–800.

Spanemberg, F. E. M. (2019) "Effects of sugar composition on shelf life of hard candy Optimization study using D-optimal mixture design of experiments", *Journal of food preservation engineering*, 3(6), pp. 1–10.

Subramaniam, P. J. (2009) "Shelf-life prediction and testing, Science and Technology of Enrobed and Filled Chocolate, Confectionery and Bakery Products", *Woodhead Publishing Limited*. 3(7), pp 233-254.



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