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Effect of sodium diacetate and/or sodium lactate on binding stability of restructured turkey steak

(Kesan natrium diasetat dan/atau natrium laktat terhadap kestabilan pengikatan stik ayam belanda yang distruktur semula)

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Key words: sodium lactate, sodium diacetate, turkey, fibrimex

Abstract

Research was carried out to determine the effects of sodium diacetate (NaD) and/or sodium lactate (NaL) treatments on the binding strength and binding integrity of restructured turkey steaks processed with the *Fibrimex* binding system. The restructured turkey breasts were treated with 1.5% NaL, 2.0% NaL, 1.5% NaL + 0.1% NaD, 2.0% NaL + 0.1% NaD, 0.1% NaD, or control. All sample treatments were stored at –30 °C for 0, 1, 2, and 3 months. At each storage period, the restructured turkey breasts were sliced into 1 cm thick steaks, and evaluated for its binding integrity and binding strength. Even though steaks treated with NaD and/or NaL had lower binding strength (p <0.05), the *Fibrimex* binding system was able to hold the meat pieces together without falling apart when handled.

Introduction

There is always an interest in utilizing low value meat to produce higher value products. Such approach is the basis for restructured meat research work. Restructured or engineered meat is defined as the reassembling of pieces or particles of meat in such a way that the end product has pleasing flavour, textural, and masticatory properties. Product development efforts have resulted in restructured beef roasts (Liu et al. 1990) which resemble intact cuts of meat in appearance and taste. The value of red meat products can be enhanced through restructuring techniques (Akamittath et al. 1990). Restructuring is an evolving technology which facilitates the production of new meat products of enhanced value from cuts of lesser value, or from value cuts that could further increase the choice for consumers to purchase new meat products.

Restructuring offers the opportunity to produce a product with both weight and shape control. Products can be formulated to specified compositional standards. Fat content can be carefully controlled. Mouthfeel, juiciness and binding of the product can also be controlled. Meat used in restructured meat products can be trimmings from high quality cuts such as the striploin or from lower quality cuts of the hind-quarter and fore-quarter (Boles and Shand 1999).

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Restructuring makes possible effective utilization of trimmings and low-value primal cuts which are good sources of protein, but which are often under-utilized. Restructuring enhances the use of less uniform or tender cuts of meat (Huffman et al. 1984). Therefore, with restructuring technology, it is possible to provide the consumer with a highly palatable product at a reasonable cost. Restructured meat products can be sold in the chilled and raw state and have that eating characteristics similar to cuts from intact muscles (Means and Schmidt 1986; Kuraishi et al. 1997).

In restructured meat research, work is aimed at finding methods of increasing meat binding properties so that the texture of restructured meat products better simulates that of intact muscle meat. In restructured meat products, binding could be achieved through the formation of gel matrix that set either requiring heat (hot-set) or without heat (cold-set) (Boles and Shand 1998). Previously, restructured meat products were made with binders where heat was required. These products, however, must be either frozen and cooked while in frozen state, or sold as already cooked products. Given the choice, consumers preferred chilled meat rather than frozen meat since they associate freshness with chilled meat. Therefore, researchers are continuously searching for binders not requiring heat. Such binders that could bind meat without requiring heat are called cold-set binders, and could bind meat pieces at cold storage conditions.

Many binders have been tested for their suitability as cold-set binders for production of restructured products. One such binder that has been greatly researched is *Fibrimex*. *Fibrimex* is a 100% natural product from blood which is composed of fibrinogen and thrombin, and is approved by the Agriculture Canada, Health Protection Canada, USDA and FDA (FNA Foods Inc. 1996). However, *Fibrimex* is a non-halal food ingredient. With *Fibrimex* there is no need to freeze the product. Good binding characteristics were achieved with whole tenderloins stuffed in a tubular casing, stored for 6–8 h in a cooler that yielded 99% centre cut steaks (FNA Foods Inc. 1996). *Fibrimex* could bind whole muscles or pieces of fresh meat, poultry, fish, seafood, or any combination of the four into one. The binding is due to the formation of fibrin network.

The objectives of this research were to determine the effects of sodium diacetate (NaD) and/or sodium lactate (NaL) treatments on the binding strength and binding integrity of the restructured turkey steaks processed with the *Fibrimex* binding system. If binding strength and binding integrity could be achieved, then uniform shape and weight of turkey steaks could be produced.

Materials and methods

Materials

Fibrimex was obtained from FNA Foods Inc., Calgary, Alberta, Canada. It is derived from blood and composed of fibrinogen and thrombin. These two components were individually packed, and maintained in frozen storage until needed. Sodium lactate (60% solution of sodium lactate) *(Purasal S)* was supplied by PURAC America Inc., Lincolnshire, IL 60069, and sodium diacetate (71% solution of sodium diacetate) by CHR Hansen, Inc., Gainesville, Florida 32606. Whole turkey breast meat samples were purchased from a single supplier from Jacksonville, Florida. The supplier obtained the meat from Rocco Turkeys, Inc., Dayton, Virginia 22821.

All the turkey breast meat samples were in a frozen state upon arrival at the Meat Research Laboratory, Department of Animal Science, University of Florida, Gainesville, Florida 32611. The meat samples were wrapped in plastic, and boxed. Each box contained 18 kg boneless/skinless turkey breast meat. Upon arrival, the turkey meat samples were immediately stored at –30 °C. The restructured turkey product was processed in the Meat Research Laboratory.

Table 1. Slope values for binding integrity scores of steaks (stored at 0 °C for 8 days) sliced from restructured turkey breasts (stored at –30 °C for 0, 1, 2, and 3 months) made with *Fibrimex* and treated with sodium lactate (NaL) and/or sodium diacetate (NaD)

Month	Sodium diacetate level (%)	Sodium lactate level (%)		
		0	1.5	2.0
0	0	0.00	0.00	0.00
	0.1	0.00	0.00	0.00
1	0	0.00	0.00	0.00
	0.1	–0.03*	0.00	0.00
2	0	0.00	0.00	0.00
	0.1	0.00	0.00	0.00
3	0	0.00	0.00	0.00
	0.1	0.00	0.00	0.00

*Significant at $p < 0.05$

Preparation of Fibrimex

The experimental design is presented in *Table 1*. A 6% *Fibrimex* binding solution containing a ratio of 20:1 fibrinogen: thrombin was prepared. The fibrinogen and thrombin were thawed for 1 h by immersion in warm water (26 °C) in a water bath (Precision Scientific, Chicago, IL 60647). The thawed fibrinogen was mixed thoroughly to ensure even distribution of the protein in the package. Prior to combining the fibrinogen and thrombin, NaL and NaD were incorporated into the restructured turkey breasts at levels of 1.5% or 2.0%, and 0% or 0.1%, respectively. A control sample was prepared containing no NAL or NaD. This experiment was replicated three times.

Processing of restructured turkey breast

The frozen whole turkey breasts were thawed in a cooler (0–3 °C) for 3 days before being further processed. On the processing day, the whole turkey breasts were cut into 5 cm thick strips. The cut was made parallel to the muscle fibre. For each treatment, 18 kg of 5 cm thick turkey breast strips were weighed and placed in an individual container.

For each treatment, a solution mixture was prepared. For treatment 1, 2, 3, 4, 5, and 6, the solution mixtures were composed of 1.5% NaL + 0% NaD, 2.0% NaL + 0% NaD, 1.5% NaL + 0.1% NaD, 2.0% NaL + 0.1% NaD, 0% NaL + 0.1% NaD, and 0% NaL + 0% NaD, respectively. These solutions were formulated to contain 5% water. For the control treatment, the solution contained only 5% water without the addition of NaL or NaD.

Initially, half of the treatment solution was added to the meat, then mixed in a mixer (Model 60 Keebler, Chicago, IL) for 1.5 min. The remaining solution mixture was then added to the meat, and mixed again for 1.5 min. The total mixing time was 3 min. The treated meat was divided into 2.3 kg batches. Each batch of meat was coated with *Fibrimex* at a level of 6%. Due to rapid formation of fibrin clot (i.e. 10 min), thrombin was added to the fibrinogen solution at the point of coating the meat. The combination of fibrinogen to thrombin was carried out based on the 2.3 kg batch of meat to be stuffed into a casing tube which formed one meat log. Therefore, for each treatment, 2 meat logs were allocated for each storage study (0, 1, 2, and 3 months).

Once the meat was coated with *Fibrimex* (ratio of 20 parts fibrinogen to 1 part thrombin), the coated meat was quickly stuffed (Aligned Grain Stuffer (AGS), StanFos, Inc., Edmonton, AB T6B 2V2-1000, Canada) into a tubular casing, 12 cm in diameter by 94 cm in length (Package

Concepts & Materials Inc., Greenville, South Carolina 29607). The end of the tubular casing was then clipped (Tipper Tie, Rheem Manufacturing Company, Apex, North Carolina 27502). The stuffed meat was packaged in cardboard boxes, and stored in a blast freezer (–30 °C) until evaluated.

On each sampling day, the meat was sliced (Butcher Boy Bench Saw Model SA20, Lasar Manufacturing Company, Inc., Los Angles, CA 90059) to 1.0 cm thick steaks, placed on a styrofoam tray (Tenneco Packaging, Northbrook, IL 60062) containing an absorbent pad (Dri-Loc 40, Sealed Air Corporation, Saddle Brook, NJ 07663), wrapped with PVC film, stored in cardboard boxes and placed in a walk-in cooler (0 °C). Samples were evaluated for its binding properties at predetermined intervals.

Binding measurement

Objective measurements for binding strength of the restructured steaks were conducted for frozen storage at 1, 2, and 3 months storage using the grip method. Grips (Catalogue Number 2710–002, Instron Corporation, Atlanta, GA 30340) were attached to the Instron machine (Model 1011, Instron Corporation, Atlanta, GA 30340). A crosshead speed of 200 mm/min and a 50 kg load cell were used. Four raw steaks (1.5 cm thick and 7.5 cm in diameter) from each treatment were analysed to determine binding strength of the restructured turkey steaks. Only steaks with centrally located bind junction were selected for the binding strength using the Instron machine. Each steak was cut into 2.5 cm in width and 7.5 cm in length strips. The grip was applied to each end of the strip, and the peak force was recorded by pulling the strip apart until the bind junction was completely separated. Peak force in kilogramme was the unit used to measure strength of the bond between the meat pieces.

Binding strength and integrity of the steaks were also evaluated for the simulated retail display steaks. Scores were assigned based on the amount of separation between the bond (5 = 100% intact, 4 = 75% intact, 3 = 50% intact, 2 = 25% intact, and 1 = 0% intact or 100% separation). For the binding score, each steak was held on the second finger for 10 sec, while for the integrity test score, the steaks were observed for breaks in the bind junctions. Three steaks were evaluated for each replicate within each treatment.

Statistical analysis

The incorporation of NaD and/or NaL in the *Fibrimex* study follows a 2 x 3 factorial design (2 levels of NaD 0% and 0.1%; 3 levels of NaL 0%, 1.5%, and 2.0%). SAS software program (SAS Inst. 1990) was used to determine significant differences among the treatments at $p = 0.05$. The procedure PROC MIXED or PROC GLM from SAS (SAS Inst. 1990) was used for the analyses of repeated measures. For comparisons among treatments, CONTRAST statements were used in the analyses.

With respect to meat and poultry products, limited research has been done on NaD. In the present study, the effects of NaD on restructured turkey steaks were compared to NaL, combination of NaD + NaL, and untreated steaks (control). Besides NaD, research on NaL with *Fibrimex* has never been reported in literature. Therefore, the effects of NaL on restructured turkey steaks were compared with the combination of NaD + NaL, and the untreated steaks.

Results and discussion

Binding integrity

For most of the storage periods, the changes in the binding integrity scores for the steaks were not affected by the treatments *(Table 1)*. Throughout the storage periods, the steaks were all intact with binding scores of 5.0. However, at storage period of 1 month, steaks on day 6 and 8 at 0.1% NaD had some weak binding integrity between the meat pieces with integrity score of 4.78 and 4.83.

There was no interaction effect between treatment and month of storage for the binding integrity scores. Steaks that were treated with either NaL, NaD, or combination of NaL + NaD behaved the same when compared with steaks that were not treated *(Table 2)*. There were no significant differences for all the comparisons made among the treatment groups *(Table 3)*. Basically, in all the treatments, the meat pieces were held together by the *Fibrimex* without falling apart when stored at 0 °C for maximum of 8 days. The data demonstrated that 1.5% or 2.0% NaL, 0.1% NaD, and combination of NaD + NaL could be used together with the *Fibrimex* binding system for production of steaks from restructured turkey breasts without affecting the binding integrity of the product. The *Fibrimex* binding capability was not significantly affected by freezing the product for up to 3 months at –30 °C.

Binding score

The binding scores for steaks treated with NaL and/or NaD at different storage periods are shown in *Figure 1*. Majority of the restructured turkey steaks were held together by *Fibrimex* even when treated with NaL, NaD, or combination of NaL + NaD. The changes in the binding scores over time of storage for the restructured turkey steaks kept at 0 °C were very small *(Table 4)*. Throughout the 8 days of storage at 0 °C, steaks that were treated with NaL and/or NaD were still able to maintain good binding capability by *Fibrimex* comparable to the untreated steaks. Based on the mean value, all the treatments had scores of 4.6 or higher throughout the storage periods. The only exception occurred for steaks on day 0 from restructured turkey breasts that were stored for 1 month at –30 °C, and treated with combination of 1.5% NaL + and 0.1% NaD which had binding score of 4.3. However, the steaks with binding score of 4.3 were still strong enough to hold the meat pieces together without falling apart when handled.

Table 2. Least square mean values* of binding integrity scores** for restructured turkey steaks made with *Fibrimex* and treated sodium lactate (NaL) and/or sodium diacetate (NaD)

Sodium diacetate level(%)	Sodium lactate level (%)		
	0	1.5	2.0
0	5.00a	5.00a	5.00a
0.1	4.98a	5.00a	5.00a

*Means bearing the same letter are not significantly different (p >0.05)

**Binding integrity score: 1 = 100% fall apart and 5 = 100% fully intact

Table 3. *P*-values of comparisons for binding integrity scores of steaks made with *Fibrimex* and treated with sodium lactate (NaL) and/or sodium diacetate (NaD)

Comparisons[a]	P-values[b]
5 vs 3,4	0.0639
1,2 vs 3,4	1.0000
6 vs 1,2	1.0000
5,6 vs 1,2,3,4	0.1835

[a]1 = 1.5% NaL, 2 = 2.0% NaL,
3 = 1.5% NaL + 0.1% NaD,
4 = 2.0% NaL + 0.1% NaD, 5 = 0.1% NaD,
6 = Control

[b]Value significantly different if p <0.05

There was no interaction effect between treatment and month of storage for the binding scores. All the steaks that were treated with NaL and/or NaD behaved similarly to the untreated samples irrespective of the duration of storage *(Table 5)*. All the treatment groups comparisons were not significantly different from each other *(Table 6)*. Basically, for all the treatments, the meat pieces were held together by the *Fibrimex* without breaking apart when handled. Therefore, the data demonstrated that NaL at 1.5% and 2.0% with or without 0.1% NaD could be used together with *Fibrimex* binding system for the production of restructured turkey steaks. The *Fibrimex* binding capability was not significantly affected by freezing the restructured turkey breasts for up to 3 months at –30 °C.

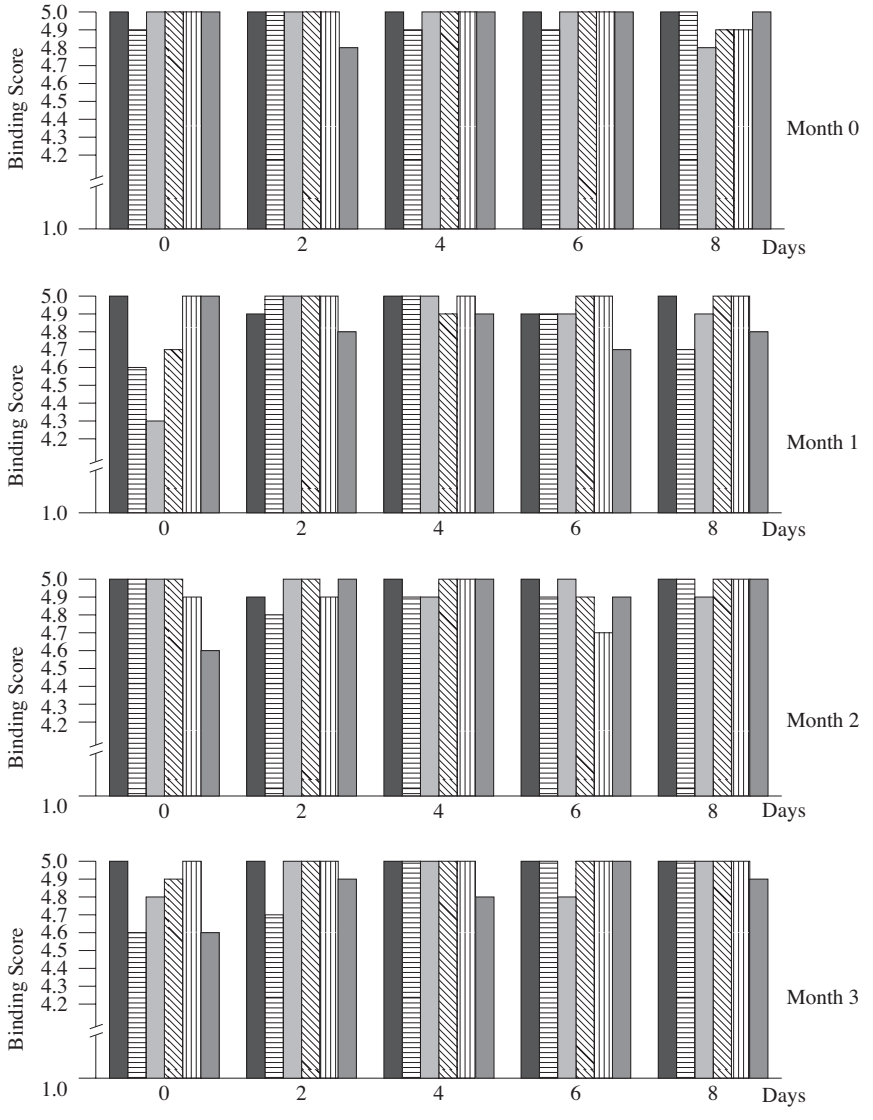

Figure 1. Mean binding scores for steaks stored for 8 days at 0 °C that were sliced from restructured turkey breasts made with ***Fibrimex****, treated with sodium lactate (NaL) and/or sodium diacetate (NaD), and stored at different storage times (0, 1, 2, and 3 month) at –30 °C (1.5% NaL, 2.0% NaL, 1.5% NaL, + 0.1% NaD, 2.0% NaL + 0.1% NaD, 0.1% NaD, Control).*

This is the first study to be documented on the use of NaL and NaD with *Fibrimex*. With *Fibrimex* alone, Boles and Shand (1999) had successfully demonstrated that steakettes with similar bind can be manufactured using beef from chuck clod, chuck tender, tip or inside round. *Fibrimex* binds cooked steakettes stronger when sliced meat was used (Boles and Shand 1998). The bind values of cooked steakettes were similar for *Fibrimex* and alginate binders when sliced meat was used to manufacture the steakettes.

Table 4. Slope values for binding scores of steaks (stored at 0 °C for 8 days) sliced from restructured turkey breasts (stored at –32 °C for 0, 1, 2, and 3 months) made with *Fibrimex* and treated sodium lactate and/or sodium diacetate

Month	Sodium diacetate level (%)	Sodium lactate level (%)		
		0 1.5	2.0	
0	0	–0.006	–0.000	0.003
	0.1	0.011	–0.017	–0.006
1	0	0.000	–0.000	0.006
	0.1	–0.028	0.058*	0.028
2	0	–0.003	0.006	0.003
	0.1	0.039*	–0.006	–0.003
3	0	0.000	–0.000	0.053*
	0.1	0.031*	0.008	0.011

*Significant at $p < 0.05$

Table 5. Least square mean values* of binding scores** for restructured turkey steak made with *Fibrimex* and treated with sodium lactate and/or sodium diacetate

Sodium diacetate level (%)	Sodium lactate level (%)		
	0	1.5	2.0
0	4.98a	4.99a	4.90a
0.1	4.88a	4.93a	4.97a

*Means bearing the same letter are not significantly different *(p >0.05)*
**Binding score: 1 = 100% break and 5 = 100% binding

Table 6. *P*-values of comparisons for binding scores of steaks made with *Fibrimex* and treated sodium lactate (NaL) and/or sodium diacetate (NaD)

Comparisons[a]	*P*-values[b]
5 vs 3,4	0.0573
1,2 vs 3,4	0.9248
6 vs 1,2	0.4212
5,6 vs 1,2,3,4	0.0721

[a]1 = 1.5% NaL,
2 = 2.0% NaL,
3 = 1.5% NaL + 0.1% NaD,
4 = 2.0% NaL + 0.1% NaD,
5 = 0.1% NaD, 6 = Control
[b]Values are significantly different if $p < 0.05$

Binding strength

There was no interaction effect between treatment and month of storage for the binding strength of the restructured turkey steaks. The *Fibrimex* binding capability was not significantly affected by freezing the product for up to 3 months at –30 °C. Therefore, all the treatments behaved the same irrespective of the storage duration. Steaks that did not receive any NaL and/or NaD had significantly higher binding strength when compared with steaks treated with NaL and/or NaD *(Table 7)*.

Steaks that were treated with only NaD did not differ significantly when compared with steaks treated with either 1.5% or 2.0% NaL. Similarly, steaks that were treated with only NaD did not differ significantly in the binding strength when compared with steaks from the treatment groups with the addition of both NaL and NaD *(Table 8)*. Besides, steaks from the treatment groups with the addition of only NaL did not differ significantly when compared with steaks from the treatment groups that received both NaL and NaD. The addition of NaD with the absence of NaL resulted in significantly lower binding strength when compared with steaks from the treatment groups that were treated with NaD in the presence of NaL *(Table 8)*.

Table 7. Least square mean values* of binding strength (kgf) of the restructured turkey steak made with *Fibrimex* and treated sodium lactate and/or sodium diacetate

Sodium diacetate level (%)	Sodium lactate level (%)		
	0	1.5	2.0
0	0.145b	0.105a	0.108a
0.1	0.115a	0.107a	0.114a

*Means bearing the same letter are not significantly different *(p* >0.05*)*

Table 8. *P*-values of comparisons for the binding strength (kgf) of restructured turkey steaks made with *Fibrimex* and treated sodium lactate and/or sodium diacetate

Comparisons[a]	P-values[b]
5 vs 3,4	0.6155
1,2 vs 3,4	0.5308
6 vs 1,2	0.0001
5,6 vs 1,2,3,4	0.0319

[a]1 = 1.5% NaL,
2 = 2.0% NaL,
3 = 1.5% NaL + 0.1% NaD,
4 = 2.0% NaL + 0.1% NaD,
5 = 0.1% NaD, 6 = Control
[b]Values are significantly different if $p < 0.05$

The effect of adding NaD and/or NaL on the binding strength of *Fibrimex* has not been documented in the literature. However, with algin-calcium binding system, decreasing the pH reduces the binding strength (Clarke et al. 1988; Johnson et al. 1990). Muller et al. (1991) found that the addition of adipic acid to beef steakettes manufactured with algin-calcium binding system decreased the binding strength with freezing, however, the meat was still able to maintain its binding strength integrity.

Even though restructured turkey breasts when treated with NaL and/or NaD and stored for 3 months at –30 °C produced steaks that had lower binding strength when compared with control, the preservatives still have potential to be used with *Fibrimex*. From the binding and binding integrity score studies, the meat pieces were held together by *Fibrimex* even in the presence of NaL and/or NaD. Therefore, 1.5% and 2.0% NaL, with or without 0.1% NaD could be used together with *Fibrimex* for the production of steaks for retail meat from restructured turkey breasts. The binding strength of treated steaks was lower, yet the steaks could be displayed and handled without falling apart.

Conclusion

The restructured turkey steaks when treated with sodium diacetate and/or sodium lactate had significantly ($p < 0.05$) lower binding strength. However, based on the binding integrity and binding scores, the *Fibrimex* binding system was able to hold the meat pieces together without falling apart when handled. Therefore, the method used in this study could be utilized in production of restructured turkey steaks and broaden available purchasing selections for the consumers.

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Abstrak

Kajian dijalankan untuk menentukan kesan natrium diasetat (NaD) dan/atau natrium laktat (NaL) pada kekuatan pengikatan dan integriti pengikatan stik ayam belanda distruktur semula yang diproses menggunakan sistem *Fibrimex*. Stik ayam belanda yang distruktur semula dirawat dengan 1.5% NaL, 2.0% NaL, 1.5% NaL + 0.1% NaD, 2.0% NaL + 0.1% NaD, 0.1% NaD, atau sebagai kawalan. Kesemua sampel disimpan pada –30 °C selama 0, 1, 2, dan 3 bulan. Pada setiap peringkat penyimpanan, stik ayam belanda yang distruktur semula dipotong setebal 1 cm, dan dinilai untuk kekuatan pengikatan dan integriti pengikatannya. Walaupun stik yang dirawat dengan NaD dan/atau NaL mempunyai kekuatan pengikatan yang rendah, tetapi sistem *Fibrimex* dapat mengikat ketulan-ketulan daging tanpa lerai apabila dipegang.

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