The Use of Surimi in Restructured Meat Products

Progress, Interim and Final Project Reports

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Prepared for:

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FINAL REPORT

submitted to

Alaska Fisheries Development Foundation

by

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This study was proposed to develop a method or methods of restructuring meat and/or poultry products using surimi as a binder. Surimi has a very desirable characteristic that is useful in restructuring meat without heating and that is the ability to form very cohesive gels at refrigerator temperatures. For this reason surimi was the protein of choice for restructuring meat without the use of heat for coagulation and with extremely low levels of salt, only enough to activate the surimi. Another important objective of this project was to use the largest pieces of muscle that could be effectively bound to maintain whole muscle characteristics of the final restructured product.

Objective 1. To develop market-acceptable restructured meat product using surimi without heat and with minimum salt.

An acceptable restructured beef steak was developed using muscles from beef knuckles and the chuck. The pieces were reduced to cubes approximately 2 inches per side with a resulting product that had the appearance of intact muscle. It was determined that the fat content of the restructured product had to be minimal not because of any effect on the binding ability of surimi, but rather because of the appearance of the final product and product acceptability. The presence of fat was unsightly, therefore subsequent tests were conducted with defatted meat pieces. Levels of surimi that could be used were from 1% to 5% with increasing binding at the higher surimi content. The surimi was activated with 5% salt (wt/wt with surimi).

Objective 2. To determine the conditions under which these products (from Obj 1) could made.

The technology for making restructured products from beef and surimi is fairly straightforward and should be easily transferred to industry. The beef pieces are placed in an efficient mixer and mixed 2 minutes without any additives. The surimi was activated with salt then added to the mixer along with 0.05% sodium tripolyphosphate and the mixture allowed to mix for an additional 4 minutes. The product was removed from the mixer and transferred into a vacuum stuffer and stuffed into bologna casings. After stuffing, the product is held in a 4C cooler for 24-36 hours to allow the surimi gell to set. The product can then be sliced and vacuum packaged and returned to the cooler for storage.

Objective 3. To determine the storage life of the restructured surimi/meat product.

There were essentially no effects on flavor, aroma or texture due to the incorporation of surimi. There was a very significant improvement in the binding of the meat particles due to the presence of surimi. Microbial plate counts of the surimi steaks were comparable to those of control steaks with the numbers increasing to 10 million by day 14 of refrigerated storage, which is normal for restructured steaks. In other experiments, surimi steaks have been held up to 21 days in refrigerated storage before off odors and flavors are detected. Studies are currently under way to determine the keeping qualities of these steaks under frozen conditions. Steaks are being stored in a freezer and will be served to a large sensory panel in the Atlanta area who will evaluate the steaks for acceptability. This study will be completed later this year.

SUMMARY:

Surimi an be used as an effective binder to make restructured beef steaks that can be marketed fresh or frozen. These steaks with surimi have very low salt and bind without heating. Surimi appears to be an exceptional binder protein with unique properties which should find wide application within the processed meat and poultry industry. The problem of USDA approval still needs to be resolved.

REFERENCES: All Previous Periodic Reports.

THE USE OF SURIMI AS A BINDING MECHANSIM IN RESTRUCTURED BEEF STEAKS

Interim Report Submitted to

THE ALASKAN FISHERIES DEVELOPMENT FOUNDATION, INC.

by

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September 8, 1988

The following report is a culmination of highlights and accomplishments of all previous and presently ongoing research. Additionally, concepts for future research and technology transfer for the present product are presented.

An initial investigation was launched to ascertain the efficacy and performance of surimi as a binding mechanism to hold pieces of beef together to produce a restructured meat product. In very early pilot studies, surimi levels as high as 15% of the total meat block were used to facilitate binding of the meat pieces. Furthermore, beef pieces used in these studies were as small as 1/2" ground pieces. These preliminary studies revealed a restructured meat loaf that was held together in a highly congealed state. Upon slicing of the product, the cutting texture was likened to that of hard rubber. This portion of the study revealed that not only did the surimi hold the beef together by a gelation mechanism, but that there existed a protein / protein interaction between the beef and surimi that further accommodated the binding effect. The exact biochemical reaction that takes place has not yet been investigated. From these results, it was determined that much less surimi could be used and that larger meat pieces could be successfully bound in the raw state.

Upon completion of this inaugural study, a second project was initiated to determine the tensile strength of restructured beef steaks using larger pieces of beef (2"x2"x4"). Moreover, the levels of surimi were greatly reduced. Various levels of surimi were used, they included 0.5, 1.0%, 1.5%, 2.0%, 3.0% along with a combination of 1.0% surimi and 1.5% sodium caseinate. Products from these treatments were evaluated for tensile and binding strength with the Universal Instron Testing Machine. Findings from this study showed that the larger beef chunks exhibited adequate binding strength at surimi levels of 1.0% through 3.0%; However, the 0.5% surimi level did not bind well due to an insufficient amount of the fish protein dispersed throughout the product to coat the surface of the meat. The surimi / sodium caseinate combination did not possess adequate binding due to competition for available water by the sodium caseinate. It was concluded that of surimi levels used successfully, the 1.0% level was the most desirable. In terms of binding ability and texture, this product was the closest to the intact muscle cut used for control purposes.

The final phase of the project involved the separation of whole muscle groups from USDA Choice chucks into four muscle groups according to tenderness. These muscles were then used to develop restructured beef steaks from each of the respective groups. These steaks are currently undergoing consumer sensory analysis in an attempt to corroborate our findings from the Instron test analysis.

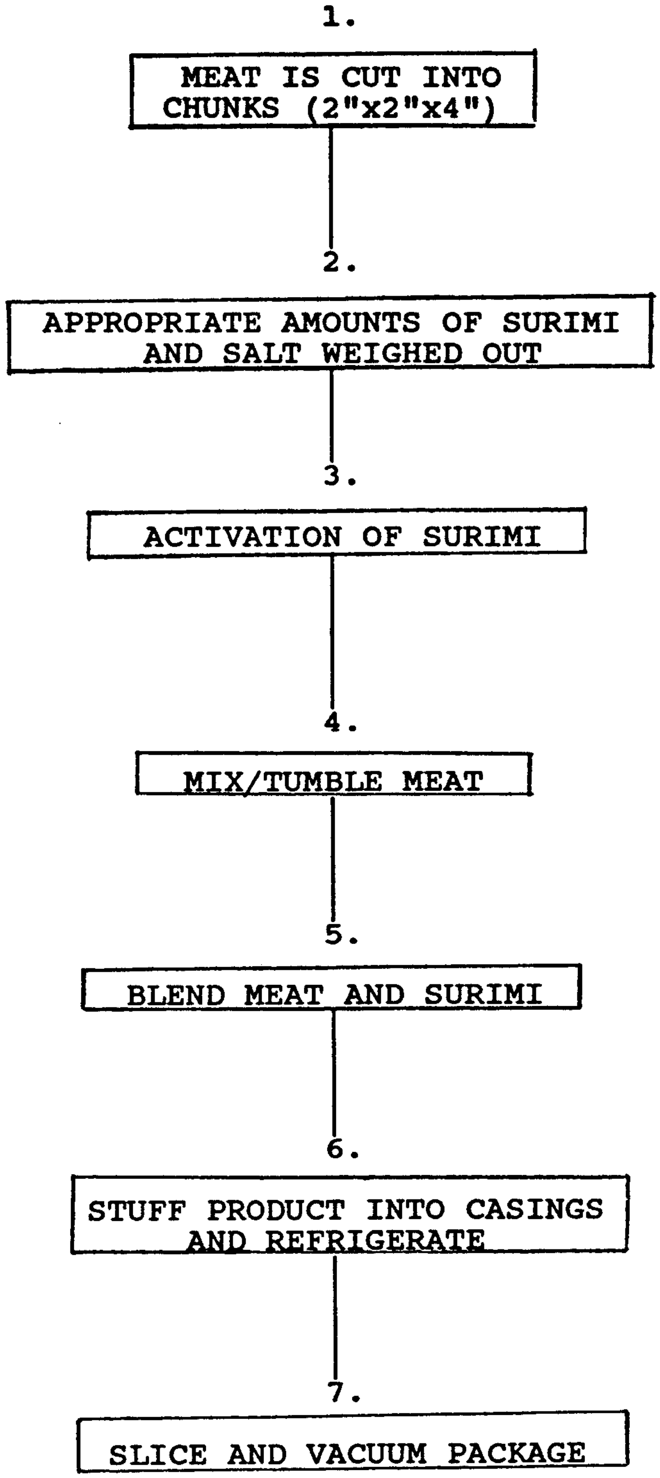
After completion of the restructured beef / surimi project, possibilities remain to conduct similar research in the area of pork and lamb. Likewise, marketing for such products has an almost limitless number of applications. The fast food market may prove to be a strategic marketing point for this type product. In unofficial testing here at the University of Georgia, the restructured beef steaks with surimi were taken out of refrigeration after 14 days. They were subsequently cooked and served as steak sandwiches to various people in the student and faculty population. They were very well received.

One immediate objective is to educate the pork producers and processors to the advantages of restructured, whole muscle products using surimi as a binder. A couple of different avenues exist to accomplish this task. One is to develop restructured pork "chop type" products utilizing undervalued cuts (picnic shoulder and Boston Butt) of the carcass to produce a value added product. Another possibility exists for producing a restructured, uncooked boneless ham product. Such a product could eventually be used to replace canned ham products. It would certainly have greater visibility and eye appeal as it could be marketed with other fresh pork products. Both the chop and the ham product could be produced in the cured and uncured state. Both products would be low in fat and salt.

TECHNOLOGY TRANSFER OF RESTRUCTURED BEEF STEAKS WITH SURIMI FROM RESEARCH TO COMMERCIAL PRODUCTION

In many cases, the transfer of technology from a research environment to that of a commercial or an industrial environment can prove to be quite difficult. Even if a particular manufacturer considers that a particular product may be profitable, what research has accomplished on a small scale may well impede "scale-up" of the product in a commercial operation. Moreover, it is not very likely that the processor will have the exact equipment, to use in production of the product, as that of the research facility. In cases such as this, studies must be initiated to assess what equipment may be used and what improvisations must be made to develop an end product comparable to that developed by research.

Regarding the wide variety of problems that could arise, the transfer of technology for restructured beef steaks with surimi as a binding mechanism should prove to be fairly easy. There is no requirement for any special equipment since most commercial meat processors are equipped with choppers, grinders, mixers and stuffers. The attached pages will reveal a flow diagram of the process as well as step wise directions.


1.
MEAT IS CUT INTO CHUNKS (2"x2"x4")
2.
APPROPRIATE AMOUNTS OF SURIMI AND SALT WEIGHED OUT
3.
ACTIVATION OF SURIMI
4.
MIX/TUMBLE MEAT
5.
BLEND MEAT AND SURIMI
6.
STUFF PRODUCT INTO CASINGS AND REFRIGERATE
7.
SLICE AND VACUUM PACKAGE

DIRECTIONS

Step 1. Beef will be cut into chunks of a pre-determined size (i.e. 2"x2"x4"). The beef chunks used should offer optimum surface area for binding, as well as maintaining the products' standard of identity (visible muscle fiber integrity, cold binding properties, ect.)

Step 2. Weigh out the appropriate amounts of surimi and NaCl to be used. 0.5% to 1.0% surimi per meat wet weight should be sufficient. Insure that the temperature of the surimi does not rise above 11^{o}C. The nearer the surimi temperature is to 0^{o}C, the better for processing. The salt should be in the amount of 5.0% per surimi wet weight.

Step 3. Activation of surimi may be accomplished in a standard silent chopper. Best results are obtained if the surimi is in a semi-frozen state. Begin chopping the surimi at medium speed while simultaneously adding the salt. After 30 seconds shift into high speed and continue to blend the salt in with the surimi for another 1.5 minutes. The resulting surimi/salt blend should have a consistency similar to that of creamed potatoes. Constantly monitor the temperature in this step as temperature abuse may occur very rapidly.

Step 4. Place meat chunks into the mixer. Mix/tumble the meat by itself for 2 minutes. This action will facilitate release of surface proteins on the meat, in addition to insuring the homogeneity of the meat block.

Step 5. After the initial 2 minute mix has been achieved, begin adding the surimi to the meat block while concurrently mixing/blending the surimi into the meat block for an additional 4 minutes. Again, insure the temperature of the blend does not rise above 11^{o}C.

Step 6. When the blending process is completed, place the blend into a stuffer (preferably a vacuum type). Stuff product into a fibrous casing, the size and type of which may be determined by the processor. When stuffing is completed, place product into cooler for an optimum 18 hr gelling time. Cooler temperature should remain between 2^{o}C and 4^{o}C.

Step 7. After 18 to 24 hr gelling time, remove the product from the cooler, slice into desired thickness, vacuum package and market the product under refrigeration.

June 27, 1988

PROGRESS REPORT

EFFICACY OF SURIMI AS BINDER IN STRUCTURED STEAKS

A series of experiments were conducted with the purpose of producing structured beef steaks using available meat plant machinery. Fresh vacuum packaged peeled beef knuckles were purchased from a local provisioner. On the day of the experiment the vacuum bags were opened and all the fat, connective tissue and muscle sheaths removed. The muscle portion was cut into the appropriate cubes and divided into 10 pound portions and placed in a mixer. An appropriate level of partially thawed surimi was activated by chopping in a food processor for two minutes with 0.5 % sodium chloride added to extract the salt soluble proteins. While the surimi was being activated the meat block was mixed for two minutes in the forward motion. During this time 5% sodium tripolyphosphate was added. Surimi was added by means of a syringe with the tip cut off. This created a bead that easily dispersed through the meat block. An additional four minutes mixing in reverse motion was done before taking the meat block out of the mixer. The product was stuffed with a vacuum stuffer into bologna casings immediately after mixing. All the stuffed samples were allowed to equilibrate for at least 36 hours and not more than 48 hours at $4^{0}C$ before slicing into 3/4 inch steaks. Immediately after slicing the steaks were vacuum packaged and held at 4°C until tested. In producing the structured steaks, meat particle size, level of surimi, and duration of storage were examined. Steaks were cooked at predetermined time intervals and presented to members of a taste panel, for aroma, flavor, texture and mouthfeel evaluation (see appendix, table A1). In the raw state, cohesion between meat particles with different levels of surimi were evaluated using an Instron machine. In addition to the objective and subjective parameters evaluated, microbial profiles across time were obtained.

A pilot experiment was designed to evaluate effect of 1" x 1" x 1" and 1" x 1" x 2" meat particle size at 0.5 % surimi. Subjective measurements, and microbial profiles were performed on days 0, 7, and 10. Analysis of variance indicated no differences across time, in aroma flavor and, in this case, the more critical mouthfeel and texture attributes ($P>0.05$). Since larger meat particles result in less surfaces to be bound, it would be advantageous to use the larger pieces of meat when structuring steaks. In all subsequent experiments, only 1" x 1" x 2" pieces were used.

In the second phase of the study, steaks made with varying levels of surimi and sampled at different times were evaluated. Surimi levels were 0.5%, 1%, 1.5%, 3% and a combination of 1% surimi and 1.5% sodium caseinate. Evaluation times were 0, 7, 14, and 20 days. Panelists detected no initial differences in cooked aroma, flavor, mouthfeel, and texture between 0.5% and 1% surimi. On the seventh day, panelists indicated a significantly ($P<0.05$) lower score for aroma and texture; flavor and mouth feel were not affected, However by day fourteen this trend had disappeared. Levels of surimi means by day are presented in Table 1. In one experiment, panelists were able to detect and downgrade in aroma, flavor, and mouthfeel, steaks that were structured with 1.5% surimi, when compared to 1 % surimi (table 2). Differences in aroma and flavor were also detected after a storage period of twenty days (table 4). Textural differences were not detected between these two surimi levels or during the storage period. Under the present circumstances, a storage time of twenty days yielded an objectionable product. The detection of off-flavors or aromas would result in a product with no market value.

A further experiment, designed to clarify the influence of surimi levels and surimi with sodium caseinate on aroma flavor, mouthfeel and texture, yielded no differences in aroma between 0, 1, and 3% surimi ($P>0.05$) on day zero; however, 0% surimi had a better aroma score when compared to 1% surimi and 1% sodium caseinate (P<0.05). Surimi in conjunction with sodium caseinate also had the lowest score for flavor thus indicating the ability of panel members to detect 1% sodium caseinate in structured steaks. Texture scores yielded clear evidence that structured steaks with no surimi had the lowest binding and the highest standard deviation of any of the treatment combinations, followed by 1% surimi with 1% sodium caseinate. Steaks with 1 and 3 % surimi levels were significantly better than ones with 0% surimi (P<0.05) but not 1% surimi with 1% sodium caseinate (P>0.05). Table 4 illustrates the effect of various surimi levels at day 0.

The pliable nature of meat and the relative weak binding caused by surimi, are major contributing agents to the difficult task of objectively measuring cohesion in surimi treated meat. Since surimi acts as a binding agent between meat surfaces, these need to be nearly equal in size, parallel, and touching each other to accurately measure cohesion. Abnormal boundary geometries, such as longitudinal or oblique junctures would serve to introduce variation in the measurements. In an attempt to control artificial differences between treatments, the various levels of surimi treated meat were stuffed into one inch cellulose casings. Each casing was stuffed with two pieces of meat taken from each surimi level batch of ten pounds. The two pieces of meat formed a visible boundary near the center. Holes were punched in the casing to ensure evacuation of any air between the pieces of meat, and pressure was applied and the ends tied to ensure proper contact. After refrigeration for 60 hours, each casing was mounted on a specially made holder, attached to the instron machine and the cellulose casing removed. Tension was applied to the two pieces of meat until rupture occurred, using a load of one pound. Measurements were based as the percent of one pound at which rupture occurred. Meat stuffed without any surimi had the lowest breaking force of any of the treatments, followed by 1% surimi with 1% sodium caseinate. These two treatments were inferior to 1 and 3% surimi treated meat ($P<0.05$). The addition of 3% over 1% surimi did not improve the cohesion between meat pieces ($P>0.05$). Since detection of abnormal aroma and, flavors can be linked to higher levels of surimi, 1% appears to be the best level of surimi to add. Cohesion differences due to level of surimi are shown in Table 5 and figure 1.

Surimi structured steaks have the unique potential to be marketed in the fresh state. In this study all samples were stored at $4^{0}C$ until tested. Peeled beef knuckles under vacuum, were purchased from a local provisioner. Initial microbial loads and subsequent microbial changes during storage were examined on the day the experiment and at each taste panel session. Microbial loads increased from the initial baseline on days seven and fourteen. The microbial loads however remained with in safe levels as measured by aerobic plate counts (figure 2),. and the acceptance by the panel members. When microbial loads were examined according to level of surimi across time, an unexpected small increase in colony forming units was seen at the lower level. Although no statistical analyses were performed on microbial numbers the difference between 0.05 and 1% surimi appears to be within normal variance levels (figure 3).

TABLE 1. DAY MEANS FOR STRUCTURED STEAKS EVALUATED BY SUBJECTIVE MEASUREMENTS.

Day	N	Aroma	Flavor	Mouthfeel	Texture
0	38	5.7 a	5.5a	5.2a	5.7 a
7	38	3.6 b	4.7a	6.4a	4.3 b
14	9	4.5 a b	6.3a	6.7a	5.3 ab

a,b Means within the same column bearing unlike letters are significantly different ($P<0.05$).

TABLE 2. SURIMI LEVEL MEANS FOR STRUCTURED STEAKS EVALUATED BY SUBJECTIVE MEANS.

Surimi*	N	Aroma	Flavor	Mouthfeel	Texture
1	25	4.2 [a]	4.4[a]	4.5[a]	5.5[a]
1.5	11	6.2 [b]	6.5[b]	6.5[b]	5.3[a]

* Surimi levels in percentages.
a,b Means within the same column bearing unlike letters are significantly different ($P<0.05$).

APPENDIX

SENSORY EVALUATION FORM

Name:______________________________ Date:____________

Please draw a vertical line through each horizontal line scale to indicate the response to the quality listed.

1. AROMA

Fresh grilled aroma no off odor.	Very strong off odor.

2. FLAVOR

Fresh grilled flavor. no off taste.	Very strong off taste

3. MOUTHFEEL

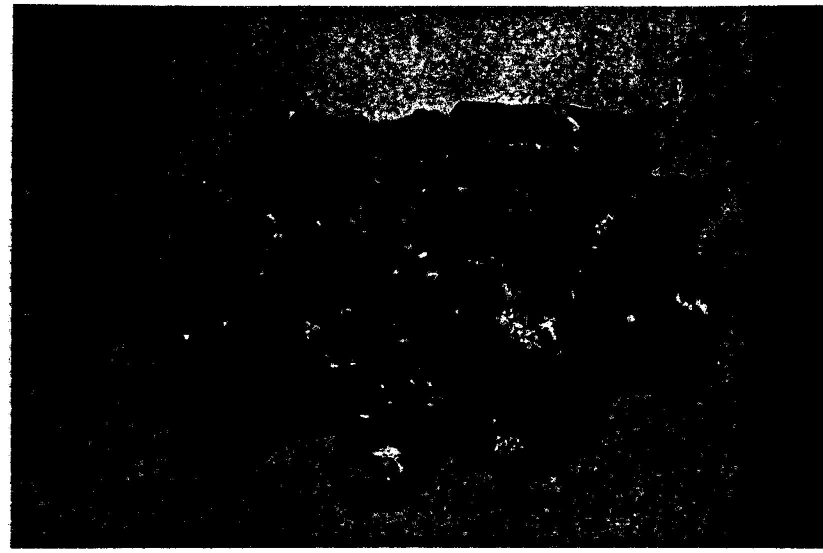
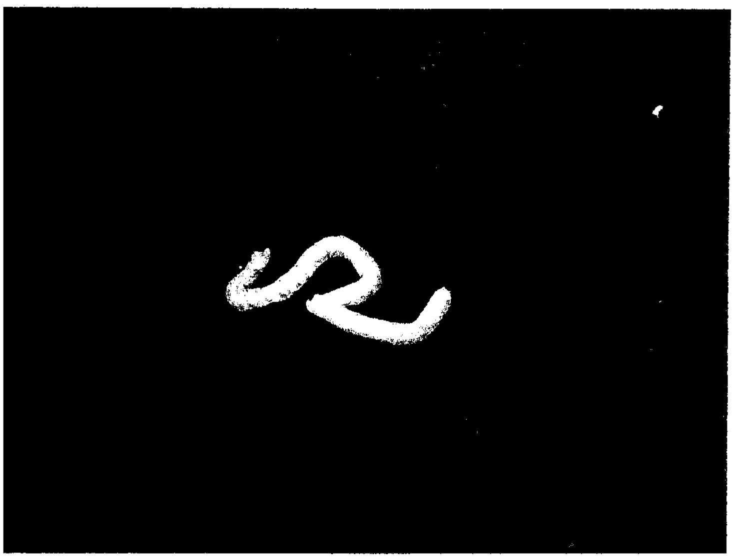
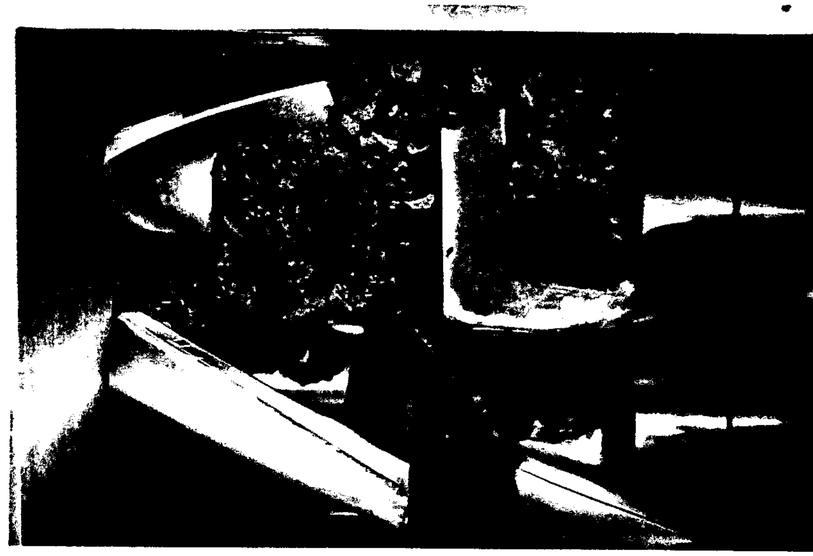
Extremely Tender	Extremely Tough

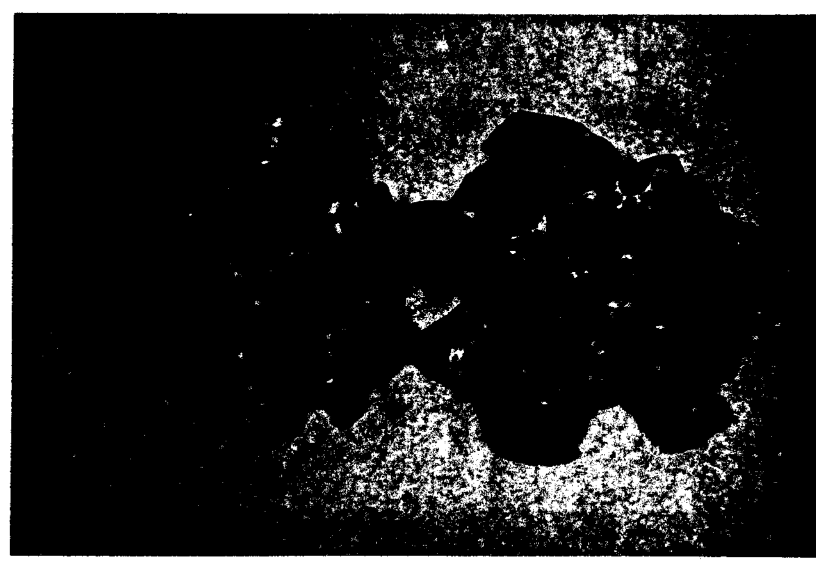
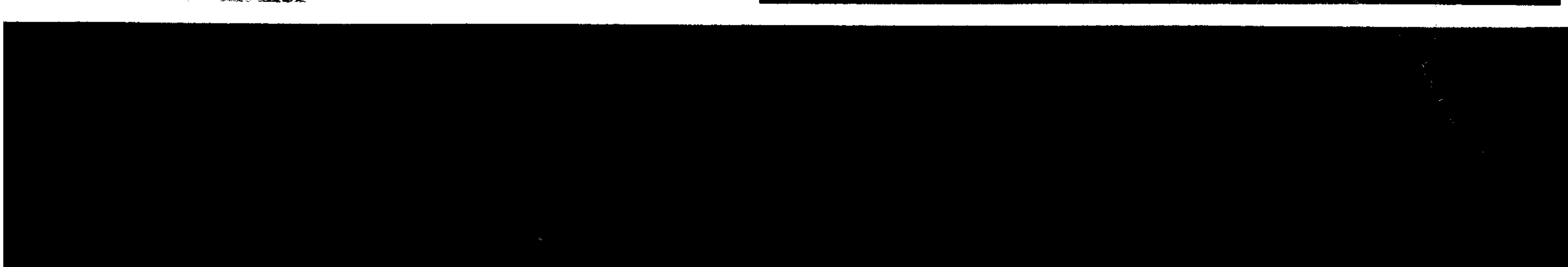
4. PERCEIVED TEXTURE

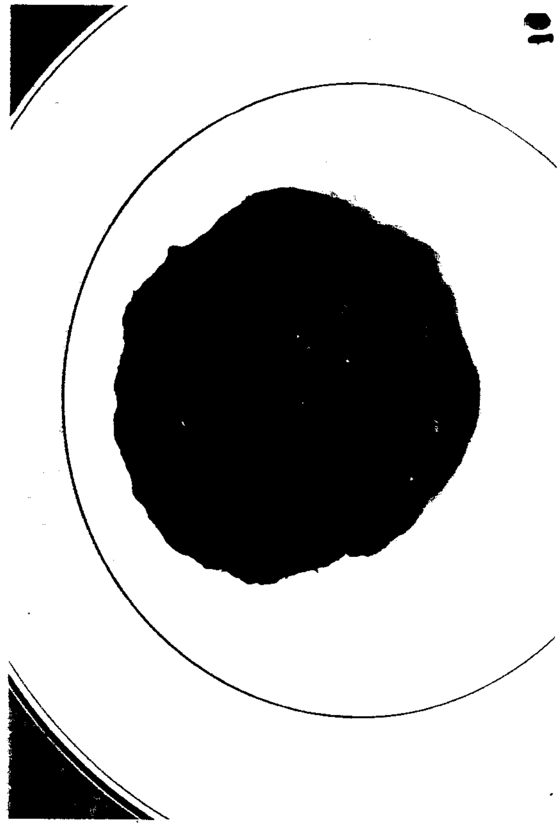
Very strong Bind.	Very little Bind.

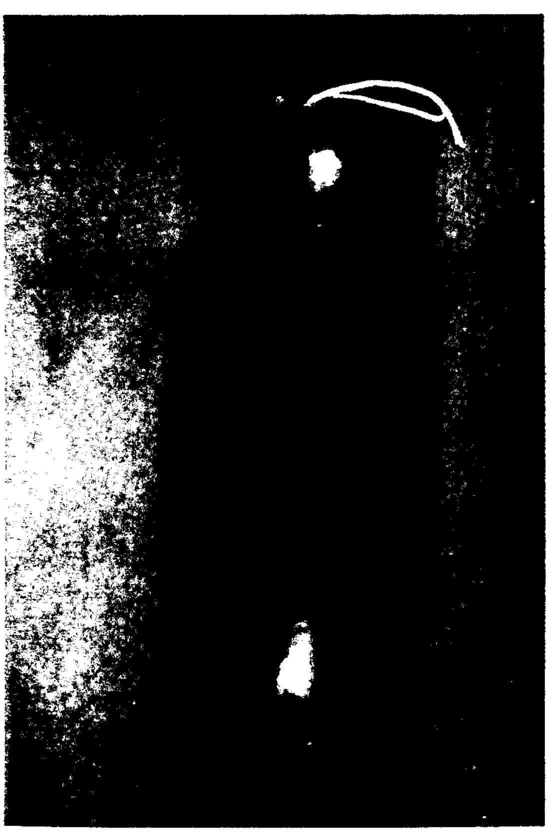
DESCRIPTION OF PRINTS

Print	
1 & 2	Pealed beef knuckle chunks measuring 1"x1"x2" were used.
3	Main ingredients (surimi & beef) used in structured steaks.
4	The meat chunks are mixed for two minutes in forward and four minutes in reverse.
5	After the first two minutes, surimi is added.
6	On the left is beef that has been mixed with surimi, on the right are intact chunks of beef.
7	Inmediately after mixing, stuffing is done in bologna type casings.
8	After 36 hours, slices 3/4" thick are cut and vacuum packaged.
9	A steak portion that has been removed from the bag.
10	The steaks are broiled for 11 minutes on one side, and 9 minutes on the other side.





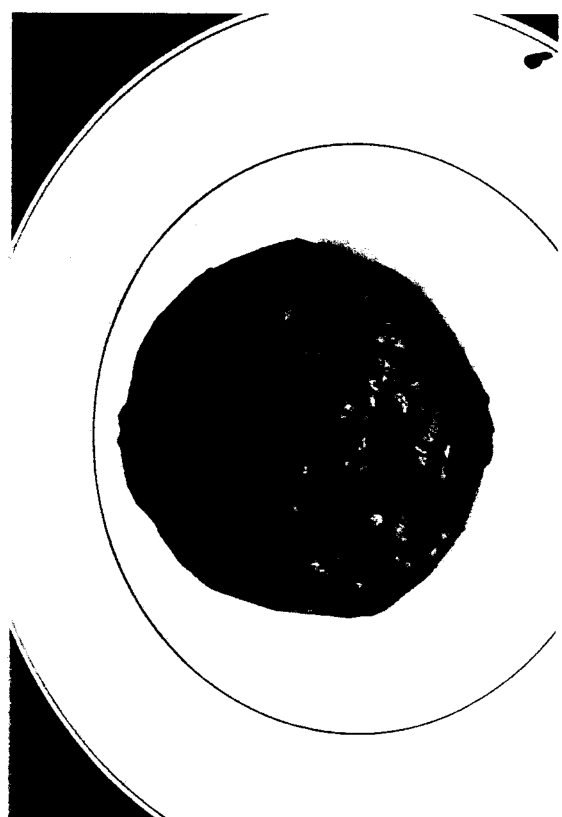


TABLE 3. DAY MEANS FOR STRUCTURED STEAKS EVALUATED BY SUBJECTIVE MEANS.

Day	N	Aroma	Flavor	Mouthfeel	Texture
0	23	4.6 [a]	4.8[a]	5.4[a]	5.5[a]
20	13	7.4 [b]	7.7[b]	6.8[a]	5.3[a]

[a,b] Means within the same column bearing unlike letters are significantly different ($P<0.05$).

TABLE 4. SURIMI LEVEL MEANS FOR STRUCTURED STEAKS EVALUATED BY SUBJECTIVE MEANS.

Surimi*	N	Aroma	Flavor	Mouthfeel	Texture
0	14	4.2[a]	4.4[ab]	5.7[a]	7.7[a]
1	11	5.4[a]	5.3[ab]	7.0[a]	5.9[cd]
3	11	4.7[a]	4.0[a]	5.4[a]	6.6[bd]
1%+1%[y]	16	5.8[b]	5.8[b]	7.1[a]	6.8[a]

* Surimi levels in %.
y 1% surimi with 1% sodium caseinate added.
a,b,c,d Means in same column bearing unlike letters are significantly different ($P<0.05$).

TABLE 5. INSTRON COHESION MEANS ACCORDING TO DIFFERENT LEVELS OF SURIMI.

Surimi*	N	Cohesion**
0	17	31.0[a]
1	17	37.8[a b]
3	17	40.4[b]
1%+1%[y]	15	22.0[c]

* Surimi levels in %.
** Cohesion expressed as percent of one pound.
y 1% surimi with 1% sodium caseinate added.
a,b,c Means in same column bearing unlike letters are significantly different ($P<0.05$).

FIGURE 1. INSTRON COHESION VALUES EXPRESSED AS PERCENT OF A POUND.

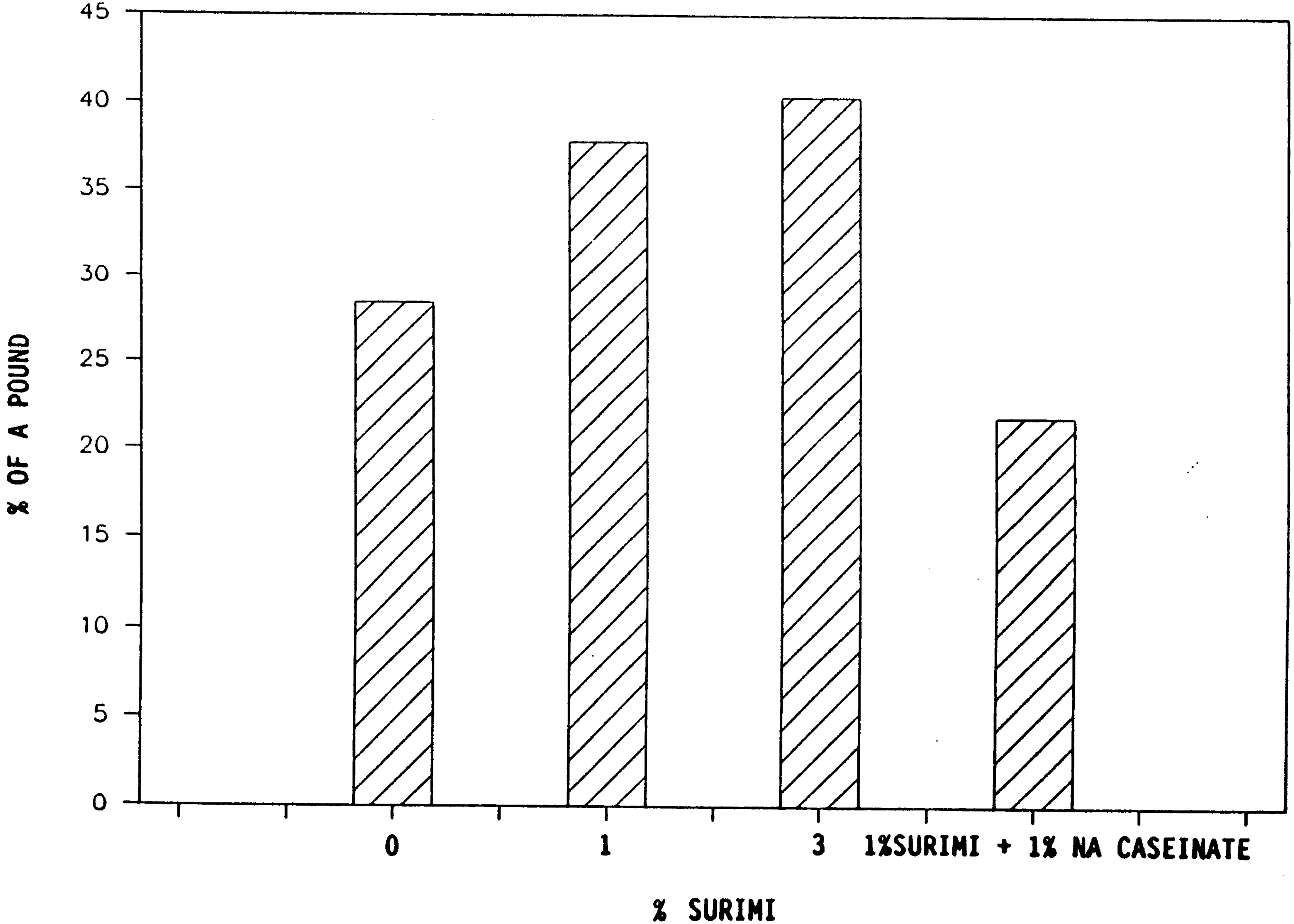


FIGURE 2. MEANS OF COLONY FORMING UNITS ACCORDING TO DAY OF STORAGE.

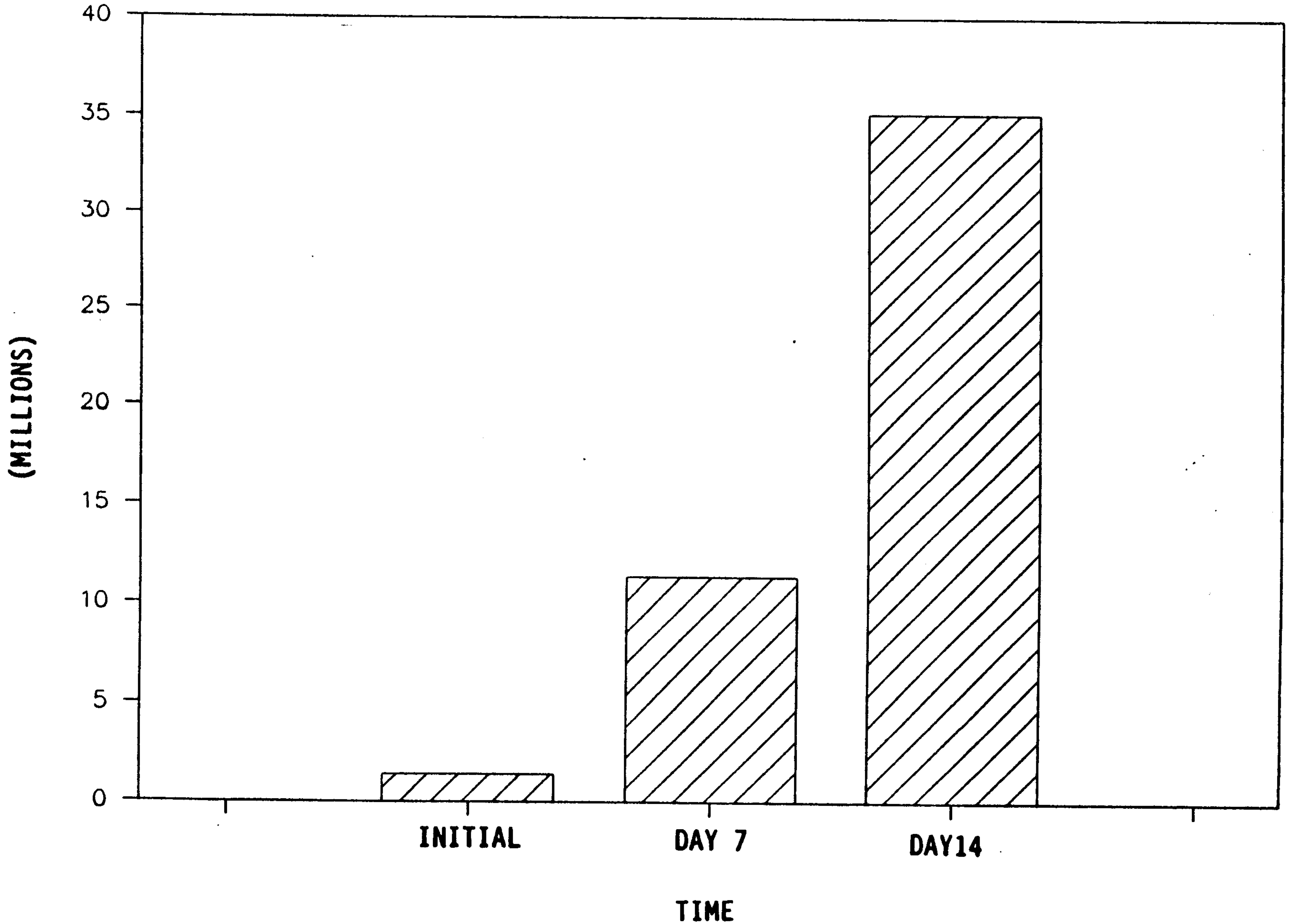


FIGURE 3. MEANS OF COLONY FORMING UNITS EXPRESSED ACCORDING TO LEVEL OF SURIMI, ACROSS TIME.