

Biological vs. Non-Biological Texturizing of Meat Patties

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ABSTRACT

The aim of the present study is investigating the effect of some biological binders such as microbial transglutaminase "MTGase" and non biological binders such as textured soy protein "TSP", soy protein concentrate "SPC" and sodium alginate on the texture of meat patties using the texture profile analysis (TPA) comparing with sensory evaluation.

The results indicated that the patties samples containing SPC and MTGase had the highest values of hardness (3.65 N), chewiness (2.70) and number of chewings (25.30). Also, the results of sensory evaluation showed that the patties sample containing SPC and the MTGase was more acceptable than the other samples. It can be concluded that using plant protein binders such as SPC and cross- linking enzyme "MTGase" enhanced the texture of meat patties. Also, the texture profile analysis can be used successfully for measuring some characters in meat products.

Keywords: Microbial transglutaminase, Textured Soy Protein, Soy Protein Concentrate, Texture Profile Analysis, Meat Patties

INTRODUCTION

Modification of protein structure via chemical, physical or enzymatic methods leads to effective and powerful structuring and/ or restructuring of protein molecules .

The different methods used for modification of protein molecules could be simply classified into two groups; referring to the nature of the tool used. The first is non-biological structuring which is done through chemical and/ or physical effects, while the second is biological structuring in which enzymes are the tools used.

Evaluation of the texture is an important aspect of meat and meat products quality. The methods applied to evaluate texture can be divided into three groups: sensory methods (subjective), instrumental methods (objective) and indirect methods e.g. determination of collagen content of meat (Combes *et al.*, 2004).

A new direction of catalytic technology is the use of microbial transglutaminase (MTGase) to produce the inter-and intramolecular cross linking, isopeptide, bonds in the protein enabling the formation of new structures for protein molecules. The enzyme MTGase have many

exclusively characteristics which may not present in many other enzymes enabling its broad activity and its divers applications in food industry such as the restructuring of meat products. It is also used for the preparation of variety of products such as patties, meat balls (Kebabs and Sausage) (Huang *et al.*, 1992, Motoki & Seguro, 1998 and Uran & Yilmaz, 2018).

The enzyme did not need any specific condition of application, it could be added simply through many point along the processing line. The methods for applying MTGase: direct addition to the prepared recipe, sprinkling the powdered enzyme of the surface of the food, or by incorporating it in a solution form (Motoki & Seguro, 1998 and Ali *et al.*, 2010).

The enzyme is classified by the FDA as generally recognized as safe (GRAS) product. All these characteristics give MTGase the ability to modify many of food proteins. (Ali *et al.*, 2010 and Goes-Favoni & Bueno, 2014).

Also, plant proteins have been used as binders and extenders in comminuted meat products such as chickpea, lentil, and soya flour. Restructured meat products allow flexibility for novel formulations to be developed which can help meet specific nutritional goals, such as targeted protein content. Using extender and/ or binders to the animal protein, meat, provides a way to use high quality and not expensive products (Baugreet *et al.*, 2018).

The soy protein products, soy protein concentrate (SPC) and textured soy protein (TSP) are used widely in protein products. Properties such as volume, elasticity, chewiness and hardness similar to those found in meat are generated by the addition of sodium alginate which increase chewing as well as holding capacity and density of extruded soy products (Wi *et al.* 2020).

The texture profile analysis (TPA) is successfully used in meat and meat products. The TPA is a mechanical device measure some characters in short time and clear presentation. The TPA parameters can be classified into primary parameters (hardness, springiness, cohesiveness and adhesiveness) and secondary parameters (gumminess, chewiness, resilience). Primary parameters can be directly determined from the obtained force/time graph, but secondary parameters are derived from the primary

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parameters (Novakovi & Tomašević, 2017 and Schreuders *et al.* 2021).

Xiong *et al.*, 2006 reported that it seems that texture parameters assessed by a TPA and performed on cooked meat are the best predicated of sensory texture in borine meats, mainly for hardness and juiciness. Also, TPA is one of the methods that simulate the conditions that the food exposed to in the mouth.

The aim of this work is studying the effect of some binders (biological and non biological) on the texture of meat patties using the texture profile analysis. Also, the correlation between sensory and the instrumental measurements was investigated.

MATERIALS AND METHODS

Materials

Minced beef meat and spices were purchased from the local market in Alexandria, Egypt governorate. Textured soy protein (TSP) (50% protein) was obtained from Bulk Barn Foods Limited, Ontario. Soy protein concentrate (SPC) (50%) supplied from Trust Group for Import and Export, Egypt. Sodium alginate was purchased from S.d. Find-CHEM Ltd, Mumbai. Microbial transglutaminase (MTGase) was obtained from Ajinomoto Foods Europe, S.A.S., France.

Onion (powder), ginger, garlic (powder), salt, and spices were purchased from the local market in Alexandria, Egypt.

Methods

Meat patties preparation

Textured soy protein (TSP) was ground and rehydrated using a ratio of 1: 2 (w/v) (Bakhsh *et al.*, 2021).

The condiment paste was prepared by mixing onion (32.5g), ginger (16.25g), garlic (16.25g), salt (20g), and spices (15g).

The basic formula (control) of minced meat used in this work contained the same amount of condiments and spices for all the treatments prepared.

The meat patties were prepared by mixing all the ingredients in a mixer for 5 min. They were shaped in a die having a diameter of 5.5 cm and high of 1.2 cm. The samples which contain MTGase require 90 min of incubation before performing TPA test or before cooking. Grill was used for cooking the patties samples at 80°C.

Seven types of meat patties were prepared using various combinations of minced beef meat, TSP and SPC in presence and absence of sodium alginate and MTGase as shown in Table (1).

Texture profile analysis (TPA)

The TPA of raw and cooked patties was performed on a texture analyzer (Texture Pro CTV 1.2 Build 9, Brookfield Engineering Labs. Inc. England). The patties were placed on platform (TA-RT-KI) with 10000 g load cell, trigger load 0.07 N, test speed 1.5 mm/s using cylindrical plunger (TA10). The samples were compressed to 50% of its original height at cross hand speed of 1.5 mm/s twice in two cycles. The measured TPA parameters were; hardness, cohesiveness, springiness and chewiness. The TPA parameters were replicated three times for all samples.

Statistical analysis

F-test and analysis of variance of treatments difference was performed according to Steel & Torrie (1980). Statistical analysis was done by, ANOVA, F-test, and least significant difference (LSD) at 0.05 level of significance within the SAS software package, version 9.13 (2008).

Sensory evaluation

The samples were assessed according to the method described by (Ruiz de Huidobro *et al.*, 2005). The definitions of the sensory traits are as follows: Hardness is the force necessary to attain a given deformation or a penetration in a product; in a food it is achieved with molar teeth.

Table 1. Composition of meat patties samples

Ingredients (g)	Control (T1)	Treatment (T2)	Treatment (T3)	Treatment (T4)	Treatment (T5)	Treatment (T6)	Treatment (T7)
Beef meat	80	70	70	70	70	70	70
TSP	-	10	-	10	-	10	-
SPC	-	-	10	-	10	-	10
Condiments paste	10	10	10	10	10	10	10
Water	30	30	30	30	30	30	30
Sod. Alginate	-	-	-	1.2	1.2	-	-
MTGase	-	-	-	-	-	1.2	1.2

Springiness (or elasticity) is the rate at which a deformed food goes back to its unreformed condition after the deforming force is removed. The number of chewings is the number of molar strokes necessary to reduce food to a state that makes it fit for swallowing. Cohesiveness is the mechanical textural attributes to the degree to which a food can be deformed before it breaks (Trinh & Glasgow, 2012; Eshra, 2017 and Novaković & Tomašević, 2017).

RESULTS AND DISCUSSION

The data in Table (2) represent the texture profile analysis of raw and cooked meat patties containing the different types of binders.

Hardness

The hardness of control sample was 4.763N. The addition of TSP (T2) or SPC (T3) had no effect on the hardness of the raw samples. No significant differences were found between these samples (T1, T2 and T3).

The hardness of the sample containing TSP was 3.270 N and it decreased to 2.463 N after adding sodium alginate (Table 2). It can be noted that no significant difference ($p \geq 0.05$) was observed in the hardness between the sample containing TSP and the sample

containing TSP and sodium alginate. It means that the addition of sodium alginate had no effect on the hardness of the samples.

Also, the results indicate that the addition of sodium alginate had no effect on the hardness of the samples containing SPC. No significant difference ($p \geq 0.05$) was found between the samples which containing SPC only and that containing SPC and sodium alginate as given in Table (2).

On the other hand, the sample containing TSP and the MTGase record hardness value of 5.860N. It is clear that addition of enzyme to this sample cause an increase in its hardness. The same trend was observed in case of the sample containing SPC and MTGase which gave the highest hardness value (9.053N).

Also, the addition of the enzyme to the sample containing SPC caused an increase in the hardness by about 2 folds. From these results it is clear that the addition of MTGase to the samples either containing TSP or SPC increase the hardness.

On the other hand, the hardness increased in all treatments due to the cooking process. The data found in Table (2) indicate that in raw control treatment it was 4.763N and increased to 9.053 N after cooking (Fig. 1).

Table 2. The texture profile analysis of raw and cooked meat patties

Treatments	Hardness (N)	Cohesiveness	Springiness (mm)	Chewiness (N)
Raw patties				
T1 Meat (Control)	4.763 ^{ef}	0.563 ^{fg}	3.707 ^{fg}	10.000 ^{gh}
T2 Meat +TSP	3.270 ^{ef}	0.480 ⁱ	3.680 ^{fg}	5.700 ^h
T3 Meat +SPC	4.827 ^{ef}	0.533 ^{gh}	3.933 ^{def}	11.200 ^g
T4 Meat + TSP + Sodium alginate	2.643 ^f	0.500 ^{hi}	3.657 ^{fg}	5.800 ^h
T5 Meat + SPC + Sodium alginate	4.380 ^{ef}	0.507 ^{hi}	3.597 ^g	8.067 ^{gh}
T6 Meat +TSP + MTGase	5.860 ^e	0.577 ^{efg}	3.863 ^{efg}	13.100 ^g
T7 Meat +SPC + MTGase	9.053 ^d	0.677 ^c	4.153 ^{cde}	27.733 ^f
Cooked patties				
T1 Meat (Control)	9.053 ^d	0.740 ^b	4.327 ^{abc}	30.133 ^f
T2 Meat +TSP	21.050 ^c	0.607 ^{ef}	4.093 ^{cde}	52.367 ^d
T3 Meat +SPC	22.600 ^c	0.770 ^b	4.463 ^{ab}	83.567 ^b
T4 Meat + TSP + Sodium alginate	20.893 ^c	0.663 ^{cd}	4.090 ^{cde}	46.267 ^e
T5 Meat + SPC + Sodium alginate	28.317 ^b	0.747 ^b	4.347 ^{abc}	81.967 ^b
T6 Meat +TSP + MTGase	21.050 ^c	0.617 ^{de}	4.167 ^{bcd}	57.867 ^c
T7 Meat +SPC + MTGase	35.717 ^a	0.837 ^a	4.600 ^a	133.933 ^a
LSD _{0.05}	3.0068	0.0516	0.3023	5.06

Means followed by the same letter(s) are not significant, but different letters are significant at 0.05 level of probability according to LSD method.

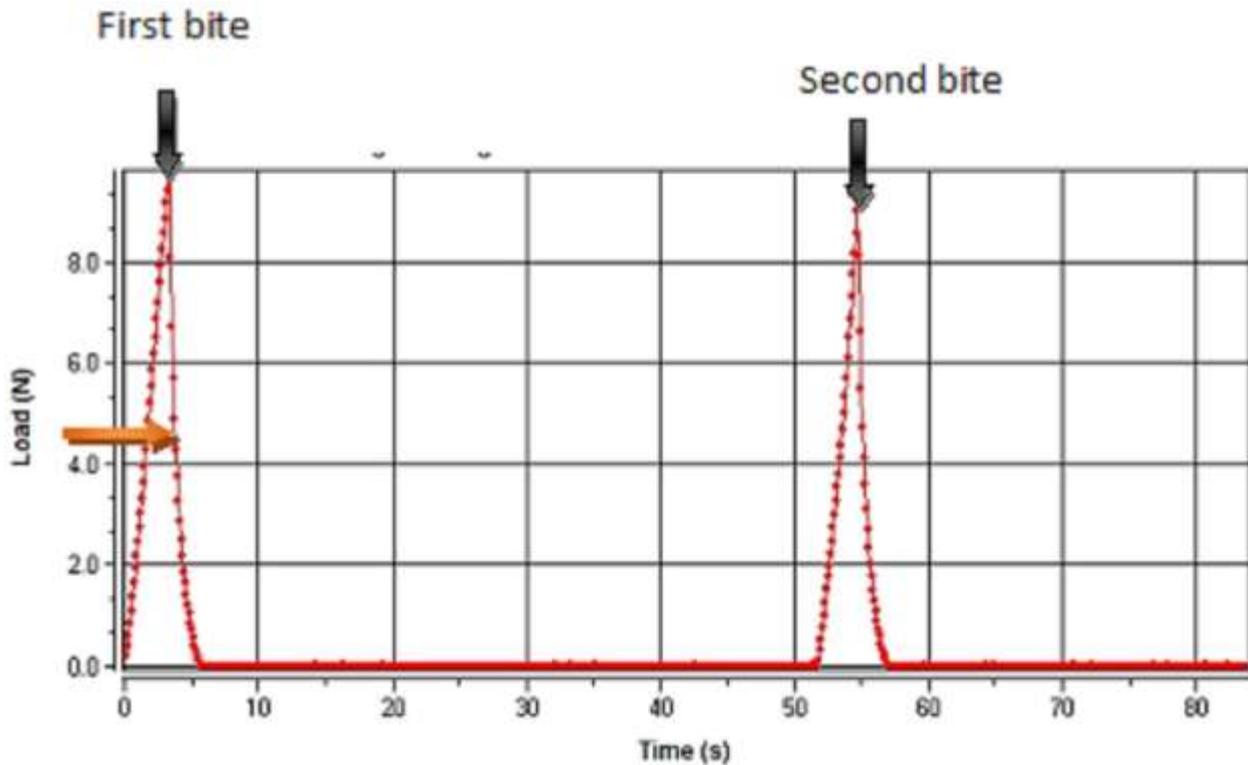


Fig. 1. Texture profile analysis of raw " → " and cooked meat patties.

There is many information may be extracted from Fig (1); (1) the first and second curves have a symmetric shape and similar initial slope which indicate that the patties had a firm of elastic symptoms (i.e., quickly returned to its original shape after probe withdrawal), (2) the curves show that no shoulders were present, this suggested no points of rupture meaning, no mechanical failure happened, (3) the second bite is some-what smaller than the first indicating little weak of the internal structure for the tested sample.

It is worth to mention that the hardness increased to 21.05N and 22.60N in the cooked samples containing TSP and SPC, respectively (Table 2 and Fig 2, 3). Also, the value of hardness 20.89N was found in the sample containing TSP and sodium alginate. No significant differences were observed between the cooked sample containing TSP, SPC, TSP + sodium alginate and TSP + MTGase. these results were in agreement with those obtained by Baugreet *et al.* (2018) who reported that beef meat restructured using the commercial transglutaminase (TG) had better binding properties than the alternative binder(transglucoseen-M). This could be explained by the presence of sodium caseinate in the commercial transglutaminase used which would contribute to forming a viscous solution and act as a binding agent for restructuring meat pieces. When TG was used with pea protein isolate at 8%, a better gel

formation was observed, where the strength of protein gels prepared using microbial transglutaminase was enhanced in the presence of soy protein isolate and caseinate.

On the other hand, there is a significant difference between the two cooked samples containing sodium alginate and either TSP or SPC. The values were 20.893N and 28.317N, respectively (Fig 4, 5 and Table 2).

Moreover, addition of MTGase caused an increase in the hardness to 21.05N and 35.717N in the cooked samples containing TSP and SPC, respectively (Fig 6, 7). Uran and Yilmaz (2018) reported that MTGase is one of the best biological methods used in the restructuring of meat products. Mehmood *etal.* (2019) reported that cooking at high temperatures resulted in more hardness. Where, loss of water during cooking is ascribed as an outcome of the protein thermal denaturation which causes the change in meat texture. Hardness, cohesiveness, springiness and chewiness are very useful parameters for assessment of meat texture (Ruiz de Huidobro *et al.*, 2005).

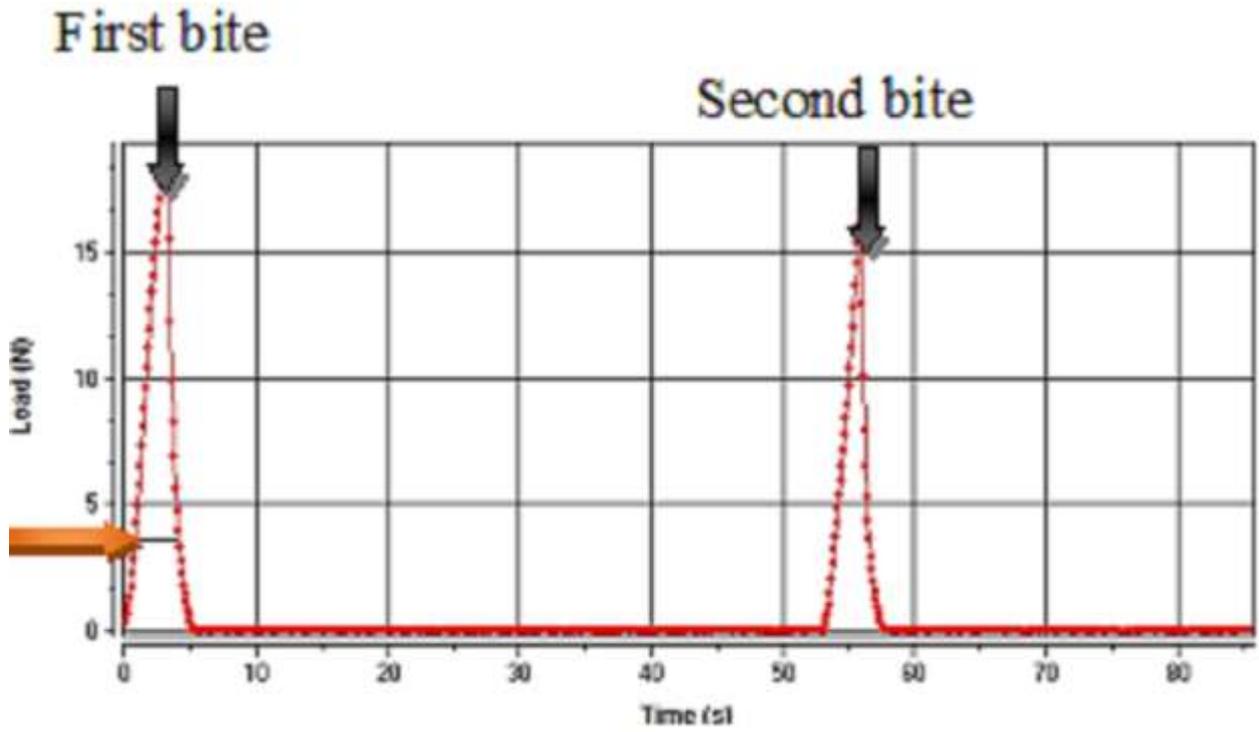


Fig. 2. Texture profile analysis of raw " → " and cooked meat + TSP patties.

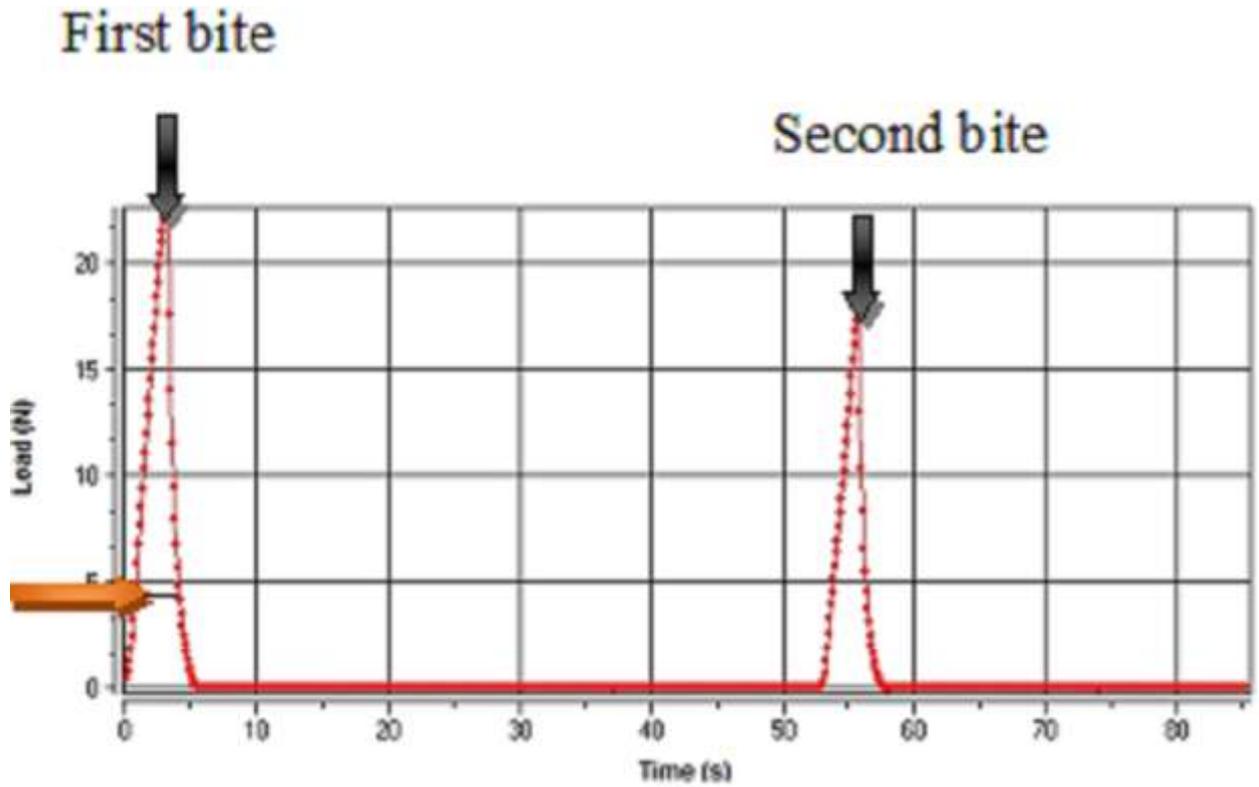


Fig. 3. Texture profile analysis of raw " → " and cooked meat+ SPC patties.

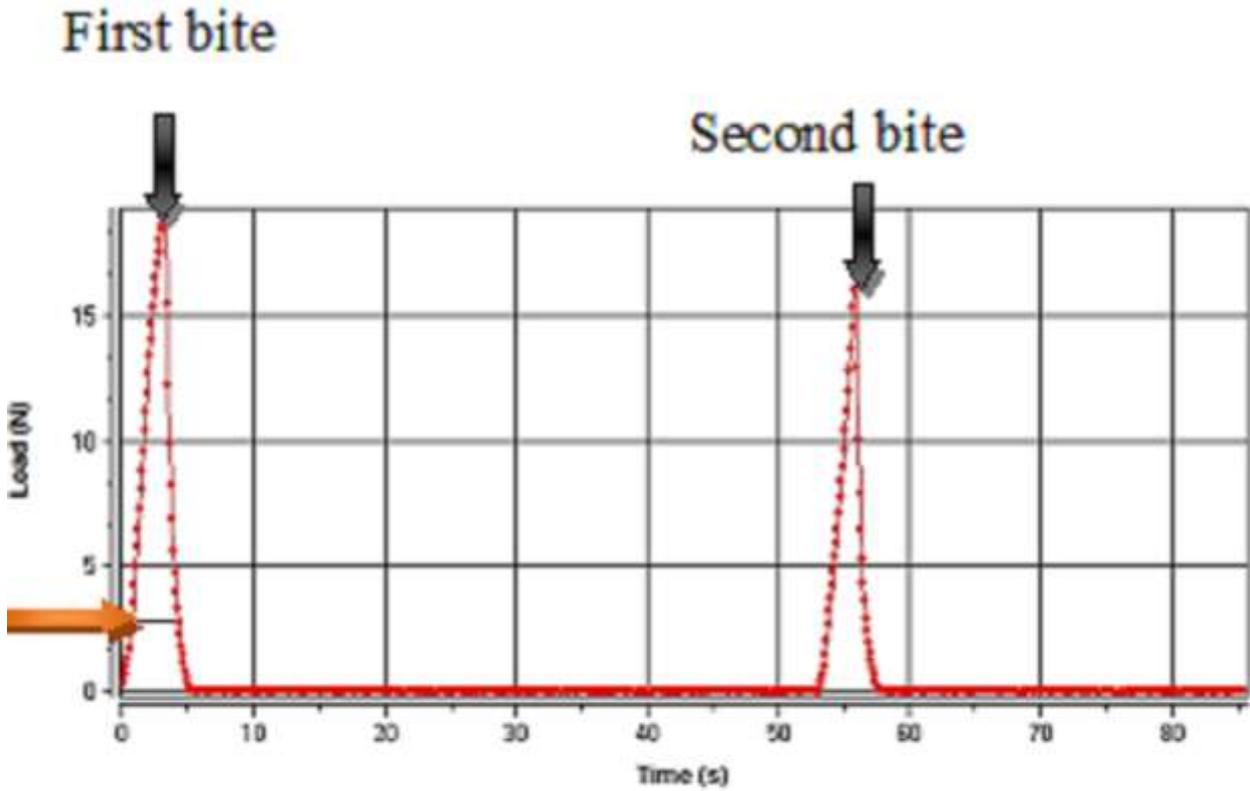


Fig. 4. Texture profile analysis of raw " " and cooked meat +TSP +sod. alginate patties.

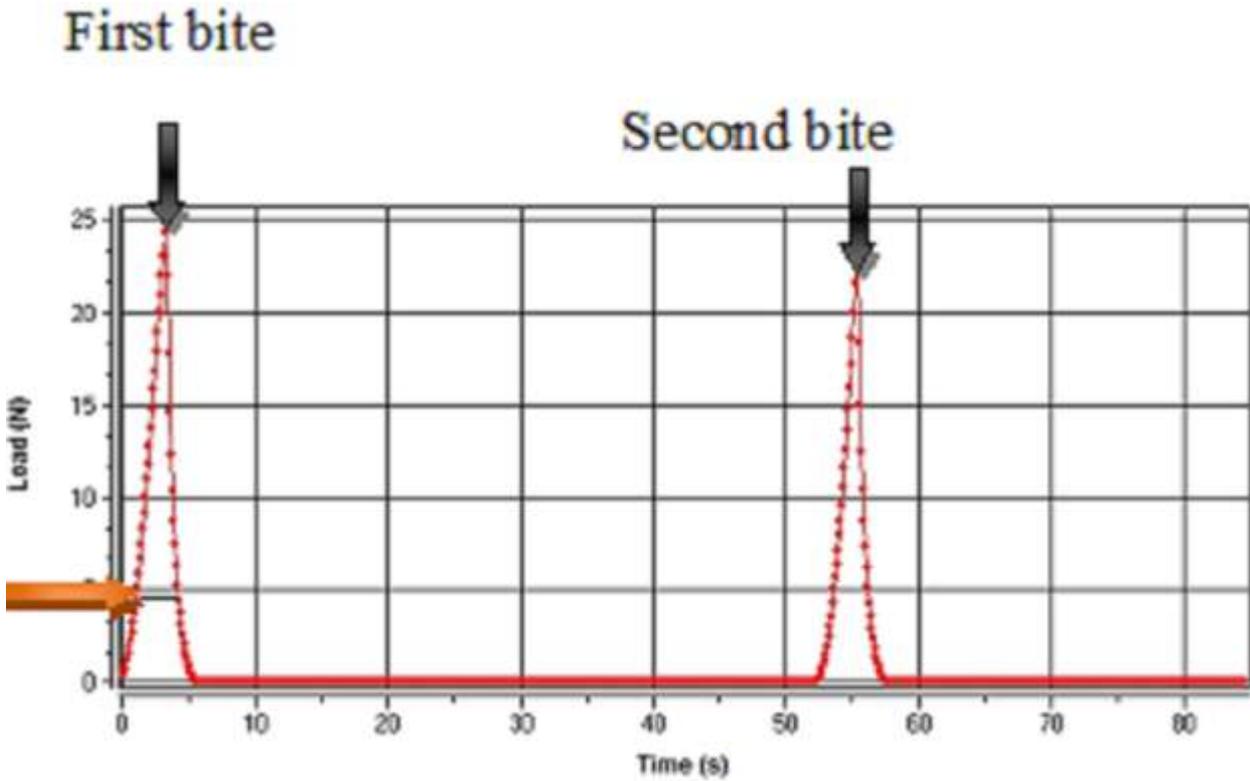


Fig. 5. Texture profile analysis of raw " " and cooked meat +SPC+ sod. alginate patties.

First bite

Second bite

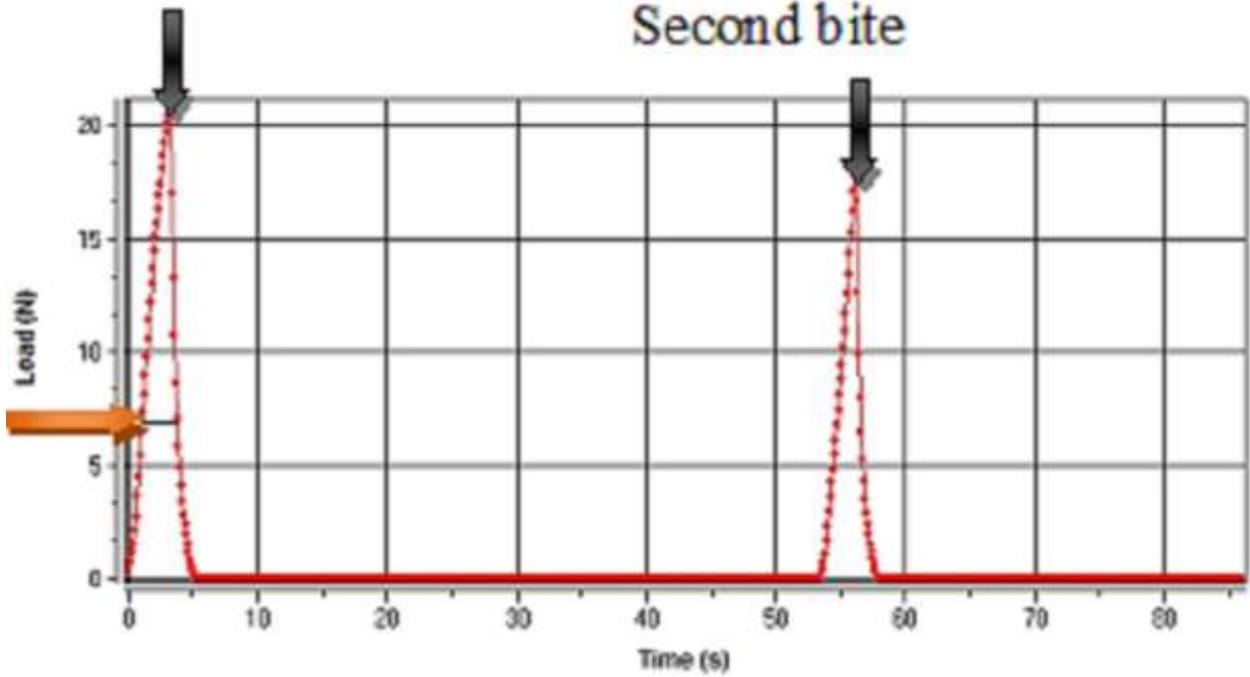


Fig. 6. Texture profile analysis of raw " → " and cooked meat +TSP + MTGase patties.

First bite

Second bite

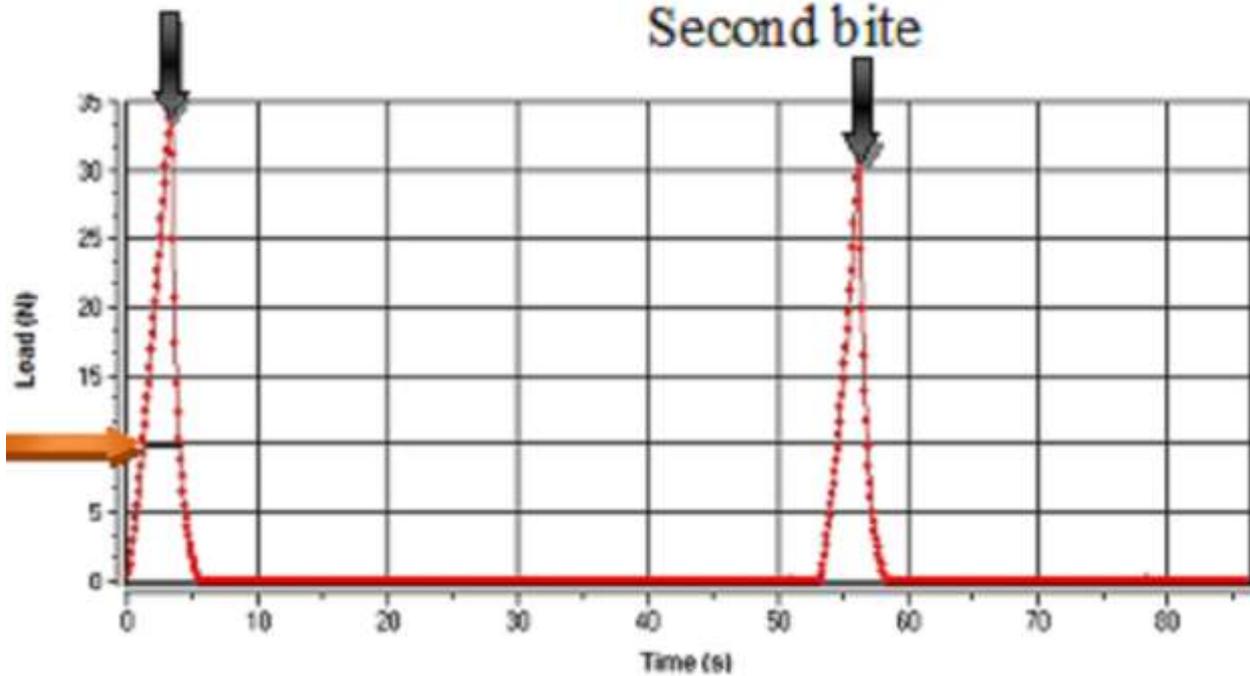


Fig. 7. Texture profile analysis of raw " → " and cooked meat+ SPC+ MTGase patties

Cohesiveness

The results given in Table (2) indicate that the cohesiveness value (0.480) of the raw patties containing TSP was lower either than that of control (0.563) or of the sample containing SPC (0.533). The sample containing SPC has a cohesiveness value (0.533) nearly similar to that of the control (0.563).

It is worth to mention that the same trend was observed in the values of cohesiveness as those of hardness when sodium alginate was added either to the samples containing TSP or SPC. No significant difference was found between raw samples containing TSP and SPC with sodium alginate as given in Table (2). Also the results indicate that addition of sodium alginate had an effect on the cohesiveness values for the cooked treatments. Meanwhile, the addition of MTGase to the samples either containing TSP or SPC caused a significant increase in their values of cohesiveness. The values being 0.617 and 0.837, respectively after cooking comparing with the raw samples (0.577 and 0.677) (Table 2).

Herrero, *et al.* (2008) found that transglutaminase addition increased the cohesiveness and springiness of pork meat systems.

Springiness

The data in Table (2) indicate that no significant differences ($p \geq 0.05$) were found between the raw control sample and other patties samples containing either TSP only or in the presence of sodium alginate. Meanwhile, the addition of sodium alginate to the sample containing SPC caused a decrease in the springiness value. On the other hand, addition of MTGase to the sample containing TSP caused an increase in the springiness value. In case of the treatments containing SPC, a significant differences was found between them in presence and absence of sodium alginate or MTGase. Setiadi *et al.* (2018) reported that addition of transglutaminase enzyme effectively can increase the level of hardness up to 100%, cohesiveness up to 90%, and springiness up to 100% in vegetable protein source. Among the meat restructuring parameters, the increasing hardness tends to be significant value as addition of dosage enzyme. However, on cohesiveness and springiness parameters with the above 1.5% enzyme dosage, the values were tendency to decrease because the sample indicated to be too hard and low elasticity.

In general, no significant differences were found in the values of the cooked sample and those containing SPC only or after addition of sodium alginate (Table 2). Also, it is clear that no significant differences were noted between the cooked samples containing TSP and

that containing TSP and sodium alginate in their springiness values. Moreover, it is worth to mention that the addition of the enzyme to the sample containing SPC gave the highest value (4.600 mm) of springiness.

Chewiness

The results in Table (2) revealed that no significant differences were found between the raw control sample and samples either containing SPC only or SPC with sodium alginate. The same trend was found in the raw samples containing TSP and that containing TSP and sodium alginate.

On the other hand, the chewiness values increased due to the addition of TSP or SPC to the samples. The highest value of chewiness was found in the sample containing SPC and MTGase (Table 2).

Meanwhile, the chewiness values of cooked patties samples containing TSP and SPC increased comparing with that of the control. It was 30.133 N for the control while it was 52.367N and 83.567N for samples containing TSP and SPC, respectively (Table 2). Also, the addition of sodium alginate slightly decrease the chewiness values of the cooked samples containing TSP or SPC (46.267, 81.967N, respectively) than those without sodium alginate.

Addition of the enzyme to the sample containing TSP enhance its chewiness value. On the other hand the addition of the enzyme to the sample containing SPC had a remarkable effect on the chewiness value (133.933 N).

It can be concluded from the aforementioned results that the parameters of TPA for the samples containing SPC and MTGase were superior than the other samples containing either TSP only or TPS and the enzyme. Also, the addition of the enzyme enhance all the TPA parameters.

Sensory evaluation

From the previous results the characteristics of patties samples containing SPC were better than the samples containing TSP. So, the sensory evaluation was undertaken only for the following samples: (control, SPC, SPC + sodium alginate and SPC + MTGase). The results are presented in Table (3).

The data in Table (3) indicate that no significant difference was found between the hardness values of the samples containing SPC only and that containing SPC and sodium alginate. On the other hand, the patties samples containing SPC and MTGase had the highest hardness value (3.65N).

Table 3. Sensory evaluation of some cooked meat patties samples

Treatment	Hardness	Cohesiveness	Springiness	Chewiness	No. of chewings	Overall acceptability
T1 Meat (Control)	2.60b	3.60b	2.70a	2.40b	22.10b	7.80a
T3 Meat +SPC	1.70c	3.50b	2.40a	2.20bc	19.90c	6.80c
T5 Meat +SPC + sodium alginate	1.60c	4.30a	2.35a	2.10c	21.10bc	6.40d
T7 Meat +SPC +MTGase	3.65a	4.40a	2.30a	2.70a	25.30a	7.35b
LSD _{0.05}	0.53	0.41	0.41	0.28	1.98	0.38

It is clear that there is no significant difference was found between the values of cohesiveness of the control and the sample containing SPC only. Also, between the values of the sample containing SPC and sodium alginate and that of SPC and the enzyme Table (3).

On the other hand, the values of springiness were nearly similar for the control and all the samples and no significant differences were observed between them.

The sample containing SPC and the enzyme had the highest value of chewiness being 2.70 and number of chewings (25.30)

The data in Table (3) indicate that the control patties sample was more acceptable followed with that containing SPC and the enzyme. In contrast, the sample containing SPC only and SPC and sodium alginate were the least acceptable ones. Forghani *et al.* (2017) reported that the addition of MTGase to the veggie burgers formulations enhanced the cohesiveness of batters and improved their hardness, springiness, and chewiness. MTGase and sodium casinate addition showed synergistic interaction effects on TPA samples. The veggie burgers made with MTGase plus sodium casinate had higher hardness, chewiness, fracturability, and cohesiveness values than other samples.

The correlation between sensory and instrumental measurements of texture results is useful for the following: (1) finding instrument(s) to measure quality control of food in industries, (2) predicting consumer response, as the degree of linking and the overall acceptance of new products, (3) understanding what is being sensed as perceived in the mouth during the sensory assessment of texture, (4) improving or optimizing instrumental methods to complementary the sensory evaluation (Paula & Silva, 2014).

CONCLUSION

From the aforementioned results it can be concluded that the addition of biological binders such as cross-linking enzyme (transglutaminase) and non-biological binders such as soy protein products; soy protein concentrate; will improve the texture of meat products.

Moreover, the texture profile analysis parameters can be used as an instrumental test for evaluation the quality and texture of meat products beside the sensory evaluation in food industries.

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الملخص العربي

التشكيل البنائي الحيوي مقابل غير الحيوي لأقراص اللحم

سمير محمود العراقي، داليا حسن عشرة

كانت أكثر تقبلا من العينات الأخرى. أيضا من النتائج المتحصل عليها يمكن استنتاج أن استخدام المواد الرابطة البروتينية ذات الأصل النباتي مثل مركز بروتين الصويا بالإضافة الى انزيم الربط العرضي (الترانسجلوتاميناز الميكروبي) يعزز قوام أقراص اللحم. علاوة على ذلك يمكن استخدام القياسات الخاصة بجهاز تقدير القوام كوسيلة فعالة لتقييم جودة و قوام منتجات اللحوم في مصانع الاغذية وذلك الى جانب وسائل التقييم الحسى.

الكلمات المفتاحية: الترانسجلوتاميناز الميكروبي، بروتين الصويا المشكل، مركز بروتين الصويا ، جهاز تقدير القوام، أقراص اللحم.

الهدف من هذا البحث هو دراسة تأثير بعض المواد الرابطة الحيوية مثل انزيم الترانسجلوتاميناز الميكروبي والمواد الرابطة غير الحيوية مثل كل من بروتين الصويا المشكل، مركز بروتين الصويا والجينات الصوديوم وذلك على قوام أقراص اللحم باستخدام جهاز تقدير القوام مقارنة بالتقييم الحسى.

أوضحت النتائج أن عينات أقراص اللحم المحتوية على مركز بروتين الصويا وانزيم الترانسجلوتاميناز الميكروبي كانت لها أعلى قيم لكل من خصائص الصلابة (3,65 نيوتن)، المضغية (2,7) وعدد المضغات (20,30). كما أظهرت نتائج التقييم الحسى أن أقراص اللحم المحتوية على مركز بروتين الصويا وانزيم الترانسجلوتاميناز الميكروبي