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Formulation and Texture Characterization of Zein Chewing Gum

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ABSTRACT

Chewing gum can be seen as environment pollutant, when left over gum becomes sticky residue, which adheres to various surfaces in public places. Most of the chewing gum formulations include gumbase, plasticizer, softeners, sweeteners, flavouring agent, bulking agent. Gum base is the most important entity of chewing gum formulation, mostly synthetic gum base are used as gum base, which is responsible for stickiness and chewy texture of gum. In current study texture characteristic of corn gum like guminess, juiciness, stickiness, springiness, cohesiveness are determined with help of texture analyser. Corn zein as a gum base offers nonadhesive and biodegradable property. Out of the corn zein gum the use of triacetin as plasticizer shows maximum values for hardness and other texture parameters. The study shows corn zein is best suited to be used as biodegradable gum base which can be developed as acceptable product for consumers.

Key words: Corn zein, plasticizer, gumbase, texture analyser, biodegradable property.

INTRODUCTION

Endosperm of the corn kernel contains zein, prolamine protein, which is found in maize. Powder from corn gluten is the chief source which is used for manufacture of zein. Corn zein has a variety of confectionery, food and industrial uses. Pure zein is odorless, tasteless, tough, water-insoluble, and edible, making it valuable in processed foods and pharmaceuticals. It is used as a coating for encapsulated foods and drugs, candy, nuts, fruits and pills. It is classified as Generally Recognized as Safe (GRAS) by the U.S. Food and Drug Administration.

Zein can be processed into resins and other biocompatible polymer, which can be extruded or rolled into a variety of products. With increasing environmental concerns about synthetic coatings and the current higher prices of hydrocarbons, there is increased focus on zein as a raw material for a variety of nontoxic and biocompatible polymer applications. There are also a number of potential new food industry applications.

Kruppa and coworkers in 1984 (1) used zein to coat sodium fluoride granules to create an anticariogenic chewing gum. In chewing gum formulation to promote primary texture characteristic like chewiness and juiciness, various plasticizers are used. Glyceryltriacetate (Triacetin), PEG-600, oleic acid and tributyl citrate are used as plasticizer for chewing gum formulations.

MATERIALS AND METHODS

Ingredients for preparation of gum sample

Four different formulations of corn zein chewing gum sample were included in the study, which varied in the plasticizer used. The corn zein gum formulations used Triacetin, Tributyl citrate, Oleic acid, and PEG 600 as plasticizer. Other than the plasticizer, all of the ingredients and the amounts of each ingredient were the same for each formulation.

The ingredients used in making each of the corn zein chewing gums consisted of 100 g corn zein (regular grade M P Biomedical, LLC), 500 mL of 60% ethanol (C.D.H. New Delhi), 5 g distilled monoglycerides (Estelle Pvt Limited), 16 g partially hydrogenated soybean oil (Krishna Oil extraction limited, pachor, Rajgarh, M.P.), 10 g artificial cinnamon flavor (GLEE Gum kit U.S.A.), 100 g of 70% sorbitol solution (C.D.H. New Delhi), and 70 g each of plasticizer, either oleic acid (C.D.H. New Delhi), PEG-600 (C.D.H. New Delhi), triacetin and tributyl citrate (C.D.H. New Delhi).

Corn zein is a food-grade protein, and all the other ingredients used in the gum formulation for this study were also food-grade quality. Table 1 shows a summary of the corn zein gum formulation.

Table 1: Formulation of various corn zein chewing gum

S. No	Ingredient	CZ-1	CZ-2	CZ-3	CZ-4
1.	Corn Zein	100g	100g	100g	100g
2.	Distilled Monoglyceride	5g	5g	5g	5g
3.	Soyabean Oil Partially Hydrogenated	16g	16g	16g	16g
4.	Plasticizer	A 70g	D70g	B 70g	C 70g
5.	Sorbitol solution	100g	100g	100g	100g
6.	Artificial flavor	10g	10g	10g	10g

Corn zein gum were made either with (A) Triacetin, (B) Oleic acid and (C) PEG 600. One corn zein gum sample (D) contain Tributyl citrate as plastisizer.

The exact amounts of each ingredient for the samples steps are summarized in Table 1.

Method for making corn zein chewing gum samples (2)

All of the corn zein gums were prepared under a chemical vapour absorbtion chimney to absorb the vapors released by 60% ethanol. Aqueous ethanol solution was poured into a stainless-steel mixer, followed by the corn zein and then the remaining ingredients were added except for the partially hydrogenated soybean oil. These ingredients were mixed together at for 5 min. The mixer has a temperature-control device that allows the temperature to be maintained at a specified level. The temperature was measured intermittently until it reached 70 °C. Mixing was continued at for an additional 10 min at 70 °C. This mixing time and temperature thoroughly mixed all the ingredients into a homogenous mixture.(3)

The mixing action and heat help to promote the evaporation of the ethanol present in the solution. To limit exposure to heat, the partially hydrogenated vegetable oil was added to the mixture 5 min before mixing was complete. The corn zein mixture was then poured into a metal container, which held 4 litter of purified ice water (4.5 °C). As the mixture was being poured into the container, the water was quickly stirred for no longer than 20 seconds using a metal spoon. The cold water caused the zein to precipitate from the ethanol solution. The zein particles were able to aggregate together and entrap the rest of the ingredients. A dough-like resinous matter was formed.

The dough was kneaded and rinsed in two separate containers of purified water for 20 min to form a flexible gum base. The kneading action further blended the ingredients and rinsed away any remaining ethanol. The gum base was then spread into a thin sheet with a roller and cut into strips of 2 g each. Each strip was approximately 4 cm long, 1 cm wide, and 2 mm thick. The strips were rolled in flavoring liquid consisting of 20 g sorbitol and 5 drops artificial flavor. The individual strips were then placed in 20-mL plastic cup container. All the gum samples were stored at room temperature.

Characterization of medicated chewing gum:

1. Physical evaluation of Medicated Chewing Gum: All Medicated Chewing Gum formulations were visually inspected; various physical properties of gum base were studied on basis of their solubility studies, relative humidity, color and moisture absorption. Following parameters were studied:

- a) Weight variation: Weight variation of all formulation was done by method described in experimental work.
- b) Physical evaluation of Corn Zein Gum: All formulation prepared by above procedure were physically evaluated for following parameters, Appearance, Color, Stickiness, Hardness, Weight variation and texture analysis.
- c) Hardness/Plasticity: Texture analyser was used for determining strength and degree of deformation. Values obtained indicate flexibility of sample.
- d) Weight variation: Weight of ten chewing gum was taken in one batch, then average weight is calculated, from that standard deviation is calculated.
- e) Stickiness: Texture analyzer from stable micro system model TA.XT-EXPRESS was used for determining Texture profile analysis (T.P.A). Values obtained indicate uniformity of sample.

2. Stability study of synthetic gum base: 5 gm of corn zein gum base was stored in container at $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ at 75% RH \pm 5% RH (According to ICH Q1A(R₂) (4) guidelines for stability for a period of six months. After six months the gum was examined for signs of ageing and physical deformalities.

Table 2; Physiochemical properties of synthetic gum base after stability studies

S.NO	Properties	Observations
1.	Color(before ageing)	Off white to brown
2.	Color(after ageing)	Off white to dark brown
3.	Softening range(before ageing)	50 to 70 ⁰ C
4.	Softening range(after ageing)	57 to 68 ⁰ C
5.	Texture(before ageing)	Chewee
6.	Texture(after ageing)	Chewee

3. Texture Analysis of corn zein chewing gum :

a)- Objective: Comparison of the hardness of 2 types of coated chewing gum by penetration with a 3mm cylinder probe.(5-7)

TA Settings

Sequence Title: Return to Start (Set Dist)

Test Mode: Compression

Pre-Test Speed: 0.5 mm/sec

Test Speed: 1.0 mm/sec

Post-Test Speed: 10.0 mm/sec

Distance: 3.0 mm

Trigger Type: Auto (Force)

Trigger Force: 5.0 g

Points per second: 250

Test Set-Up:

Place the Heavy Duty Platform onto the machine base. Position the sample on the platform, centrally under the probe, and commence the test. It is important that regular shaped samples are selected and it is advantageous for the pellets to have a flat under side

Observations:

The probe approaches the sample and once the 5g trigger force is attained, a rapid rise in force is observed, as the probe penetrates through the coating of the chewing gum. A drop in force is observed when the probe enters the interior of the gum. The probe returns to its original starting position when a penetration distance of 3mm from the trigger point is reached. The peak force is measured as an indication of the coating hardness. The force value at the distance of 1.5mm is considered as the interior hardness.

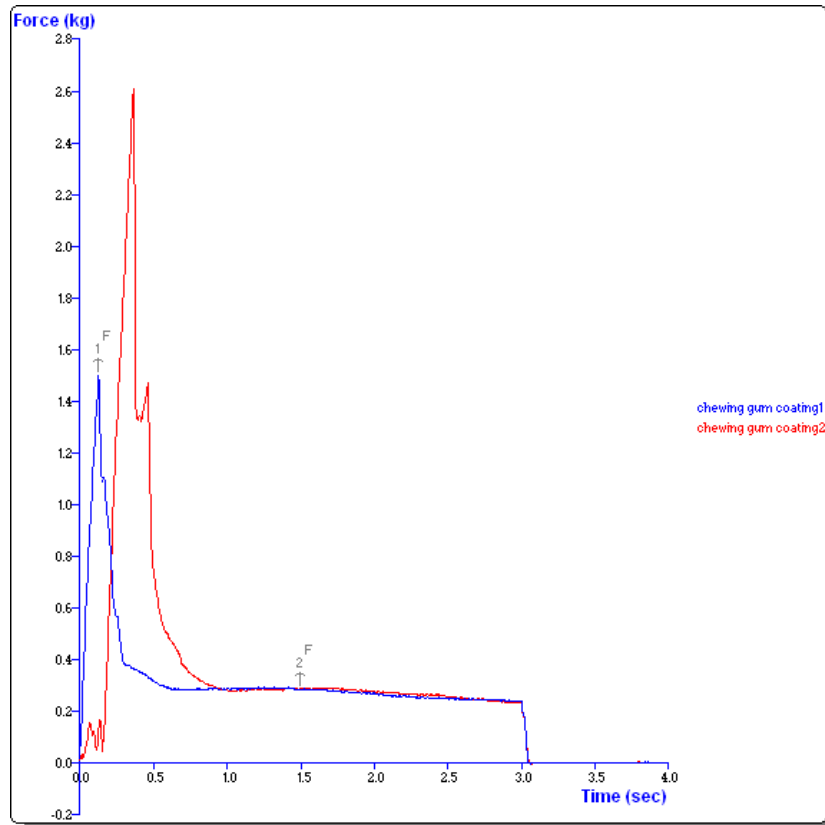


Fig1.Coating hardness of corn zein formulation

RESULTS

Test ID	'Coating Hardness'	'Interior Hardness'
	Force 1	Force 2
	G	G
chewing gum coating1	1497.252	284.52
chewing gum coating2	156.744	288.413

b)- Objective: Testing of chewing gum by penetration with a 3mm cylinder probe

TA Settings

Sequence Title: Return to Start (Set Dist)

Test Mode: Compression

Pre-Test Speed: 0.5 mm/sec

Test Speed: 1.0 mm/sec

Post-Test Speed: 10.0 mm/sec

Target Mode: Distance

Distance: 4.0 mm

Trigger Type: Auto (Force)

Trigger Force: 5.0 g

Stop Plot At: Start Position

Points per second: 250

Test Set-Up:

Place the Heavy Duty Platform onto the machine base. Position the sample on the platform, centrally under the probe, and commence the test. It is important that regular shaped samples are selected and it is advantageous for the pellets to have a flat under side

Observations:

The probe approaches the sample and once the 5g trigger force is attained, a rapid rise in force is observed, as the probe penetrates through the coating of the chewing gum. A drop in force is observed when the probe enters the interior of the gum. The probe returns to its original starting position when a penetration distance of 4mm from the trigger point is reached. The peak force is measured as an indication of the coating hardness. The force value at the distance of 3.5mm is considered as the interior hardness.

RESULTS

Test ID	Coating Hardness'	Interior Hardness'
	Force 1	Force 2
	G	G
chewing gum coating3	168.628	44.684

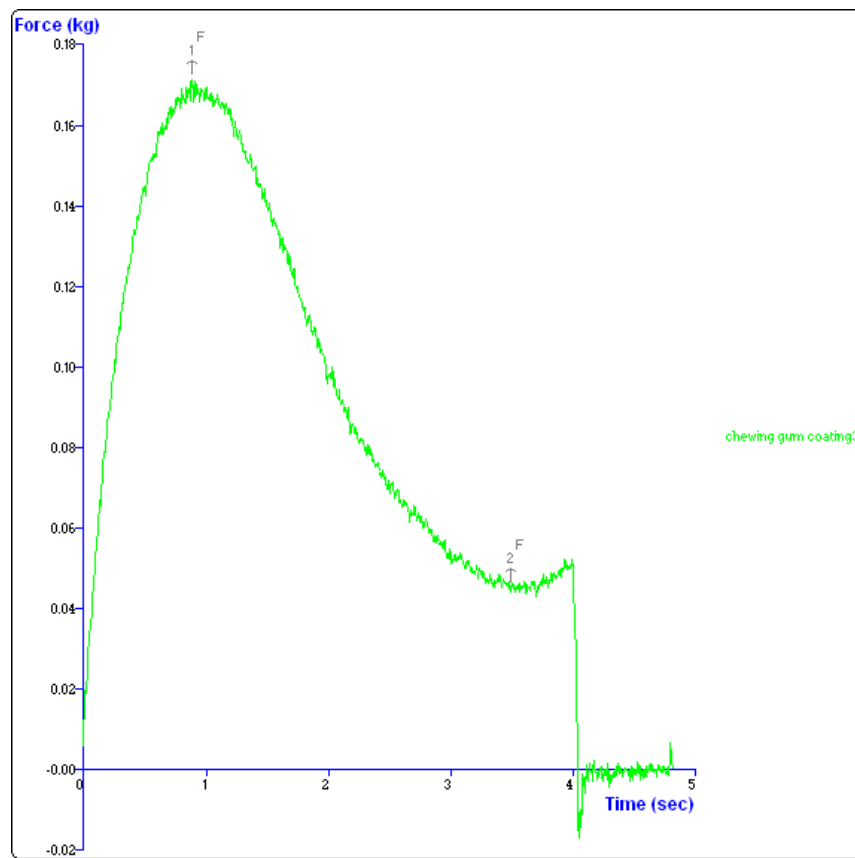


Fig2.Coating and interior hardness of zein chewing gum.

c).TPA Analysis for Corn Zein gum-

Probe Used: P/75; 75mm COMPRESSION PLATEN

Texture profile analysis (TPA) is an objective method of sensory analysis by compressing standard-sized samples of food twice. The test consists of compressing a bite-size piece of food two times in a reciprocating motion that imitates the action of the jaw and from the resulting force-time curve a number of textural parameters can be calculated, that correlate well with sensory evaluation.

Different chewing gum samples were tested by using a Compression platen of 75 mm diameter (P/75) with Texture Analyser and Texture profile analysis (TPA test) was performed for measurement of properties like Hardness, Fracturability, Springiness, Cohesiveness, Adhesiveness, Gumminess, Chewiness and Resilience.(8)

T.P.A(Texture Profile Analysis) Analysis curve for corn zein

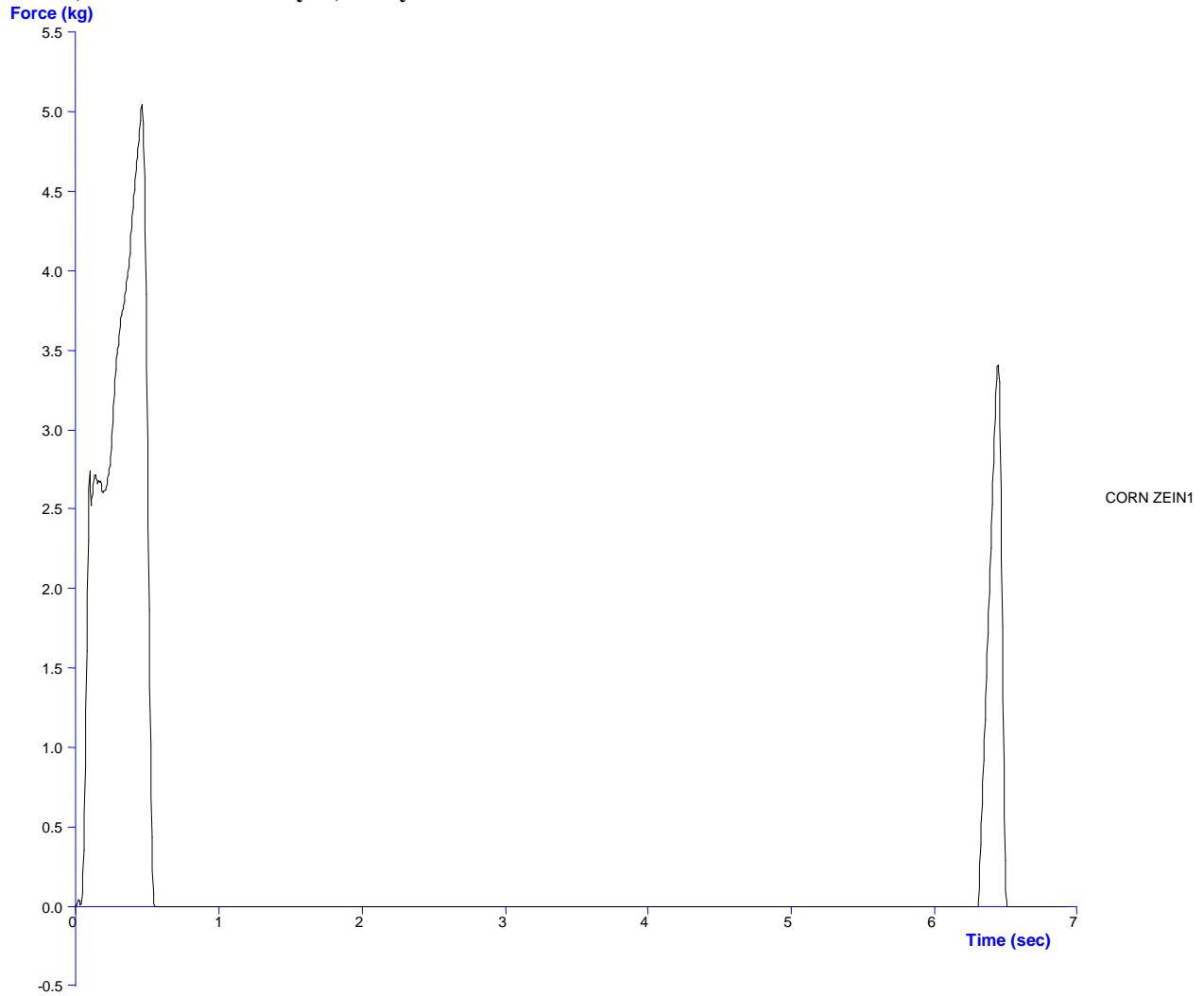


Fig3:TPA Analysis curve for corn zein-1(cz-1) formulation

Table 3:TPA analysis of corn zein chewing gum

Test ID	Hardness	Fracturability	Adhesiveness	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
	g	g	g.sec					
CORN ZEIN1	5056.711	2746.095		0.289	0.224	1133.039	327.063	0.115
CORN ZEIN2	2664.95	2796.109		0.295	0.177	472.177	139.168	0.073
CORN ZEIN3	3806.81	2615.966	-0.233	0.283	0.185	705.706	199.439	0.093
CORN ZEIN4	2793.82	3130.644	-0.498	0.276	0.176	491.306	135.36	0.065
Average:	3580.573	2822.204	-0.366	0.285	0.191	700.557	200.257	0.087
S.D.	1108.679	219.198	0.187	0.008	0.023	307.143	89.487	0.022
Coef. of Variati	30.964	7.767	-51.195	2.885	11.904	43.843	44.686	25.794

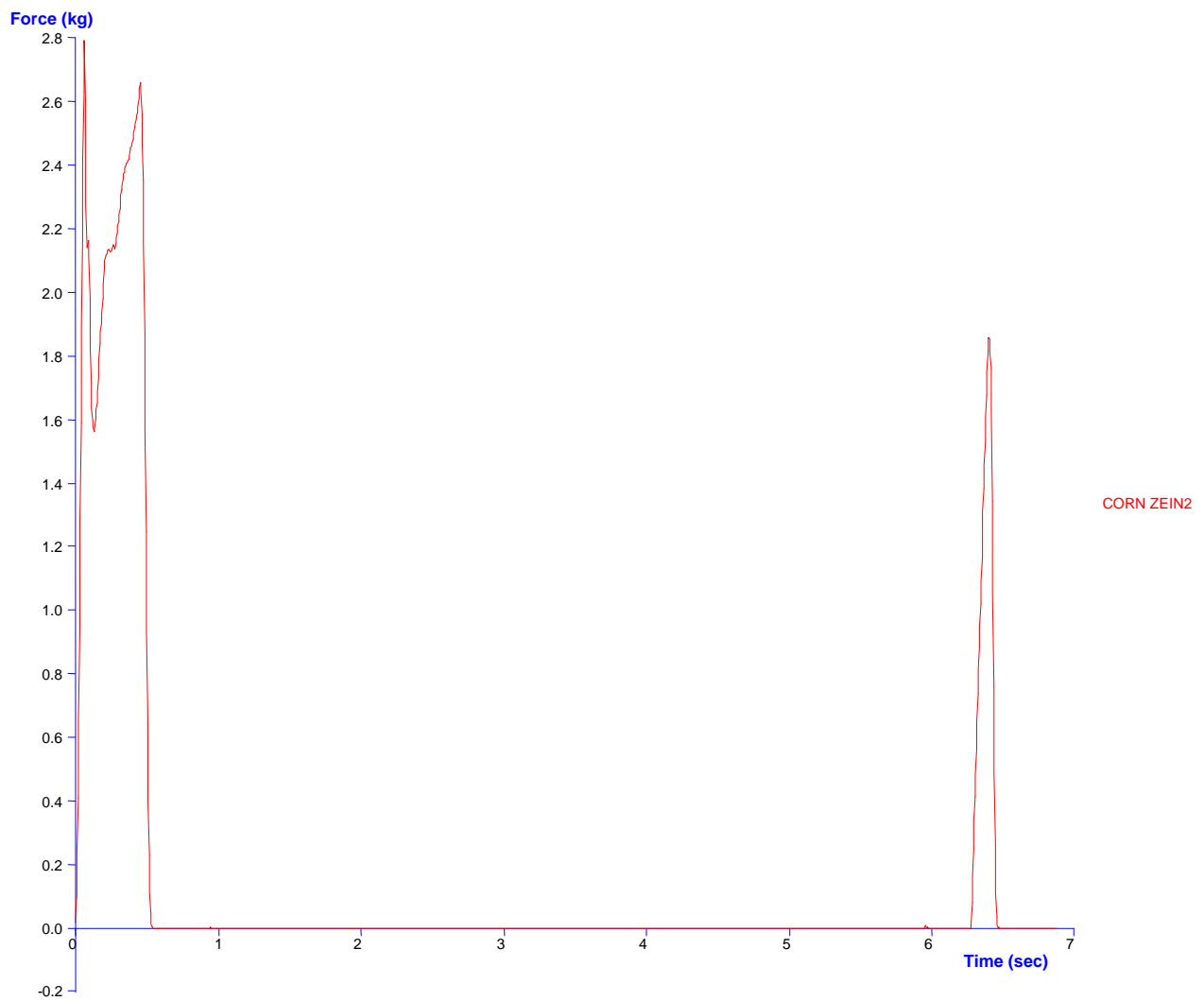


Fig4:TPA Analysis curve for corn zein-2(cz-2) formulation

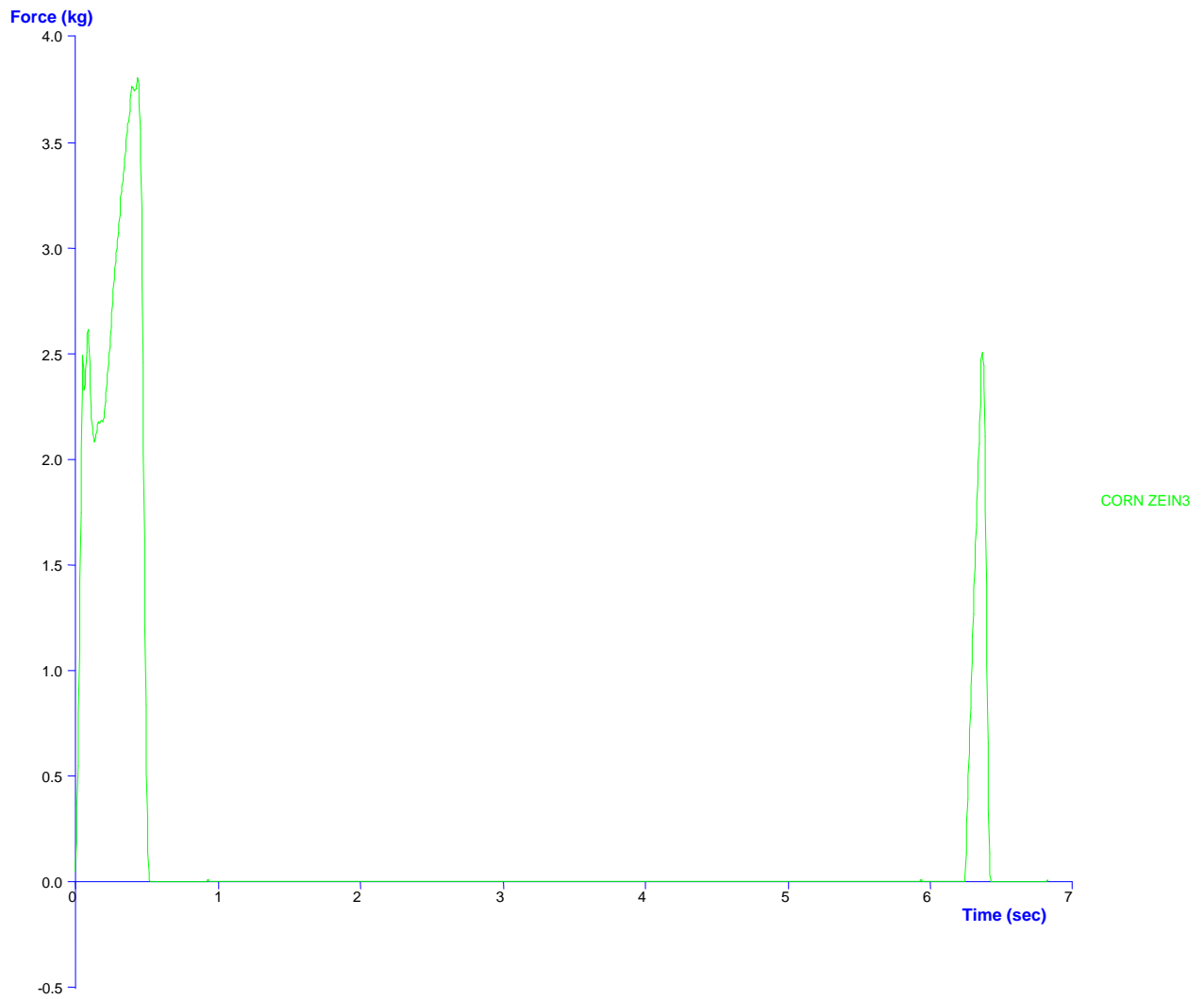


Fig5:TPA Analysis curve for corn zein-3(cz-3) formulation

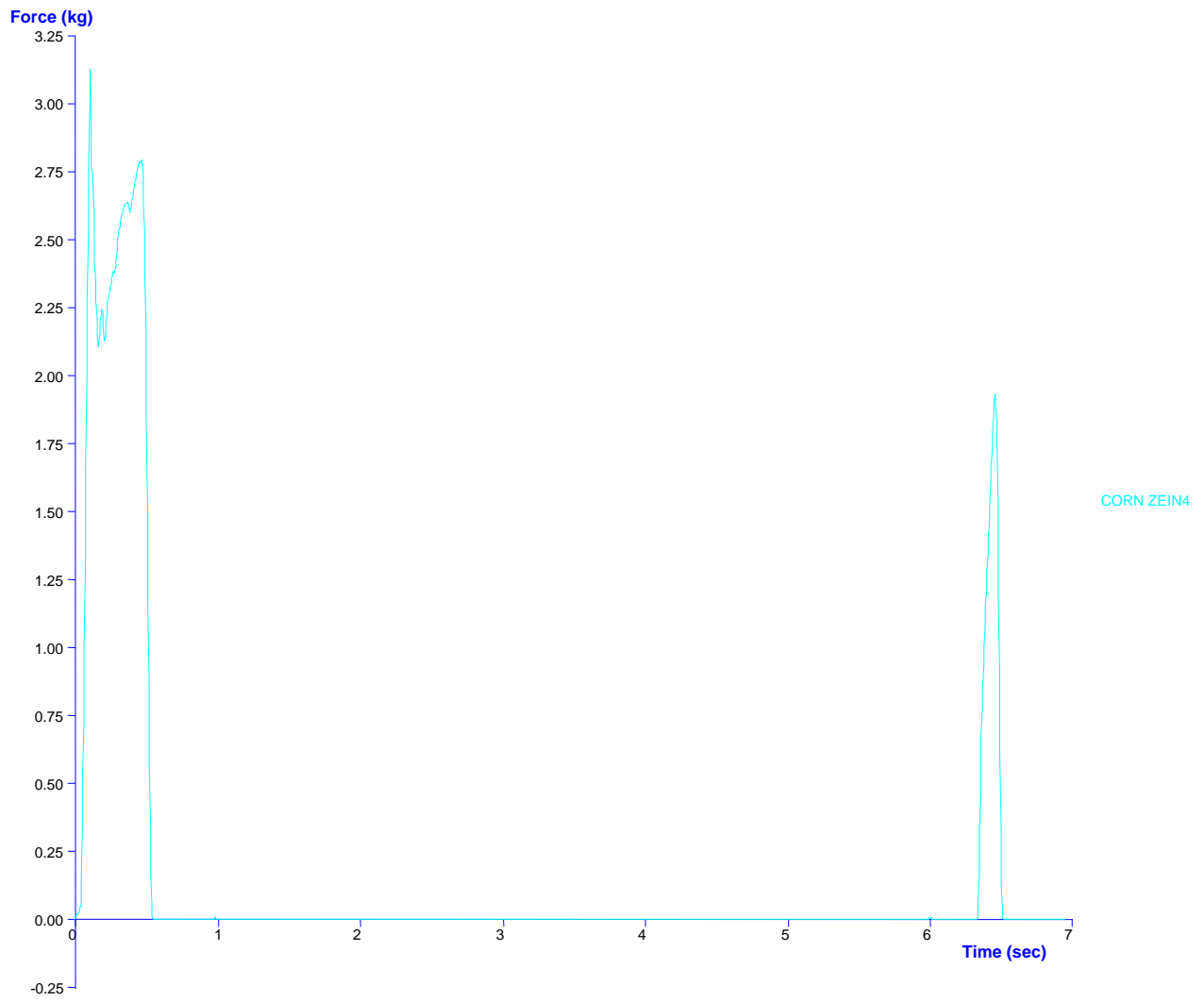


Fig6:TPA Analysis curve for corn zein-4(cz-4) formulation

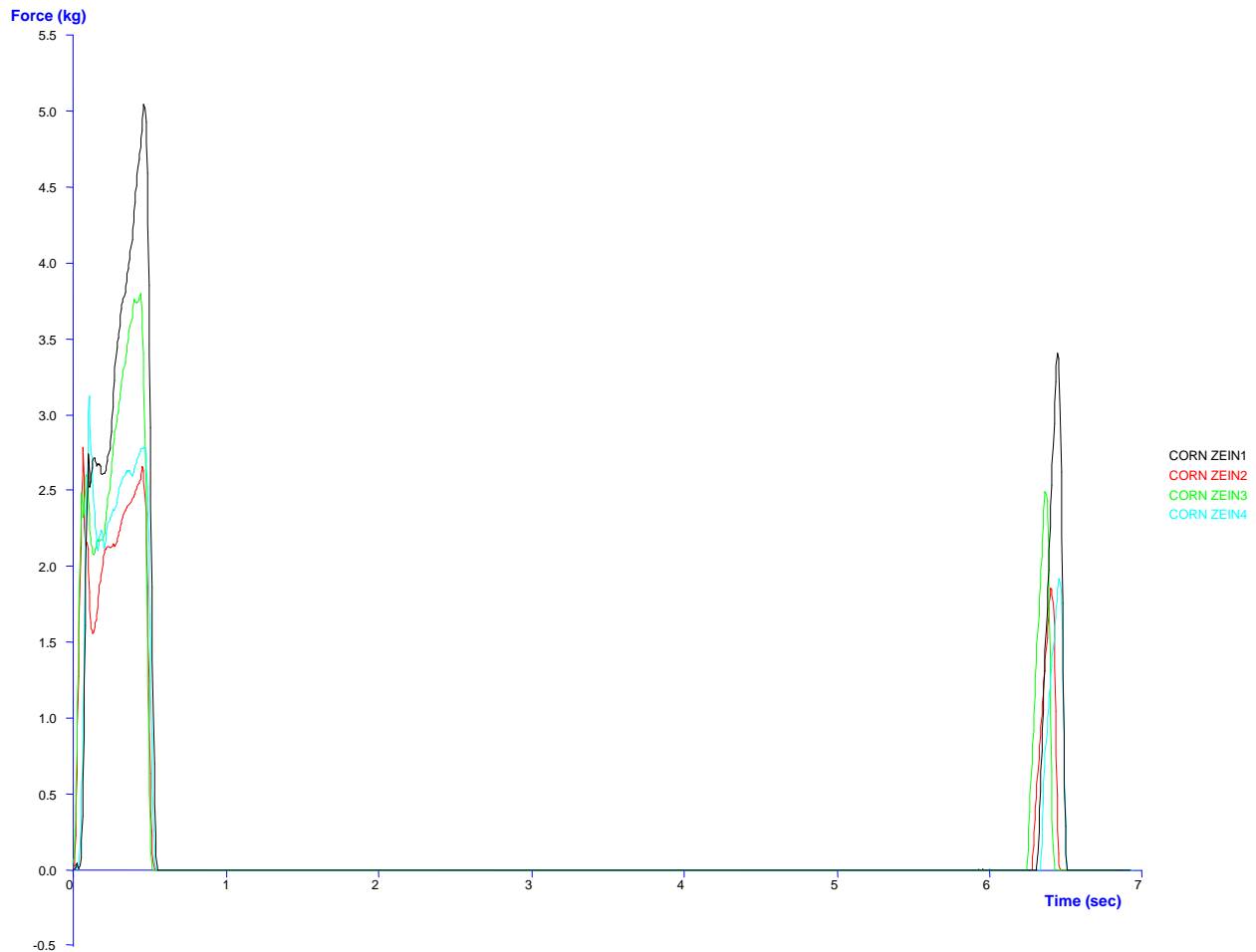


Fig7: TPA analysis curve overlap of corn zein chewing gum formulation

DISCUSSION

Melting Point: The Melting point of the corn zein chewing gum was found to be in the range of 45°C to 60°C.

CONCLUSION

Effect of different formulations of chewing gum on final product's textural characteristics was successfully shown by Texture Analyser.

The Texture Analyser does not require in-depth rheological training of the operator, either to run the test or interpret the results, which makes it very suitable for use in research & development. Using the same data results can be calculated repeatedly as per the convenience of operator without repetition of test. Testing with this instrument is ideally suited to product development or product standardization.

Corn zein gum made up of triacetin,(CZ-1) as a plasticizer shows maximum gumminess value of 1133, chewiness of 327 and hardness of 5056g, which is highest among all other formulations and most flexible. Values indicate triacetin as best plasticizer for corn zein chewing gum.

Corn zein gum made up of oleic acid,(CZ-3) as a plasticizer shows gumminess value of 705, chewiness of 199 and hardness of 3806g, which indicate oleic acid is less suitable to make Corn Zein chewing

gum as its value are less than standard values. Corn zein gum made up of PEG-600,(CZ-4) as a plasticizer shows gumminess value of 491, chewiness of 135, which is the lowest of all formulation and hardness of 2793g was reported.

Though chewing gum as a drug delivery system has gained wide acceptance only within smoking cessation and oral health care, clinical trials have proven that there are therapeutic advantages to be gained by using chewing gum as a drug delivery system through exploiting the effects achieved by chewing gum per se, the convenience of the delivery system, and the possibilities of having buccal absorption or local effect of an active substance. Furthermore, one of the trials has indicated that chewing gum as drug delivery systems are possibly safer for active substances that are susceptible to abuse. Chewing gum formulations may also be less prone to accidental overdose.

Variation in significant properties like springiness, cohesiveness, chewiness is also shown successfully by texture analyser.

Corn-zein chewing gum samples were coated and these coatings are brittle in nature and thus shown as fracturability in the results obtained. Different values of fracturability (of coatings) are observed in the graphs.

Above studies shows that all the parameters obtained by texture analysis by Texture Analyser from SMS, UK can be complemented by the sensory evaluation data.

This study demonstrated the feasibility of using corn zein as a gum base and its potential for future optimization. Corn zein samples included in this study showed potential for future optimization. The formulation containing triacetin demonstrating its desirable textural characteristics.

A possible way to further improve on sensory properties of zein gums is to incorporate waxes in the formulation, which can improve flavor release, shelf life, and texture. By examining the results of this study, advances can be made in the application of corn zein to chewing gum and possibly to other food products.

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