CULTURE OF FRESHWATER PRAWNS (MACROBRACHIUM ROSENBERGII) USING GEOTHERMAL WASTE WATER

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ABSTRACT

The farming of freshwater prawns (*Macrobrachium rosenbergii)* in geothermal-heated water has been demonstrated to be feasible in a non-tropical climate. The husbandry of prawns is being done in two outdoor raceway ponds, 9.1 m by 2.5 m and 29 m by 3.5 m that are 1.2 m deep. The ponds are not shielded from the ambient climate which during the winter months has recorded air temperatures as low as -20°C. A selected brood stock is held in a small spawning building where larvae are hatched in artificial saltwater and reared to the post-larvae stage which makes the facility self-supporting. This project is providing a model for potential investors to utilize the low-temperature geothermal resources in the western United States for warm water aquaculture.

Zooplankton, macroscopic crusteans, from a local euthrophic lake are being fed to the post-larvae and adult prawns in addition to prepared commercial dry pelleted foods to keep operational costs at a minimum.

Initial measurements of growth and weight gains indicate the production of two crops of prawns per year at seven to the pond is possible. No work on intensive culture has been done. Plans to enlarge the facility and do work on developing intensive culture are being considered.

INTRODUCTION

The use of low-temperature geothermal water, 80 to 100°C is being used for residential and commercial space heating and agribusiness in communities such as Klamath Falls, Oregon and Boise, Idaho, as well as other small communities in the northwest United States. Oregon Institute of Technology at Klamath Falls, a state-operated college, is using geothermal energy to heat over 18,400 m^2 of classrooms and laboratories as well as heat the potable water supply with water being pumped from three wells. The water is received from the wellhead at 95°C and is circulated directly into the college heating system and discharged at an average of 52°C. This wasted geothermal water was bioassayed and found to be a satisfactory life-support system for warm-water fin fish and crustacea in December 1975.

A report by the Committee on Aquaculture Board of Agriculture and Renewable Resources Commission on Natural Resources, National Academy of Sciences (1978) reports that isolated water resources such as geothermal in Idaho and Colorado permit culture of warm-water species of fish in zones traditionally growing only cold water fish.

The climate at Klamath Falls is not conducive for warm-water aquaculture; however, with geothermal energy, it is possible to culture warm-water species in open raceway ponds. The area usually has less than 100 frost-free days during the summer and a mean January temperature of -8°C. The annual precipitation is 30 cm of which most is in the form of snow. This type of climate is typical of much of the Great Basin of the United States east of the Cascade Mountains; where, there are numerous geothermal warm-water supplies suitable for the culture of tropical and semi-tropical species of fish.

The giant Maleysian prawn, *Macrobrachium rosenbergii*, was selected to culture at Oregon Institute of Technology because of its commercial value, excellent ability to grow in geothermal discharge water and the limited amount of available water to use for aquaculture, 180 L/min in summer months to 1,600 L/min in winter months.

This project was supported by Oregon State University Sea Grant Program for the feasibility stage of the project. Holding tanks, plumbing for the tanks, and post-larvae prawns were provided. The Pacific Northwest Regional Commission provided two grants, $17,568 and $45,848, for the construction of ponds and hatchery facilities, and the operation and maintenance of the project from July 1, 1976 to March 30, 1978. The Ore-Ida Potato Co. subsidiary of H. J. Heinz provided operation and maintenance money for the project from April 1978 to October 1978 to make it possible to complete a full-life cycle for prawn culture.

MATERIAL AND METHODS

Ten test tanks, 1.20 m by 1.20 m and 80 cm deep, plumbed with geothermal water, potable cold water and separate drains, were used for a pilot study to determine the feasibility of using the college geothermal resource for aquaculture. Within four months, the work was concluded, which indicated that the water quality was adequate to provide a life-support system for prawns (Table 1).

Table 1. Water Analysis of Oregon Institute of Technology Geothermal Well Water at Wellhead

Temperature 95°C	
pH	8.2
H_2S	Trace
HCO_3	44.0
SO_4	384.0
SiO_2	72.5
Na	331.0
K	3.5
Ca	25.1
Mg	1.0
TDS	816

An outdoor demonstration raceway pond was built in July 1976. The pond was 9.1 m long, 2.5 m wide and 1.2 m deep with a drop board structure at the outlet to control the water level from zero to full using 15 cm wide boards. The pond was plumbed with 1.8 cm diameter black steel pipe for its water supply. The water is pumped with a 1-hp centrifugal pump from the geothermal effluent to the pond side a distance of 40 m then forced through a 0.25 m^2 rapid sand swimming pool filter, then is controlled by a thermostat motorized valve which is set to provide water to the pond if the temperature is lower than 27°C. This water is usually 50°C when received. A diffuser pipe was laid on the bottom of the pond, its full length, drilled with 8 mm holes spaced approximately every 30 cm to provide even distribution of the inflow water. An analysis of this water was made to see if any heavy metal pollution was present since it had passed through more than 1000 m of copper tubing, (Table 2) before it was used.

Table 2. Heavy Metal Analysis of Water Supplies*

	Cadmium PPb	Copper PPb	Zinc PPb
Geothermal effluent demonstration raceway pond	11.0	20.3	66.0
Geothermal effluent to raceway pond	1.1	11.1	20.0

* Analysis made by EPA Western Fish Toxicology Laboratory, Corvallis, OR

A large raceway pond, 29 m long, 3.5 m wide and 1.3 m deep with a similar water supply system in addition to a redundant supply of water from the waste geothermal effluent of the neighboring hospital and a supply of primary geothermal heating was built in August 1977. The thermostatic controls are identical to those used on the demonstration pond. However, the supply pipes are 3.8 cm diameter black steel. Figure 1 provides a schematic sketch of the plumbing for the aquaculture facility.

A brood stock, hatchery building about 4 m by 5.2 m was also built to hold selected brood stock tanks and aqura for the rearing of larvae prawns to post-larvae stage. The building provides space for storing a limited supply of food and space for recording data. The brood stock holding tank was designed to be a self-contained tank and filter system. It is constructed out of high density 2.0 cm plywood. The system consists of a sand filter with two parallel tanks 27 cm wide, 30 cm deep and 240 cm long that can be divided into eight separate compartments, 27 cm by 29 cm using clear plastic perforated dividers. The two tanks are 1 m above the sand filter. The sand filter is 210 cm long and 60 cm wide with a water collection well on its end 60 cm by 60 cm and 60 cm deep. The overall dimensions of the tanks and filter is 2 m high, 240 cm long and 60 cm wide. The water is pumped by a 1.2-cm discharge submersible electric pump to the tanks through a teflon hose. The water then flows through the tanks and returns to the filter through a 2.5 cm plastic pipe which completes the circulation.

A salt water aquarium, 1.20 m by 1.20 m, 80 cm deep in the building with an attached 200 L sand and activated charcoal filter is used to rear the larvae to the post-larvae stage.

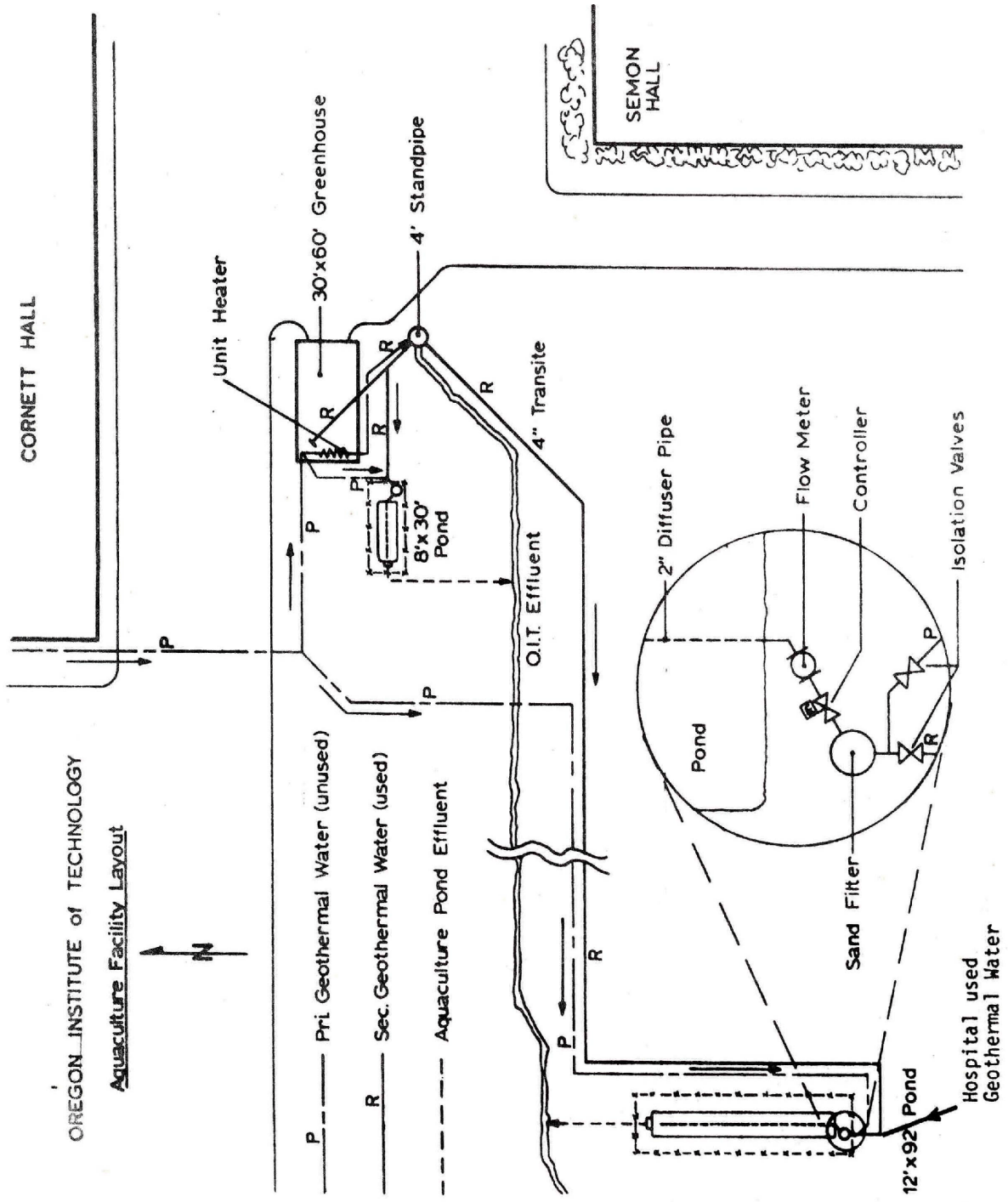

Figure 1.

A shipment of 2000 post-larvae prawns was received from Syntex Corp. at Palo Alto, California in April 1976. They were evenly divided into four tanks holding approximately 620 L of water. The temperature was set at 27°C by mixing cold potable water with 95°C geothermal water. The water

was adjusted to flow through at 0.7 L a minute. The prawns mean length when received was 11.4 mm from the tip of the rostrum to tip of the telson. They were fed commercial turkey starter, 27 percent crude protein and small amounts of frozen zooplankton (80 percent Daphnia, 20 percent Copepods). The amount of food fed to each tank was about 20 to 30 grams twice a day. All uneaten food was siphoned from the tanks daily. The room was kept dark, lights were used when the prawns were fed. The dissolved oxygen content of the water varied between 6.0 to 6.5 mg/L during the experiment. Growth was determined by measuring sub-samples of the prawns, no data was collected on molting frequency. A shipment of 2000 post-larvae prawns were also obtained from the Weyerhaeuser Co. in Homestead, Florida in May of 1977 and from the Hawaii Department of Fish and Game in September of 1977. These shipments were all cultured the same way by placing them in holding tanks and when a lot reached an average size of 7 cm to 9 cm, they were stocked in the outdoor ponds to study survival and growth.

The demonstration pond was stocked on November 22, 1976, with 300 juvenile prawns with a mean length of 8.7 cm at a density of about 12 per m^2. This pond was drained on February 8, 1977, and 117 prawns were recovered of these, 11 ripe females were obtained. The remaining prawns were returned to the pond after measurements of length and weight were obtained from a sub-sample. The pond was then drained on August 12, 1977. The gravid females collected on February 8, 1977, were placed in artificial seawater 10 to 12 ppt larvae hatched, but died before metamorphizing to post-larvae. Techniques for culturing larvae described by Fujimura (1970) were used.

The large pond was stocked on October 6, 1977, with about 1200 juvenile prawns at an average length of 4.2 cm at a density of 10 m^2. The pond was fed daily about 1 to 1-1/2 kg Ralston Purina Marine Chow 25. Frozen zooplankton was also fed about 1 to 2 kg three times a week. The frozen food would float and as it melted would "shower" the benthic area with tiny bits of food.

The college geothermal well pump failed on February 19, 1978, during the Washington Birthday weekend and the valve stem for the motorized valve broke. Consequently, the pond temperature dropped to 16^{o}C and a large prawn kill occurred. The pond was drained and only 23 were found alive and they ranged in size from 10 cm to 17 cm. Four were gravid females and were transferred to the brood tanks for observation and when their eggs turned brown were placed in artificial seawater, 12 ppt. The eggs from these females hatched and grew to post-larvae. They were fed exclusively, *Artemia*, nauplii. An estimated seven to eight thousand were cultured to the post-larvae stage and have provided prawns for restocking the outdoor ponds.

RESULTS

The first group of prawns received (2000) were on April 28, 1976, they were observed carefully, and random samples were taken on May 20, 1976 and July 2, 1976 (Table 3). Small samples were taken because of fragility of the organism to measuring and weighing. There appeared to be both cannibalism and natural mortality in the stock because by November, there were less than 400 juveniles left in the grow-out tanks. These prawns were used for the initial stocking of the demonstration pond.

Table 3. Prawn (*Macrobrachium Rosenbergii)* Growth Measurements

Received April 28, 1976
Mean Length - 11.4 mm

May 20, 1976 - Random Sample of 14

Length*	No.
12 mm	1
14 mm	2
15 mm	1
16 mm	1
17 mm	3
18 mm	2
19 mm	1
20 mm	1
22 mm	2
Total	14

Mean Length - 17.21 mm

July 2, 1976 - Random Sample of 11

Length*	No.
20 mm	2
25 mm	3
27 mm	1
30 mm	2
35 mm	3
Total	11

Mean Length - 28.0 mm

* Measurements made from rostrum to tip of telson.

The demonstration pond was drained on August 12, 1977, and only 37 adults were found. Twenty-five of these prawns were weighed and measured (Table 4). These prawns were sexed as well as measured and the dramatic difference in size of the males and females were noted as reported in the literature, Hanson (1977).

The large pond stocked October 6, 1977, was observed to have two to three dead prawns along its edge each day starting on November 1977. Gross pathological inspection of the dead prawns and microscopic examination indicated no disease symptoms and the cause was suspected to be environmental. However, patches of water mold, *Saprolegria*, was observed at the inlet and mid-section of the pond. A flush of malachite green was run through the pond at a rate of 1:200,000 concentration for 30 minutes which controlled the mold.

A scuba reconnaissance of the pond was made on December 20, 1977. The student diver made two visual counts, 626 and 600 prawns were observed. The student had difficulty in counting the prawns

due to the algae in the water and the way the prawns camouflaged themselves. If the count was correct, almost half the prawns stocked were lost.

Table 4. Prawn (Macrobrachium Rosenbergii) Growth Measurements

August 12, 1977

	Males	
No.	Weight	Length
1	125.6 g	20 cm
2	116.0 g	22 cm
3	121.0 g	22 cm
4	105.0 g	20 cm
5	105.0 g	19 cm
6	114.0 g	20 cm
7	118.0 g	20 cm
8	115.0 g	20 cm
9	108.0 g	20 cm
10	141.0 g	21 cm
11	106.0 g	20 cm
12	135.0 g	22 cm
13	118.0 g	21 cm
Mean -	117.5 g	20.5 cm

	Females	
No.	Weight	Length
14	44.0 g	16 cm-(gravid)
15	72.0 g	18 cm
16	50.0 g	16 cm
17	65.0 g	18 cm
18	39.0 g	16 cm
19	47.0 g	15 cm
20	76.0 g	19 cm
21	65.0 g	18 cm-(gravid)
22	74.0 g	14 cm
23	47.0 g	17 cm-(gravid)
24	48.0 g	17 cm-(gravid)
25	58.0 g	18 cm
Mean -	57.1 g	16.8 cm

Measurement made from rostrum to tip of telson.

The problem of losing the heated water supply on February 19, 1978, also affected what can be accomplished in prawn culture using geothermal water in a cold climate.

The gravid female eggs hatched in March 1978 and cultured to the post-larvae stage, removed from a saltwater environment to freshwater on May 20, 1978, have provided juvenile prawns for stocking both the demonstration pond and large pond in the fall of 1978.

DISCUSSION

Climatological data including ambient air temperature, and wind velocity was obtained with a 24-hr recording equipment which provided some basic data needs to determine how much geothermal-heated water will be needed to maintain an outdoor pond temperature at 27°C. A flow recorder was installed to determine how much water was used, but did not work properly. Flow data as well as climatological data is needed to develop design criteria for developing a facility to commercially culture Maleysian prawns.

A sample of 12 adult prawns was shipped to the Ore-Ida Food Company in Boise, Idaho, in August 1978 for organoleptic tests (Appendix 1). From this test, it appears that no inimical tastes results from culturing this prawn in geothermal water.

We are fortunate to be near a large euthrophic lake, Upper Klamath Lake, 70 km long and average 10 km wide with a mean depth of 2.5 m; as, there is a great abundance of zooplankton in it which is easy to net during the winter months when it is not plagued with bluegreen algae.

RECOMMENDATIONS

1. The project should be continued for at least two years, so that two to three crops of prawns can be grown to demonstrate the feasibility of such a project.

2. More data must be collected on the heat needs of the open raceway ponds–that is essential for the planning and design of commercial prawn ventures.

3. Redundant systems must be provided for all facilities to prevent prawn losses during the cold weather periods.

LITERATURE CITED

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APPENDIX I

August 24, 1978

TO: B. N. Wankier

FROM: L. E. Tiffany

SUBJECT: Ore-Ida Evaluation of Macrobrachium Shrimp

Oregon Technical Institute shipped us 6 Macrobrachium shrimp of each type, chill killed frozen and 10 minute boil killed frozen for our evaluation.

Our objective was to profile rate Macrobrachium shrimp, compare it to commercially available shrimp and determine which type of the shrimp - chill killed or boil killed was preferred.

Procedure: Background information and the profile ballot for the test were obtained from Lois McGill at Oregon State University. The shrimp's odor, texture, juiciness, flavor and overall desirability were profiled using a 9-point desirability scale. A score of 1 being the lowest, and a score of 9 being the highest score possible. Twelve people were selected for the panel. These people were used for the entire testing. A training session was conducted where the panelists evaluated commercial raw frozen cooked shrimp; cooked frozen thawed shrimp and raw frozen cooked lobster. After evaluating each product, a group discussion was held to help panelists understand the good and bad attributes of each product. The raw fish products were steam cooked, and cooled to room temperature before serving. The cooked frozen shrimp were thawed and tempered to room temperature before serving.

With only six Macrobrachium shrimp per sample, we were forced to use only one Macrobrachium shrimp for each test. The commercial shrimp (20 - 24 count per pound) used for the test was purchased fresh each day from the market.

A total of four tests were conducted:

Test Number:

4. Commercial raw shrimp versus Macrobrachium raw were monodically profiled.
5. Commercial cooked shrimp versus Macrobrachium boiled were monodically profiled.
6. Macrobrachium raw and Macrobrachium boiled were profiled together and then a preference judgment was made.
7. Macrobrachium raw, marcobrachium boiled, and commercial raw shrimp were profiled together and then a preference judgment was made.

The test results were evaluated with a significance factor at the 95% confidence level.

Test Results:

Test 1

12 Respondents	Odor	Texture	Juiciness	Flavor	Overall Desirability
Commercial Raw	5.17	7.17	7.17*	6.08	6.25
Macrobrachium Raw	4.92	6.42	5.50	5.83	5.66
Significance Factor	±1.3446	±0.9796	±1.0683	±1.1403	±1.1315

This test indicated no significant difference in ratings given the commercial shrimp and Macrobrachium for odor, texture, flavor and overall desirability.

The commercial shrimp was rated significantly more desirable for juiciness than the Macrobrachium.

We noted that the commercial shrimp used for this test were extremely fresh with no iodine taste.

Comments made about the Macrobrachium:

1. Very mild flavor - more of a rich, slightly sweet after taste, the flavor seems closer to the shrimp family than lobster.
2. The texture is dry and more lobster like.

Test 2

12 Respondents	Odor	Texture	Juiciness	Flavor	Overall Desirability
Commercial Cooked	3.00	4.25	4.00	2.75	2.67
Macrobrachium Boiled	5.00*	5.58*	4.92	6.08*	5.66*
Significance Factor	±1.1806	±1.2092	±1.0150	±0.9514	±0.7914

This test indicated the Macrobrachium was rated significantly higher than the commercial cooked shrimp, in the areas of odor, texture, flavor and overall desirability. The juiciness of both products was rated down–the Macrobrachium because it was dry and the commercial cooked shrimp because it was watery.

* Denotes a significant difference

Test 3

12 Respondents	Odor	Texture	Juiciness	Flavor	Overall Desirability	Preference
Macrobrachium Raw	6.58*	6.25	5.92	6.75	6.75	45%
Macrobrachium Boiled	4.33	7.00	6.83	7.00	6.83	25%
Significance Factor	±1.0286	±0.7833	±0.9360	±0.8919	±0.8919	

The test results showed that the Macrobrachium raw was rated significantly higher for odor than the Macrobrachium boiled. For texture, juiciness, flavor and overall desirability, the ratings showed no significant difference in the two products. The comments indicated that the panelists preferred boil killed shrimp because of better flavor and texture.

Test 4

10 Respondents	Odor	Texture	Juiciness	Flavor	Overall Desirability	Preference
Macrobrachium Raw	7.50	7.30	6.50	7.20	7.20	40%
Macrobrachium Boiled	6.90	8.20*	7.70*	7.80	7.70	40%
Commercial Raw	5.20*	6.70 *	7.00	5.90*	5.90*	20%
Significance Factor	±0.7453	±0.6000	±0.8028	±0.6555	±0.6532	100%

The results show that the Macrobrachium cooked had significantly better texture and juiciness than Macrobrachium raw. In this evaluation, the commercial raw shrimp was rated significantly lower than both types of Macrobrachium for odor, texture, flavor and overall desirability. The Macrobrachium raw was the drier shrimp evaluated.

The commercial shrimp used for this test had a slight iodine aroma and flavor (apparently not as fresh as previous samples).

Conclusions:

Overall, the results of this testing indicated the Macrobrachium shrimp have a different flavor profile than commercially available shrimp. The flavor of the Macrobrachium shrimp is richer than commercial shrimp and very mild, present mainly in the after taste. There was no significant flavor differences in the chill killed and boil killed Macrobrachium based on these testing procedures. The only difference noted is that Macrobrachium boil killed has a juicier, more tender texture. The aroma of the chill killed Macrobrachium is fresh; whereas, the boil killed has a slightly old rancid aroma. However, the boiled is directionally preferred on reconstituted texture and flavor.

* Denotes a significant difference

LET:ck – 8/24/78