# EFFECT OF INJECTING CAMEL MEAT WITH SOY PROTEIN ISOLATE FOLLOWED BY COLD STORAGE ON MEAT QUALITY ATTRIBUTES

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*Abstract*

To up grade the less expensive, but considerably tough meat of camel, injection of samples from the Biceps famoris muscle with hydrated (9 parts of water + 1 part of soy protein isolate) soy protein isolate (SPI, Daniels Midland Co.) at the levels of 0, 6, 12, 18 and 24% was carried out followed by storage at 6°C in polyethylene bags. Chemical, physical and organoleptic properties were evaluated during storge for 6 days at 2 days intervals. The mentioned practice protected the meat from dryness, retarded the deterioration of colour as measured colorimetrically at 542 nm, increased somewhat the pH values, improved the water holding capacity and plasticity leading to lowering the cooking yield, and retarded the loss in appearance, flavor and overall-satisfaction. Injection with hydrated SPI, followed by cold-storage markedry improved tenderness of camel meat and had a distinct antioxidant effect.. Microbiological evaluation revealed that the increase of some bacteria due to this treatment was not remarkable. However, future studies should be carried out using sterilized water during SPI hydration. Changes of qualities were mostly and directly related to the level of injected SPI.

The results revealed that, injection of tough camel meat cuts with hydrated SPI. possibly at 24% level followed by 4 days of cold storage at 6°C seem to be the unique means for increasing the tenderness and improving the physical and chemical attributes of this low price meat.

## INTRODUCTION

In Egypt, camel meat, specially that from the old animals, is the cheapest

compared to other meat kinds as mutton and veal. Camel meat represent, however, an important source of animal protein for the low income people. Moreover, the number of animals slaughtered in the local abattoirs in 1988 was 87000 heads. Nevertheless, camel meat finds a limited demand due to its toughness and distinctive odor (Ahmed, 1991).

Partial substitution of meat with soy protein products decreased the price of the meat product. This because the cost per Pound of net utilizable protein from beef was ten times that of protein from common vegetable sources (FAO, 1970). Therefore, approximately 23 million pounds of rehydrated vegetable protein were used in the school lunch programs in 1971/1972 and increased to 46 million pounds in school lunch programs in 1973 (Butz, 1974). The ceaseless and rapid increase of using such large amounts of vegetative protein used within a short period of time may indicate the importance of using vegetable proteins.

Soy protein has been used extensively as meat extender and it can be used advantageously in many food products for nutritional and/or functional reasons. Pakosky (1974) reported that the use of soy proteins in meat systems increased the flavor and juiciness, while Smith *et al.* (1976) indicated that it improved the appearance of blended ground beef patties; on the other hand, the same author reported that the use of soy proteins decreased the cooking loss for two reasons; the first, their ability to bind fat and the second, their tendency to retain the moisture during cooking. Concerning the tenderness and palatability of meat, Matthew (1991) reported that soy protein isolate could be used to optimize the palatability of meat products via improving the tenderness. Lecomte *et al.* (1993) showed that soy proteins used as additive the tenderness. Lecomte *et al.* (1993) showed that soy proteins used as additive in foods, specially meat products, improved the functional characteristics of the system such as water holding capacity, yield and textural properties, while decreased the cooking loss.

Twigg *et al.* (1976) recorded that the samples containing soy protein had higher pH value than the all-beef products.

Lipid oxidation can be a significant reason for off-flavor and odor. The TBA test has been widely used for measuring oxidative rancidity in fat-containing foods. TBA values were found to highly correlate with trained sensory panelists scores for rancid flavor (Tarladgis *et al.*, 1960 and William *et al.*, 1983). An additional benefit for using soy protein was the antioxidation property which has been reported in food

systems containing soy protein isolate, in particular the meat products (Williams in Paticular and Zabik, 1975 and Romijn *et al.*, 1991).

On the other hand, from the microbiological standpoint, Judge *et al.* 1974) reported that soy protein products when mixed with ground beef stimulated total microbial growth. Also, Thompson *et al.* (1978) noticed that at the end of storage at 3°C for 6 days, the soy-beef formulations had higher numbers of staphylococci, coliforms, proteolytics and total organisms, but this was usually not statistically significant.

The aim of this work was to evaluate some of the physical, chemical, microbiological and organoleptic properties of the camel meat injected with different levels of the hydrated soy protein isolate. The evaluation was conducted after injection immediately and during the storage at 6oC for 6 days.

## MATERIALS AND METHODS

Soy protein isolate, Pro Fam, was obtained from Archer Daniels Midland Comp. (USA). Soy protein isolate (SPI) was hydrated with tap water (35oC), the proportion of water was 9 parts for 1 part of soy protein isolate. The hydrated SPI was injected at levels of 0% (control), 6, 12, 18 and 24% into fresh camel meat samples.

Samples of fresh camel meat were taken from the *Biceps femoris* muscles (round cut) which represented a relatively tough cut. The meat was obtained from local market after slaughter and transported immediately to the Meat and Fish Technology Research Department. The amount of meat was divided to 5 equal parts in weight, part No, 1, 2, 3, 4 and 5 were injected by hydrated SPI at levels 0, 6, 12, 18 and 24%, respectively.

The treated and untreated (control) samples were set in foam plates, packaged in polythylene bags and stored at 6°C for six days. Chemical, physical, microbiological and organoleptic evaluations were carried out immediately after the injection process (zero time) and during the storage period of 2 days intervals.

### Analytical methods :

Moisture, crude protein (micro Kjeldahl, T.N. x 6.25), ether extract and ash contents were determined according to the methods recommended by the A.O.A.C. (1980). The pH value was measured according to the method described by Krilova

and Liskovskaia (1961) using Became pH meter with Combined electrode. The water-holding capacity (WHC) and plasticity of meat tissues were measured by the method of Soloviev (1960). Thiobarbituric acid (TBA) value was determined as described by Pearson (1970). The cooking loss was calculated as the percentage of weight change from the raw to cooked state and consequently the cooking yield was calculated. Color (as absorbance at 542 nm) of the injected samples or control at any time of storage was determined by the method of Husaini (1950).

Twenty gm of meat was homogenized and diluted in 180 ml of tryptic soy broth. Aerobic plate and aerobic sporeformer counts after heating at 80oC for 15 minutes were performed by standard plate count agar according to A.P.H.A. (1971); incubation was carried out at 32 and 30oC (respectively) for 48 hr. Yeast and mold were grown on malt extract agar (Difco Manual, 1977) and incubated at 25oC for 5 days. Aerobic proteolytic microorganisms were grown on the nutrient emulsified oil agar (Difico Manual, 1953). Coliforms, Salmonella spp. and Staph. aureus were grown on Maconkey's bile salt agar, Bacto SS agar and Staph. Medium No. 110 (Difico, 1977) respectively, incubation was carried out at 37oC for 48 hours. Listeria monocytogenes were grown on modified McBride agar medium (Lee and McCliam, 1986).

The injected samples and control were organoleptically evaluated immediately after the injection process and during the storage period. The samples were cooked by boiling in water at 100°C for 90 minutes, removed from billing water placed in plates and then served to a panel composed of 10 members of trained panelists (5 male and 5 females) to evaluate the samples for appearance, tenderness, flavor and overall satisfaction according to Twigg *et al.* (1976) who recommended the following judging scale : 9 = best and 1 = poorest.

Data were analyzed using the analysis of variance to evaluate the effect of the injection process with different levels of hydrated SPI on the palatability scores of camel meat. Means were compared by using least significant differences (L.S.D.) at 0.05 level (Steel and Torrie, 1980).

## RESULTS AND DISCUSSION

### A. Effect of injection process of hydrated SPI (at different levels) on some physical and chemical properties of camel meat during storage (6°C):

## 1. Proximate composition :

Data of the proximate composition of the fresh camel meat (control) and fresh samples injected with different levels of hydrated SPI (immediately after the injection processes) are presented in table (1). From these results, it could be noticed that the proximate chemical composition of the fresh camel meat taken from the Biceps femoris muscle (a relatively tough cut) was 77.89, 17.82, 3.25 and 1.04% for moisture, protein, fat and ash respectively, (on wet weight basis). With respect to the injected samples, on dry weight basis, the protein and ash contents were increased, wile increasing the injected level of hydrated SPI, the moisture, protein and ash contents were increased, while the fat contents was decreased.

Table 1. Proximate composition of fresh camel meat samples injected with different levels of SPI (after injection process immediately).

| Hydrated S.P.I# level | Moisture % | Protein % | | Fat | | Ash % | |
|---|---|---|---|---|---|---|---|
| | | W.W.B.* | D.W.B.** | W.W.B* | D.W.B.** | D.W.B.* | D.W.B.** |
| Control | 77.89 | 17.82 | 80.59 | 3.25 | 14.70 | 1.04 | 4.71 |
| 6% | 78.57 | 17.38 | 81.14 | 3.03 | 14.09 | 1.02 | 4.76 |
| 12% | 79.22 | 16.97 | 81.67 | 2.81 | 13.51 | 1.00 | 4.82 |
| 18% | 79.79 | 16.61 | 82.18 | 2.61 | 12.91 | 0.99 | 4.91 |
| 24% | 80.36 | 16.25 | 82.75 | 2.41 | 12.24 | 0.98 | 5.01 |

# Soy protein isolate
* On wet weight basis. ** On dry weight basis.

## 2. Moisture content :

From results in table (2), it could be observed that during the storage period, the moisture content of the control sample was sharply decreased compared to the injected samples, where the control sample had 77.89% moisture at zero time and reached to 66.45% by the end of storage period (moisture lost was 14.7%), while the sample injected with hydrated SPI at levels of 6, 12, 18 and 24% had 78.57, 79.22, 79.79 and 80.36% at zero time showing corresponding values of 70.66, 72.00, 73.69 and 74.48% moisture by the end of storage period, respectively (moisture lost were 10.8, 9.1., 9.6 and 7.3%, respectively). This might indicate the beneficial effect of SPI; being possibly due to the improvement of water-holding capacity for the injected samples.

Table 2. Moisture contents of control and injected camel root samples with different levels of SPI at zero time** and during the storage period (6°C) for 6 days.

| Hydrated S.P.I# level | Cold storage period (in days) | | | |
|---|---|---|---|---|
| | 0 | 2 | 4 | 6 |
| Control | 77.89 | 75.60 | 73.83 | 66.45 |
| 6% | 78.57 | 76.78 | 75.28 | 70.66 |
| 12% | 79.22 | 77.10 | 75.70 | 72.00 |
| 18% | 79.79 | 77.42 | 75.99 | 73.69 |
| 24% | 80.36 | 77.54 | 76.13 | 74.48 |

# Soy protein isolate
* Fresh camel meat.
** After injection process immediately.

### 3. pH value :

Results given in Table (3) show the effect of hydrated SPI level injected into fresh camel meat samples on the pH values (compared to control sample) at zero time and during the cold storage period (6°C) for 6 days. From these results, it could be noticed that at zero time, the injected samples recorded higher pH values than the control sample, on the other hand, the sample injected at the highest level of SPI had the highest pH value. Also, it could be observed that the pH values were gradually increased either for the control or for the injected samples during the storage period. Moreover, the same trend was recorded for the pH values at zero time was observed during the storage period. These results are supported by the finding of Twigg *et al.* (1976) who reported that samples containing soy protein had higher pH than the all beef samples.

Table 3. PH values of the control and injected camel meat samples with different levels of SPI at zero time** and during the storage period (6°C) for 6 days.

| Hydrated S.P.I# level | Cold storage period (in days) | | | |
|---|---|---|---|---|
| | 0 | 2 | 4 | 6 |
| Control | 6.69 | 6.84 | 6.97 | 7.28 |
| 6% | 6.72 | 6.89 | 7.15 | 7.30 |
| 12% | 6.75 | 6.99 | 7.19 | 7.39 |
| 18% | 6.82 | 7.02 | 7.28 | 7.42 |
| 24% | 6.94 | 7.06 | 7.35 | 7.51 |

# Soy protein isolate * Fresh camel meat. ** After injection process immediately.

## 4. Water-holding capacity and plasticity :

The effect of injecting fresh camel meat with different levels of the hydrated SPI on the water-holding capacity (W.H.C.) and plasticity at zero time and during the storage period at 6oC for 6 days is presented in table (4). It could be observed that at zero time, the injected samples had the higher W.H.C. compared to the control sample while, they were nearly equal in plasticity with exception of the injection at the 24% level. Either at zero time (after injection process immediately) or during the storage period, by increasing levels of hydrated SPI, the W.H.C. was increased (least area of free water) and nearly the same tendency for the plasticity. This indicated that there was a positive relationship between the hydrated SPI level injected into the sample and the WHC and consequently the platicity. Also, it could be observed that the WHC and plasticity for injected samples were improved during the storage period, while the reverse was found for the control sample in spite of the control had a lower value for WHC at the end of storage (this means high WHC), however, this was possibly untrue value for WHC and might be due to the sharply decreasment of moisture and dryness of the control sample by the end of storage. These results were in accordance with that reported by Lecomte *et al.* (1993) who mentioned that SPI improved the functional characteristics of the system such as the water-holding capacity (WHC).

Table 4. WHC* and plasticity of the control** and injected camel meat samples with different levels of SPI at zero time*** and during the storage period (6oC) for 6 days.

| Hydrated S.P.I# level | Cold storage period (in days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | | 2 | | 4 | | 6 | |
| | WHC cm3/0.3g | Pliasticity cm3/0.3g | WHC cm3/0.3g | Pliasticity cm3/0.3g | WHC cm3/0.3g | Pliasticity cm3/0.3g | WHC cm3/0.3g | Pliasticity cm3/0.3g |
| Control | 10.1 | 3.0 | 9.9 | 3.1 | 8.0 | 2.8 | 3.0 | 2.3 |
| 6% | 10.0 | 3.0 | 9.1 | 3.1 | 8.9 | 3.1 | 8.7 | 3.3 |
| 12% | 9.8 | 3.0 | 8.6 | 3.2 | 8.3 | 3.3 | 7.9 | 3.5 |
| 18% | 9.3 | 3.1 | 8.3 | 3.3 | 7.7 | 3.4 | 7.2 | 3.7 |
| 24% | 9.7 | 3.2 | 7.6 | 3.4 | 6.9 | 3.6 | 6.3 | 4.0 |

# Soy protein isolate
* Fresh camel meat.
* Water holding capacity
** After injection process immediately.

From data of Tables (3 and 4), it could be observed that there was a positive correlation between pH values and the improvement in the water-holding capacity (WHC) during the storage period for the injected samples. Scores of the tenderness in table (8) showed the same tendency of the WHC presented in table (4). These results were supported by the finding of Ahmed (1991), who reported that the pH value influenced the tenderness of meat by affecting its WHC.

Table 5. Cooking loss and yield % of the control* and injected camel meat samples with different levels of SPI at zero time** and during the storage period (6°C) for 6 days.

| Hydrated S.P.I# level | Cold storage period (in days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | | 2 | | 4 | | 6 | |
| | Cooking loss % | Cooking yield % | Cooking loss % | Cooking yield % | Cooking loss % | Cooking yield % | Cooking loss % | Cooking yield % |
| Control | 51.13 | 48.87 | 51.90 | 48.10 | 53.02 | 46.98 | 53.81 | 46.19 |
| 6% | 47.71 | 52.29 | 47.02 | 52.98 | 46.80 | 53.20 | 46.98 | 53.02 |
| 12% | 46.77 | 53.23 | 46.10 | 53.90 | 45.75 | 54.25 | 46.00 | 54.00 |
| 18% | 44.47 | 55.53 | 43.68 | 56.32 | 43.19 | 56.81 | 43.25 | 56.75 |
| 24% | 42.76 | 57.24 | 41.95 | 58.05 | 41.30 | 58.70 | 41.35 | 58.65 |

# Soy protein isolate
* Fresh camel meat.
** After injection process immediately.

## 5. Cooking loss and yield :

Results in Table (5) show the effect of different levels of SPI injected into camel meat samples on the cooking loss and cooking yield percentage at zero time and during the storage at 6°C for 6 days. It could be noticed that the injected samples; at any level; had lower cooking loss percentage (higher cooking yield %) than the control sample either at zero time or during the storage period. Also, with increasing the injected level, the cooking loss % was decreased (cooking yield % increased). This may be probably due to the possible better water and fat binding properties for the camel meat samples contained soy protein isolate. These results were in line with the finding of Lecomte *et al.* (1993), who reported that soy protein improved the functional characteristics of the system such as WHC, yield and texture properties, and decreased the cooking loss. On the other hand, during the storage period (6 days), the cooking loss % was markedly increased for the control

sample (yield % was decreased) while it was sightly and gradually decreased for the injected samples (yield % was slightly increased) with exception of the sixth day storage, where the cooking loss % was slightly increased (yield % was slightly decreased. This indicated the importance of SPI for improving the properties of meat containing the SPI.

## 6. Color (as absorbance value) :

The results in table (6) show the effect of hydrated SPI injected at different level into camel meat samples on the color changes either at zero time or during the storage period as indicted by the values of absorbance at 542 nm. It could be observed that the values of absorbance were decreased by increasing the level of hydrated SPI injected into the sample. This might be ascribed to the dilution effect of SPI on the meat pigments. During the storage at 6°C for 6 days, it could be observed that with increasing the storage period, the values of absorbance were increased for control and decreased till the fourth day then increased till the end of storage for the injected samples.

Table 6. Colour (as absorbace at 542 nm) of the control* and injected camel meat samples with different levels of SPI at zero time** and during the storage period (6oC) for 6 dasy.

| Hydrated S.P.I# level | Cold storage period (in days) | | | |
|---|---|---|---|---|
| | 0 | 2 | 4 | 6 |
| Control | 11.55 | 1.193 | 1.920 | 2.005 |
| 6% | 1.142 | 1.140 | 1.139 | 1.210 |
| 12% | 1.111 | 1.105 | 1.102 | 1.158 |
| 18% | 0.908 | 0.855 | 0.800 | 0.824 |
| 24% | 0.827 | 0.805 | 0.782 | 0.798 |

# Soy protein isolate * Fresh camel meat. ** After injection process immediately.

For the control sample, the increase and concentration of color intensity might be due to the relatively considerable loss of moisture when compared to the injected samples. This concentration was recorded after 6 days for experimental meat. Between 0 and 4 days storage, the changes were actually slight. This might be attributed to slight oxidation of red pigments which was marked in the control meat due to intense concentration of the pigment by the appreciable evaporation of water. The appearance (organoleptic evaluation, Table 8), however, was better for injected

meat indicating that loss of pigment did not affect the preference of injected camel meat. This might be ascribed to the darker color of camel by nature, thereby, some dilution of pigment was possibly beneficial.

## 7. TBA value :

The 2-thiobarbituric acid values (TB, mg malonaldhyde/kg sample) of the fresh camel meat sample injected with different levels of hydrated SPI and the control (uninjected samples) at zero time and during the cold storage (6oC) for 6 days are summarized in table (7). From these results, it could be indicated that at zero time, the injected samples had lower values of TBA than the control, possibly because of malonaldhyde dilution in the injected meat. On the other hand, during the storage period, TBA values of all samples (either injected or control) were increased. Nevertheless, the TBA values of the injected samples were lower than the control. This confirmed the antioxidant property which has been reported in food system containing soy protein isolate. Such results were supported by Romijn *et al.* (1991) who reported that a number of compounds found in soy protein products which may show reported that a number of compounds found in soy protein products which may show the antioxidant activity, including phenolic compounds, peptides, amino acids, aromatic amines , sulfhydryl compounds, phospholipds and phytate. On the other hand, TBA values have been found to correlate with sensory panelists scores (Table, 8), whereas all samples were more preferred by the fourth day of storage when compared to that by the end of the storage period, and these results were confirmed by the findings of Tarladgis *et al.* (1960) who noticed that there was a correlation between the TBA value and the sensory panelists scores.

Table 7. Thiobarbituric acid (TBA, mg malonaldyde/kg) values of the control* and injected camel meat samples with different levels of SPI at zero time** and during the storage period (6°C) for 6 dasy.

| Hydrated S.P.I# level | Cold storage period (in days) | | | |
|---|---|---|---|---|
| | 0 | 2 | 4 | 6 |
| Control | 0.433 | 0.883 | 3.801 | 8.085 |
| 6% | 0.400 | 0.665 | 0.948 | 7.650 |
| 12% | 0.356 | 0.580 | 0.666 | 6.135 |
| 18% | 0.306 | 0.489 | 0.544 | 4.736 |
| 24% | 0.255 | 0.389 | 0.443 | 3.510 |

# Soy protein isolate * Fresh camel meat. ** After injection process immediately.

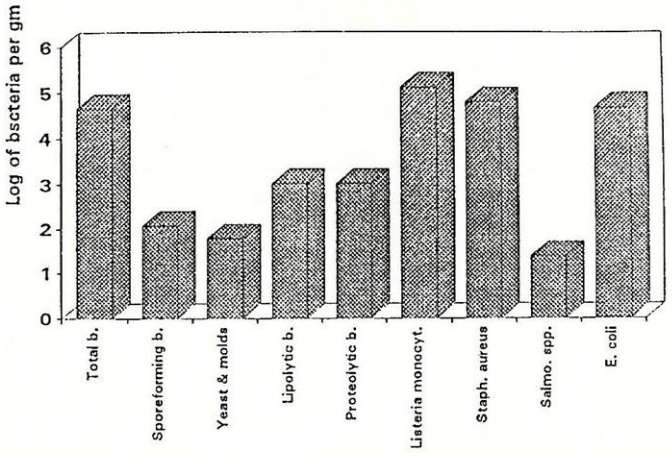


Fig.1 Microbiological evaluation of fresh camel meat (before injection)

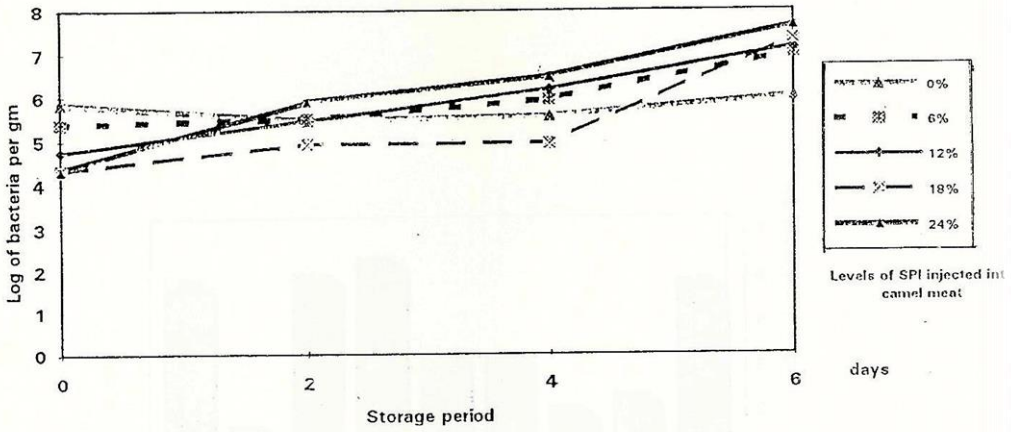


Fig. 2. Effect of treatments on number of Total bacteria (log of bacteria per gm) during storage (6°C).

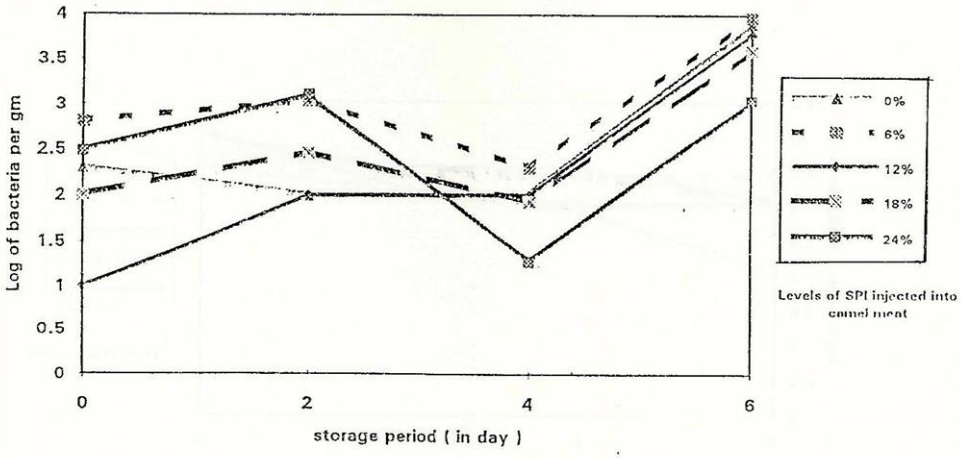


Fig. 3. Effect of treatments on number of Spore forming bacteria (log of bacteria per gm) during storage (6°C).

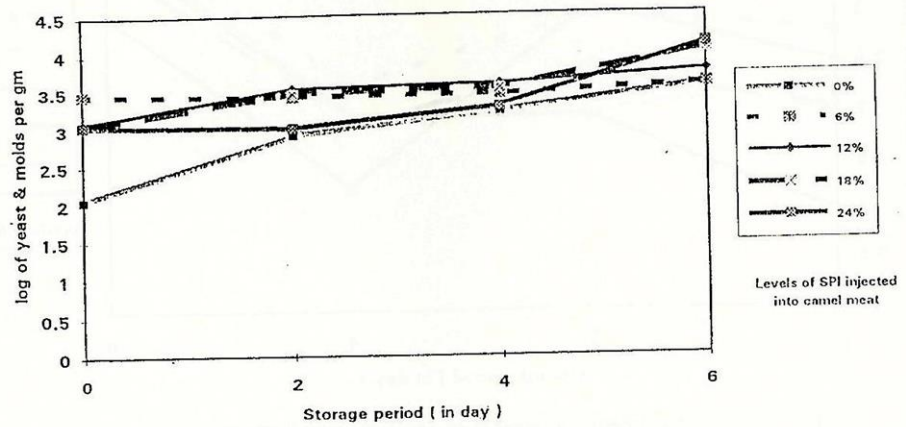


Fig. 4. Effect of treatments on number of Yeast and Molds (log of bacteria per gm) during storage (6$^{O}$C).

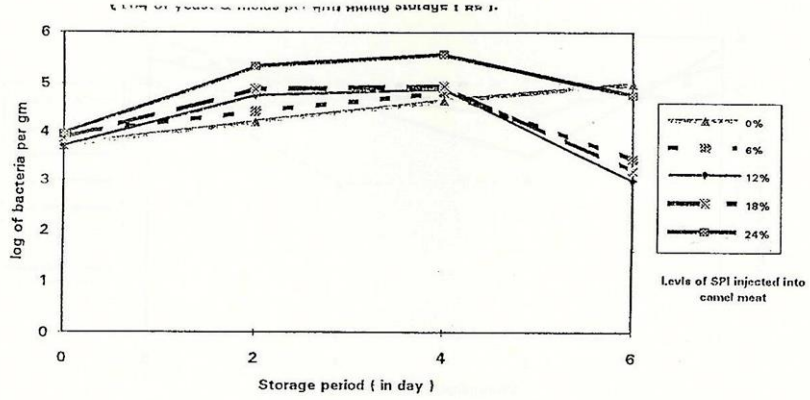


Fig. 5. Effect of treatments on number of Libolytic bacteria (log of bacteria per gm) during storage ($6^{o}C$).

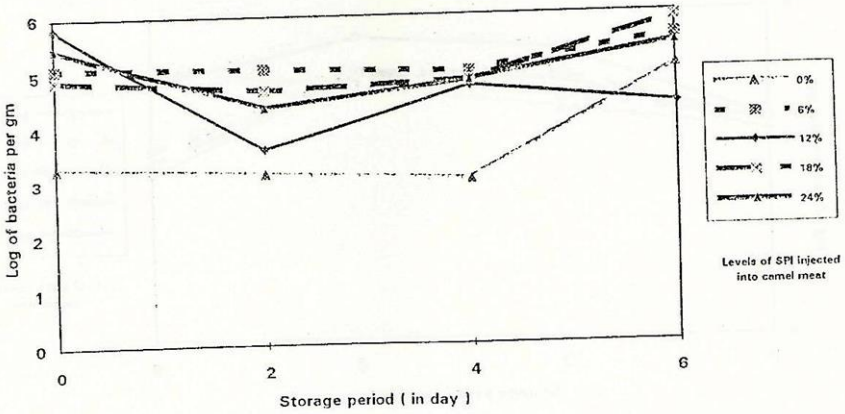


Fig. 6. Effect of treatments on number of Proteolytic bacteria (log of bacteria per gm) during storage (6$^{O}$C).

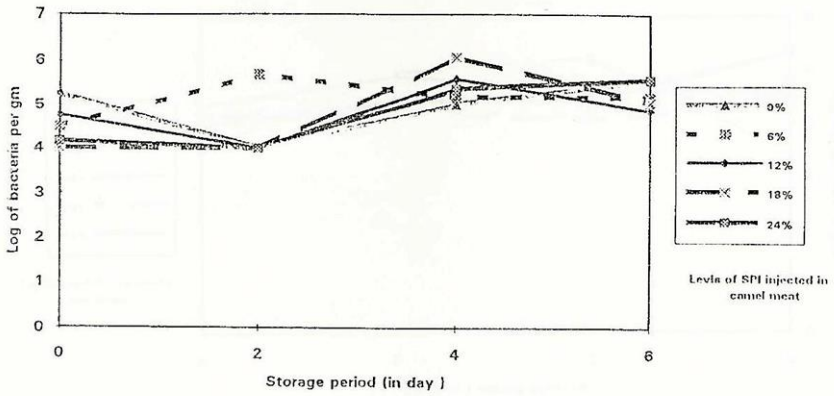


Fig. 7. Effect of treatments on number of Listeria monocytogenes (log of bacteria per gm) during storage ($6^{O}C$).

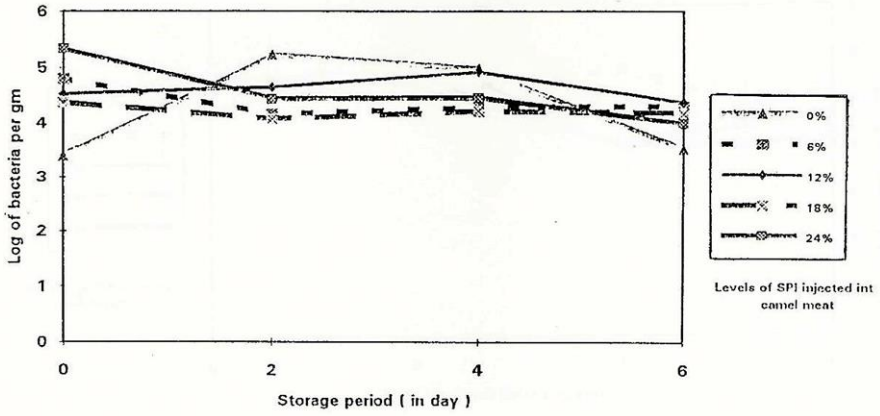


Fig. 8. Effect of treatments on number of *Staph. aureus* (log of bacteria per gm) during storage (6°C).

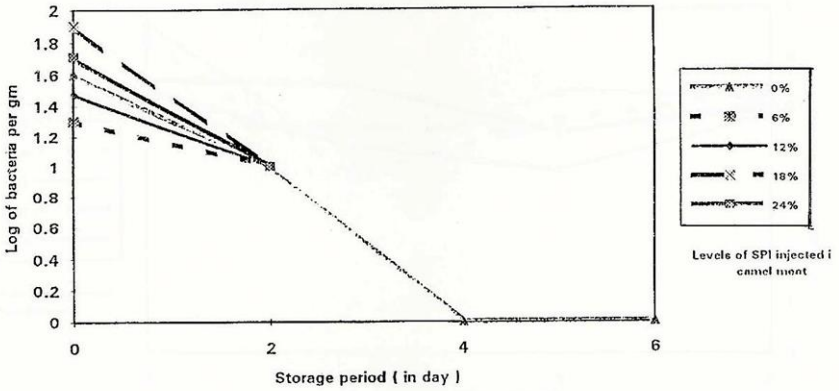


Fig. 9. Effect of treatments on number of Salmonella spp (log of bacteria per gm) during storage (6°C).

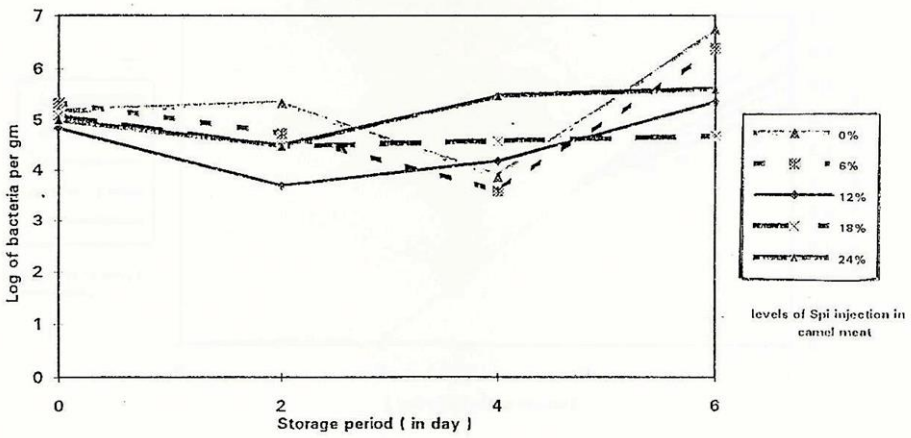


Fig. 10. Effect of treatments on number of *E.coli* (log of bacteria per gm) during storage (6°C).

## B. Microbiological evaluation:

Results illustrated in Fig. (1-10) indicated that injection of hydrated SPI increased the initial counts of meat except for total bacterial count (T.C.) and Listeria *monocytogenes*, but temporary, these counts slightly increased during the first two days (for T.C., sporeforming, yeast and molds and lipolytic) of storage (6oC) with exception of prteolytic, *Staph. aureus, Listeria monocytogenes, Salmonella* spp. and *E.coli*. This slight increase may be due to the increasing in pH values and some hydrolysis of protein because such nitrogenous substances (non-protein nitrogen) enhance the growth and enumeration of microorganisms. On the other hand, the slight decrease may be due to the more or less sudden decrease in temperature. Therefore, the reduction of counts during the first two days probably due to that the micoorganisms were trying to adapt with the low temperature conditions.

Generally, most of the detected microorganisms tend to increase after two days of storage till the end storage period. Salmonella was found in low counts at zero time and completely disappeared through the storage period (6 days at 6oC). It should be noted that the increase of microorganisms in most cases was not remarkable. Moreover, it may be of value to use sterilized tap water for injection of camel meat with hydrated SPI. This may decrease the contamination of injected meat to minimum which requires for future study.

## c. Organoleptic evaluation :

Appearance, tenderness, flavor and overall-satisfaction scores for control and the injected samples (immediately after the injection process-zero time, and during the storage period at 6oC for 6 days) are presented in table (8). At zero time, all of the samples, either injected or not were considered desirable in appearance (approximately 6.9 using 9 point scale). During the storage period, the control sample was gradually decreased in appearance to become undesirable sample (mean score 4.0) by the end of storage period. In contrary, with increasing of the storage period till the fourth day, the injected samples were improved in appearance then mean score decreased by the end of storage period. Also, till the fourth day, with respect to the injected samples, a positive relaitive relationship could be observed between the injected level of SPI and the improvement in appearance. It mitht be due to the lighter bright color of SOI sample and possibly the antioxidation effect of SPI which retarded the color deterioration (Romijn *et al.*, 1991).

As previously mentioned, tenderness scores are presented in the same table. It could be noticed that the control samples was slightly improved in tenderness by

the second day of the storage, possibly due to the effect of natural enzymes in meat, then it was decreased by the fourth day and finally, it became undersirable in tenderness by the end of storage which might be due to the considerable dryness and sharp decrease in moisture content of the samples. As regard to the injected sample, with increasing of SPI level, the improvement of the tenderness scores was observed at any time of the storage period. It was probably due to that SPI improved the waterholding capacity and consequently the tenderness of the samples treated with hydrate SPI, (Matthew, 1991).

Table 8. Appearance, tenderness, flavor and overall-satisfaction scores for control and injected camel meat samples with different levels of SPI at zero time** and during the storage period (6°C) for 6 dasy.

| Hydrated S.P.I# level | Storage period (in days) | Appearance* | Tenderness* | Flavor* | Overall-satisfaction* |
|---|---|---|---|---|---|
| Control | 0 | 7.0a | 6.0a | 6.5a | 7.0a |
| | 2 | 6.9a | 6.3a | 6.4a | 7.0a |
| | 4 | 6.0a | 6.0a | 6.6a | 6.8a |
| | 6 | 4.0a | 3.9a | 4.0a | 4.0a |
| 6% | 0 | 7.0a | 6.0a | 6.6ab | 7.0a |
| | 2 | 7.0a | 6.3a | 6.7b | 7.0a |
| | 4 | 7.5b | 6.5b | 6.8ab | 7.1b |
| | 6 | 5.6b | 6.6b | 4.0a | 4.0a |
| 12% | 0 | 6.9ab | 6.1a | 6.6ab | 7.2ab |
| | 2 | 7.0a | 6.5a | 6.8b | 7.4b |
| | 4 | 7.8c | 6.7b | 6.9b | 7.5c |
| | 6 | 6.0c | 6.8 | 3.9a | 4.1ac |
| 18% | 0 | 6.8ab | 6.1a | 6.8c | 7.3b |
| | 2 | 7.9b | 6.5a | 7.3c | 7.6bc |
| | 4 | 8.0c | 7.0c | 7.8c | 8.0d |
| | 6 | 6.4c | 7.6c | 3.8ab | 4.5b |
| 24% | 0 | 6.7b | 6.2a | 6.9c | 7.2ab |
| | 2 | 8.0b | 7.0b | 7.4c | 7.7c |
| | 4 | 8.0c | 7.6d | 7.8c | 8.0d |
| | 6 | 6.5d | 8.0 | 3.6b | 4.3bc |

* Based on 9 point hedonic scales (9= best, 1 = poorest).
Values in the same vertical column at the same time of storage bearing different letters differ significantly at 0.05 level.
* ISoy protein isolate.

From the same table, it could be observed that flavor of the samples (control or injected) was desirable till the fourth day of the storage period, nevertheless, the injected samples had the highest scores compared to the control. By the end of storage 6 days, all of the samples were unaccepted according to the panel test. On the other hand, from zero time till the fourth day of storage, there was a positive relationship between the injection level of SPI and flavor scores. In contrast, by the end of storage period (6 days), there was a negative relationship between the same two factors, possibly due to the increment of microbial activity (specially the proteolytic bacteria) which lead to the undesirable flavor at the end of the storage.

Also, results in table (8) show the overall satisfaction scores of the samples injected with different levels of SPI and the control at zero time and during the storage at 6oC for six days. It could be also noticed that all samples were accepted till the fourth day of storage, while they were unaccepted at the end of storage except the samples injected with 18% hydrated SPI level which were neutral in overallsatisfaction sensation according to the panelists scores (4.5 on 9 point scales). Also, it could be observed that the samples injected by 6% SPI level were nearly equal to the control, while that injected by 18 or 24% SPI levels were preferred by panelists compared to control.

## Statistical analysis

From data of table (8) statistical analysis revealed that, the injected samples when compared to the control, there were nearly non-significant differences in the appearance, tenderness, flavor and overall-satisfaction at zero time. With respect to the appearance at the second day of the storage, there were significant differences between some of the iniected samples (at levels of 18 and 24% only) and the control. By the fourth and sixth day of the storage, there was a significant difference (in appearance) among all samples (either injected or not). As regards, the tenderness, by the second day of storage, there were non-significant differences between the control and the injected meat except for the sample injected at level of 24% hydrated SPI, while by the fourth and sixth day, there were significant differences between the treatments and the control or within the treatments. As for the flavor, there were significant differences either within the treatments or between the treatments and the control at the second and fourth day, nevertheless, by the end of storage period, the flavor scores were sharply decreased and the differences were non-significant which possibly may be due to the loss of volatile substances contributing to meat flavor. On the other hand, with regard to the overall-satisfaction, there were significant differences and highly significant differences by the second

and fourth day respectively, while by the end of storage period, there were non-significant differences between the control and the samples injected at the levels of 6 and 12%.

On the contrary, there were significant differences between the control and the samples injected at the level of 18 and 24% hydrated SPI.

Finally, it is recommended to inject the tough camel meat with hydrated SPI, possibly at 24% level, followed by 4 days of cold-storage at 6$^{o}$C to achieve maximum improvement of the meat quality.

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# تأثير الحقن بمستويات مختلفة من بروتين الصويا المفصول والتخزين بالتبريد علي خواص أللحم الجملي

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لرفع قيمة اللحم الجملي والتي تتميز بالخشونة الكبيرة (tough meat) فقد تم حقن عينات اللحم الجملي المأخوذة من عضلة الفخذ (Biceps femoris) وذلك بمحلول بروتين (٩ أجزاء ماء + ١ جزء بروتين صويا مفصول) الصويا المفصول (SPI, Daniels Midland Co.) علي المستويات صفر، ٦ ، ١٢ ، ١٨ ، ٢٤٪ ثم التخزين علي درجة حرارة ٦ °م في أكياس البولي ايثيلين. وقد تم تقييم الجودة الطبيعية والكيميائية والحسية أثناء التخزين البارد لمدة ٦ أيام علي فترات منفصلة كل يومين. هذا وقد أدي الإجراء السابق إلي حماية اللحم من الجفاف وأخر التغير في اللون المقاس بطريقة لونية علي طول موجي ٥٤٢ نانوميتر كما أدي إلي زيادة قيم ال pH بعض الشئ وحسن القدرة علي إمساك الماء والبلاستيكية مؤدياً بذلك إلي تقليل الفقد بالطبخ وزيادة الإنتاجية بالطبخ بالاضافة الي تأخير الفقد في المظهر والنكهة ودرجة الإرضاء العام. وقد أدت عملية الحقن ببروتين الصويا المفصول المتبوعة بالتخزين البارد إلي تحسين مميز في طراوة اللحم الجملي. كما أظهرت تأثير مضاد للأكسدة بصورة واضحة. وقد أظهر التقييم الميكروبيولوجي أن الزيادة في بعض الأعداد البكتيرية نتيجة المعاملة كانت غير متميزة ومع ذلك يجب أن تجري دراسة مستقبلية بإستخدام ماء معقم خلال تجهيز محلول بروتين الصويا المفصول. هذا وقد كانت معظم تغيرات الجودة بصورة مباشرة بمستوي الحقن ببروتين الصويا المفصول.

وقد توصلت النتائج إلي أن حقن قطع اللحم الجملي الخشنة بمحلول بروتين الصويا المفصول علي مستوي حقن ٢٤٪ متبوعاً بالتخزين البارد (٦ °م) لمدة ٤ أيام من المحتمل أن تكون وسيلة جيدة لزيادة الطراوة وتحسين الخواص الطبيعية والكيميائية لهذا اللحم المخفض القيمة.