International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 05-06-2021, Accepted: 17-06-2021, Published: 05-07-2021
Volume 6, Issue 4, 2021, Page No. 08-12

Storage study of jelly mixture made with special *Carrageenan*

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Abstract
Carrageenan is a seaweed polysaccharide widely used as a food gelling and thickening agent. In a newly formulated commercially available jelly-based dessert product a special *Carrageenan* is used with the purpose of obtaining the setting at room temperature; instead of subjecting the jelly mixture to refrigeration temperature where the normal gelatin-based jelly set at. In this study two methods are employed to measure the changes in textural property of the jelly mixture with special *Carrageenan*, i.e., using the Texture Analyzer and using the trained sensory panel. The sensory evaluation test carried out showed that upon storage there is a significant degradation of the flavour and the mouth feel of the jelly mixture. The main factors influencing this may be the different temperature conditions and different storage conditions. Readings of the texture analyzer reveals that hardness of the freshly prepared jelly made with *Carrageenan* and the sample stored under different conditions for a month does not show a significant different remains almost the same although the flavour of the sample stored in room temperature without exposing to light found to be more compatible with the freshly prepared jelly sample where the flavour of the sample kept exposing to light at room temperature has considerably degraded.

Keywords: jelly mixture made, special *Carrageenan*

Introduction

Carrageenan is a collective term for seaweed-derived sulphated polysaccharide, considered as a food additive E407. It is a common gelling and thickening agent in cheese, puddings desserts and cured meat (De Ruiter & Rudolph, 1997; Blakemore & Harpell, 2010; Błaszak *et al*., 2018) [7, 3]. Generally, *Carrageenan* is prepared by alkaline extraction (and modification) form red seaweed (Rhodophycare), mostly of genus *Chondrus, Eucheuma, Gigratina and Iridaea* (Rhein-Knudsen *et al*., 2015; Moses, 2015) [23, 19]. Different seaweeds produce different *Carrageenan* (Valderrama, 2013) [27]. *Carrageenans* are linear polymer of about 25,000 galactose derivatives with regular but imprecise structure, dependent on the source and extraction conditions (Draget, 2006) [8].

In a newly formulated commercially available jelly-based dessert product a special *Carrageenan* is used with the purpose of obtaining the setting at room temperature; instead of subjecting the jelly mixture to refrigeration temperature where the normal gelatin-based jelly set at. *Carrageenan* has to be dispersed well before it is solubilization to avoid the formation of lumps and the obtain its complete functionality (Imeson, 2009). *Carrageenan* should be premixed with other dry ingredients such as sugar or salt, adding the products slowly in to cold liquid with agitation (Wüstenberg, 2015) [29]. All *Carrageenan* are dispersible in cold water and when heated above 80^0C they are completely dissolved (Kassab, 2019; Khrunyk *et al*., 2020) [16, 17]. During cooling process *Kappa* and *Iota Carrageenan* form double helix molecular structures cross-linked by potassium and calcium ions, forming a three-dimensional gel type network (Tecante & Santiago, 2012) [26]. Idealized structures are given below as *k-Carrageenan*, for example, has been found to contain a small proportion of the dimer associated with *i-Carrageenan* (Necas & Bartosikova, 2013) [21].

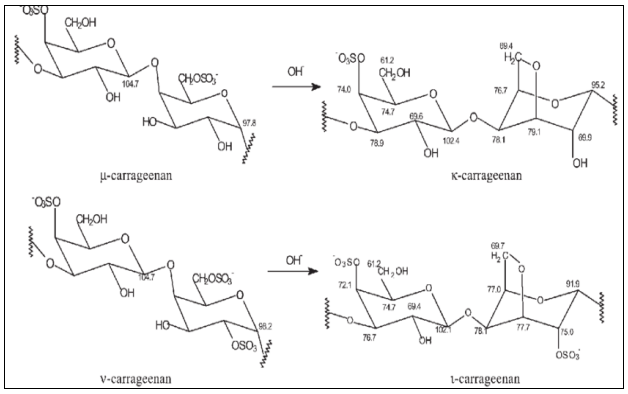


Fig 1: Structural Units of *Carrageenan* (Source: Aguilan *et al*., 2003)

Carrageenan are used mainly for thickening, suspending and gelling. *k-* and *i- Carrageenan* form thermo-reversible gels on cooling in the presence of appropriate counterions (Tavassoli-Kafrani, 2016; Aguilar *et al*., 2017) [25, 2], *k-Carrageenan* forms a firm clear, if brittle, gel with poor freeze-thaw stability; the helices [516], *k-Carrageenan* gels may be softened (and is generally regarded to be synergic ally strengthened) with locust bean gum (Cui & Wang, 2005) [6]. *i-Carrageenan* has less specific ionic binding but increased ionic strength allows helices to form junction zones in soft elastic gels with good freeze-thaw stability. *i-Carrageenan* is non-gelling as the lack of the $^1C_4$ 3,6-anhydro-link allows the initial double helix formation required for gelling (Necas & Bartosikova, 2013) [21]. Additionally, the high density of charged sulfate groups encourages an extensive conformation. *i-Carrageenan* has been found to act as a cryoprotectant and improves the freeze-thaw behavior of locust bean gum. *k-Carrageenan* stabilizes milk k-casein products due to its charge intersection with the casein micelles (~*200*nm diameter);

their incorporation in to the network preventing whey separation. Such complexes are soluble when both have same charge and are held together by counterions or oppositely charges patches (Hotrum, 1999; Rocha *et al*., 2014) [13, 24]. *Carrageenan* is also used as a binder in cooked meats, to firm sausages and a thickener in toothpaste and puddings.

It may be noted that cancer health scare concerning degraded *Carrageenan* has been recently examined by the European Commission Scientific Committee of Food, which found no evidence in support and states that *Carrageenan* is safe to be used in food (Watson, 2007; Carocho *et al*., 2014) [28, 5].

Other ingredients used in the production of jelly mixtures

In this special *Carrageenan* based jelly mixture, other ingredients used are as per in the normal gelatin-based jelly mixture. Other ingredients such as natural identical strawberry flavor, permitted food colouring (E122), Fumaric acids and Sodium Citrate are incorporated in appropriate in calculated amount (Ng, 2010).

This experiment mainly focuses on determining the effect of temperature on the gel structure/ texture of the jelly mixture made out of special *Carrageenan*. Consistency and the structure together make-up the so-called texture. Generally, texture is the overall emphasis of the sensory feeling and desirable especially the mouth feel of a product.

Texture Profile Analysis

Texture Profile Analysis (TPA) is method designed to emulate the moth feel and texture analyzer measures the characteristics of the texture of the experimental food with related to force, providing objective and insightful data (Huang, 2007; Liu & Li, 2010) [14, 18].

Descriptive sensory analysis

Descriptive sensory analysis with a highly trained panel was used to evaluate textural characteristics of carrageenan mixed jelly desserts stored under different storage conditions (Murray *et al*., 2001; Çakır *et al*., 2012) [20, 4]. Descriptive sensory analyses are distinguished from other sensory testing methods in that they seek to profile a product on all of its perceived sensory characteristics. As Dijksterhuis & Piggott (2000) explicitly mentions, 'descriptive sensory method profiles the food samples using scales, implicitly regarded as sensory properties under investigation as a static phenomenon….' (p.1).

In this study two methods are employed to measure the changes in textural property of the jelly mixture with special *Carrageenan*, i.e., using the Texture Analyzer and using the trained sensory panel.

Materials and Methods

Experiment I: Determination of textural properties using texture analyzer

Texture Analyzer measurements given the Rheological measurement of the strength of the gel, according to the qualities of different gelling compounds.

In this experiment the Backward Extrusion Rig is used to measure the strength of the jelly mixture is incorporated with special *Carrageenan* instead of gelatin which is used normally (Gao, 2017) [11], with the purpose setting at the room temperature i.e. without keeping at the refrigeration temperature.

The strength of the jelly mixture prepared can be determined either, determining the breaking strength or determining the penetration strength. The strength required for this action is measured by way of a strain gauge. The penetration measurement is taken by using texture analyzer by pressing a plunger in to a gel at a constant velocity or over a defined distance. The strength required to do this is the scale for the firmness of the gel penetration

Texture Analyzer

Determination of gel strength (Bloom Value) according to the Gelatin Manufacturing Institute of America (GMIA) (Haug & Draget, 2011) [12]

Settings of the instrument

Mode: measure force in Compression Option: Return to start
Test speed: I mm/sec
Distance: 4mm
Trigger type: 5kg

Accessory

Backward Extrusion Rig with the diameter of 35mm using 5kg load cell.

Two separate jell samples (sample I and II) were prepared

The Jelly mixture with special *Carrageenan*, colourant and strawberry flavour is mixed with the powdered sugar and further mixing was done using the Hobart Mixture to obtain a uniform dispersion. Here the sugar powder is used to enhance more uniform dispersion than when using sugar crystals.

Sample I was made in to 25g packets and packed in polyethylene bags. Packets were divided in to three portions and kept in different conditions as in the outside/ normal temperature exposing to normal light, under normal room temperature inside a closed environment (without exposing to sunlight) and inside the incubator at the temperature of 37 °C.

Same procedure is followed with sample II also.

Experiment II - Determination of textural Properties using a semi-trained Sensory Panel

Trained sensory panelists were employed to measure changes of parameters such as hardness, mouth feel, and flavour pertaining to this product, to determine the change of the sensory quality with time (after one month and two months) and different storage conditions. A simple comparative sensory test is carried out and the data collected was analyzed statistically using freedman test. Freshly prepared jelly sample (with special *Carrageenan*) is taken as the reference sample to be compared with the samples which are stored at different conditions.

Sample I -789 - sample kept inside (with-out exposing to the sunlight) at room temperature

Sample II - 456 - sample kept outside at room temperature

Figure 2 - Sample of the sensory evaluation paper

Results and Discussion

Experiment I: Determination of textural properties using texture analyzer

Textural strength was measures using the texture analyzer for a period of one month, the readings were taken as once a week of all three samples i.e. jelly samples prepared with special *Carrageenan* and kept at room temperature, at the room temperature but without exposing to sunlight and kept at 37 ^{0}C

Table 1: Results of the strength of the samples at different storage conditions

Conditions which the samples were kept	Duration	Force exerted by the texture analyzer in grams = Strength of the mixture
Room Temperature, without exposing to sunlight	After 1 week	369.0
	After 2 weeks	306.0
	After 3 weeks	232.0
	After 4 weeks	298.0
Room Temperature, normal room conditions	After 1 week	254.0
	After 2 weeks	201.0
	After 3 weeks	281.0
	After 4 weeks	214.0
At 37^{0}C, inside the incubator	After 1 week	160.0
	After 2 weeks	159.0
	After 3 weeks	148.0
	After 4 weeks	121.0

The measurements obtained for all the samples at different physical conditions shows deterioration with the time. The comparatively low values obtained for the samples kept at 37 °C shows that the special *Carrageenan* used for the preparation of the jelly is heat /temperature sensitive. i.e. at high temperatures the structure of the special *Carageenan* is tends to destabilize. Although both the other samples are kept at the same room temperature, the sample kept exposing to the sunlight has been deteriorated than the sample kept at the room temperature without exposing to the sunlight.

Experiment II - Determination of textural Properties using a semi-trained Sensory Panel

Trained sensory panelists were employed to measure changes of parameters such as hardness, mouth fell and flavours pertaining to this product, to determine the change of the sensory quality with time (after one month and two months) and different storage conditions. Nine panelists (all males, ages between 35 and 55 years) performed descriptive analysis using the Spectrum method (Drake *et al.*, 1999). Each panelist had more than 500 h of descriptive analysis experience on various products. Approximately 250 h of experience were specific to texture attributes.

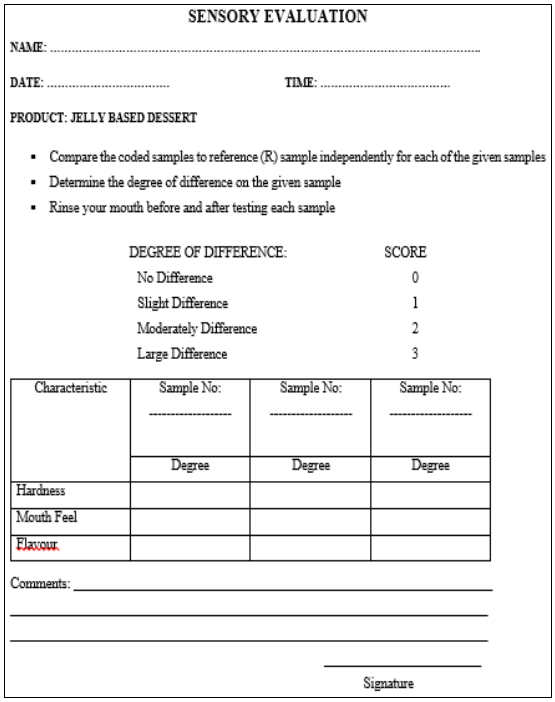
A sample comparative sensory test id carried it and the data collected was analyzed statistically using freedman test. Freshly prepared jelly sample (with special *carrageenan*) is taken as the reference sample to be compared with the sample which are stored at different conditions.

Sample I

Treatment 1–789 - sample kept inside (without exposing to the sunlight) at room temperature

Sample II

Treatment 2–456 - sample kept outside at room temperature



SENSORY EVALUATION

NAME: .....

DATE: ..... TIME: .....

PRODUCT: JELLY BASED DESSERT

- Compare the coded samples to reference (R) sample independently for each of the given samples
- Determine the degree of difference on the given sample
- Rinse your mouth before and after testing each sample

DEGREE OF DIFFERENCE:	SCORE
No Difference	0
Slight Difference	1
Moderately Difference	2
Large Difference	3

Characteristic	Sample No: ----------	Sample No: ----------	Sample No: ----------
	Degree	Degree	Degree
Hardness			
Mouth Feel			
Flavour			

Comments: _____

_____

_____

_____

Signature

Fig 2: Sample of the Sensory Evaluation Paper

Results of the first trial

Hardness

Friedman Test: response versus treatment blocked by panelists

S = 0.00 DF = 1 P = 1.000

S = 0.00 DF = 1 P = 1.000 (adjust for ties)

trt	N	Estimated Sum of	Median Rank
1	13	0.50000	19.5
2	13	0.50000	19.5

Grand Median = 0.50000

Flavour

Friedman Test: response versus treatment blocked by panelists

S = 0.08 DF = 1 P = 0.782

S = 0.11 DF = 1 P = 0.739 (adjust for ties)

trt	N	Estimated Sum of	Median Rank
1	13	1.0000	19.0
2	13	1.0000	20.0

Grand Median = 1.0000

Mouth Feel

Friedman Test: response versus treatment block

S = 0.11 DF = 1 P = 0.739 (adjust for ties)

trt	N	Estimated Sum of	Median Rank
1	13	1.0000	19.0
2	13	1.0000	20.0

Grand Median = 1.0000

Results of the second trial

Hardness

Friedman Test: response versus treatment blocked by panelists
S = 0.00 DF = 1 P = 1.0000
S = 0.00 DF = 1 P = 1.0000 (adjust for ties)

trt	N	Estimated Sum of Median Rank
1	13 1.0000	19.0
2	13 1.0000	20.0

Grand Median = 1.0000

Flavour

Friedman Test: response versus treatment blocked by panelists
S = 0.20 DF = 1 P = 0.655
S = 1.00 DF = 1 P = 0.317 (adjust for ties)

Trt	N	Estimated Sum of Median Rank
1	5 1.5000	8.0
2	5 1.5000	7.0

Grand Median = 1.5000

Mouth Feel

Friedman Test: response versus treatment blocked by panelists
S = 0.20 DF = 1 P = 0.655
S = 1.00 DF = 1 P = 0.317 (adjust for ties)

Trt	N	Estimated Sum of Median Rank
1	5 1.0000	8.0
2	5 1.0000	7.0

Grand Median = 1.0000

According to the results obtained it was shown that, hardness of sample I and sample II were almost the same as the reference samples i.e. the freshly prepared sample although the sample I and II are stored under different conditions for a month. Although there is a slight degradation in the flavour and the mouth feels of the prepared samples comparing to the reference sample there is no significant difference between them. Further these results show that the 789 is better than 456, i.e., it is more towards the freshly prepared. The sensory evaluation test carried out showed that upon storage there is a significant degradation of the structure of the jelly mixture. The main factors influencing this may be the different temperature conditions and different storage conditions.

Conclusion

The results indicated the following conclusions. 1. The measurement of the texture analyzer on hardness of the jelly samples stored under different storage conditions does not show a significant deviation from the freshly prepared sample texturally. 2. The characters such as flavour and mouth fell gauged by a expert sensory panel reveal that there is a significant degradation in the sample which was stored under room temperature yet exposing to light. Therefore, it can be concluded that the jelly product made with special *Carrageenan* which sets at room temperature (without refrigerating) is heat sensitive, and it has to be stored in a light-proof packaging when introducing to the market for commercial purposes, so that the consumers are able to experience a much fresh a like jelly dessert.

Conflicts of Interest (*required*)

None to declare.

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