BULK HANDLING OF ALASKA HERRING MEAL

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ABSTRACT

Herring meal can be stored in bulk without subsequent spontaneous heating by allowing it to go through its initial heating under controlled conditions prior to bulk storage, the findings in this report indicate. The technology of bulk handling of herring meal was investigated by plant observations, plant tests, and laboratory experiments. The spontaneous heating of stored herring meal is a major problem in bulk handling. Plant tests indicated 0.01 percent of an oil antioxidant added to the dried scrap reduced the maximum temperature observed in bulk-stored meal but did not eliminate heating. Laboratory experiments indicated that herring oil which had once spontaneously heated then cooled did not again spontaneously heat in the period studied.

BACKGROUND

Herring meal is produced in reduction plants on Kodiak Island, in the Prince William Sound area, and in the Chatham Strait area of southeastern Alaska. These producing areas are 700 to 1,400 miles from Seattle, the port of entry to the United States for most of the herring meal from Alaska. At the present time, herring meal is sacked in burlap bags holding 100 to 120 pounds of meal and shipped on barges holding approximately 440 tons of meal (fig. 1). A large portion of the herring-meal production is purchased by poultry-feed formulators who buy herring meal by the carload lot and who have facilities for bulk handling grain and other ingredients used in the mixed feed.

Fig. 1 - A tug taking loaded barges of herring meal and oil from a herring reduction plant in Alaska.

Bulk handling the herring meal in place of sacking would offer savings to the manufacturer by eliminating the cost of sacks and the labor of sacking, and by reducing labor costs through simplification of warehousing and loading. But such savings would be offset by the capital expense of new equipment necessary for bulk handling. Cost of handling at the port of entry would also be reduced because the costs of unloading, when using modern bulk-handling equipment, would be significantly less than the costs of unloading sacked meal. But facilities different from those now being used for storing the meal at the port of entry would be required.

The purpose of this paper is to report findings made during an initial investigation of the technology of bulk handling of herring meal.

PLANT TESTS AND OBSERVATIONS

THE PROCESS: The method of producing herring meal in Alaska was similar in the six plants operating during the 1956 season. Essentially, the process consists of a cooker where the fish are cooked under 3 to 10 pounds steam pressure,

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a press where much of the oil and a portion of the water are pressed from the protein residue, and a direct-fired rotary drier where the press cake is dried.

HEATING OF SCRAP AND SACKED MEAL: Since heating was considered to be the major problem in bulk handling of herring meal, it was of interest to determine the temperature rise in sacked meal. This was done by measuring the temperature in the center of a sack of meal stored in a large warehouse, where the air temperature was 55° to 60° F. (fig. 2). It will be seen that the meal temperature rose rapidly the first 2 hours after sacking and continued to rise in some cases for 6 to 8 hours or more and to as high as 168° F. The temperature of the unground material (scrap) rose rapidly to levels of the order of 225° F. during the first few minutes after it came out of the drier (fig. 2). These temperatures were measured 6 inches below the surface of a 2-foot pile of scrap.

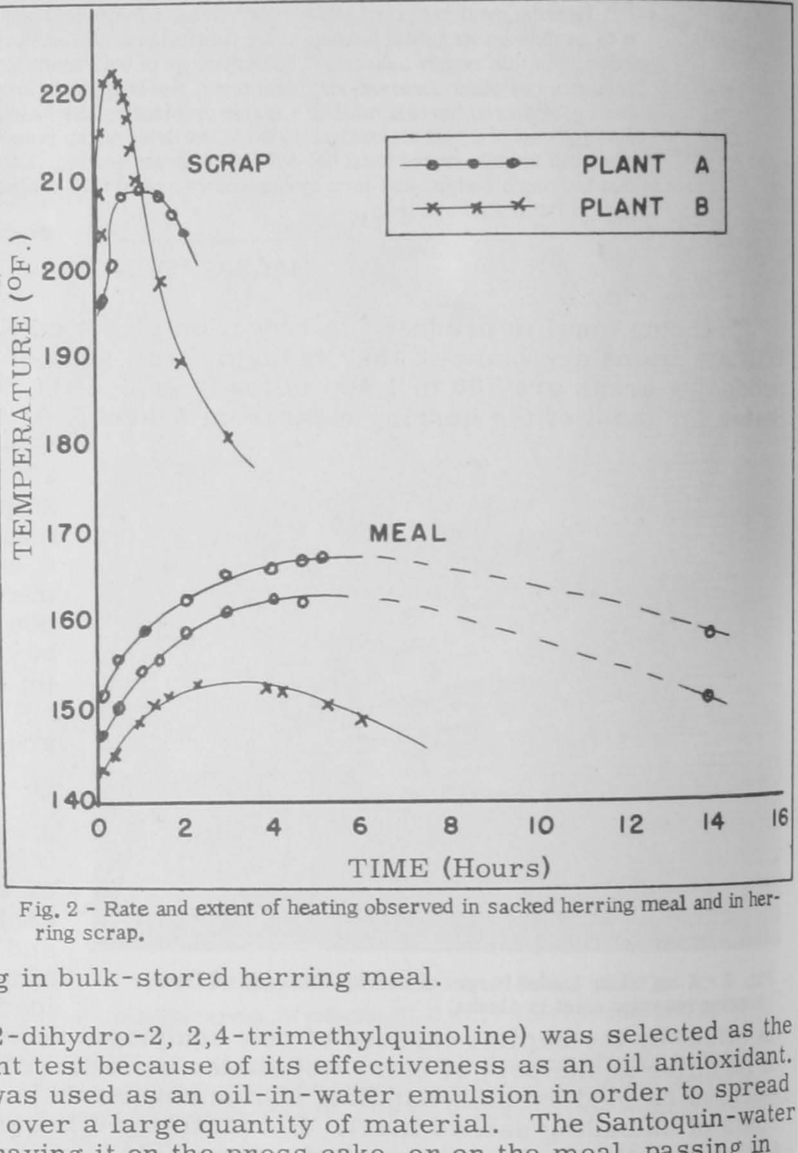

Fig. 2 - Rate and extent of heating observed in sacked herring meal and in herring scrap.

ANTIOXIDANT TESTS: It is believed that the primary cause of heating in bulk scrap and in sacked meal is the oxidation of the oil retained in the meal. Since it is feared that bulk-stored meal also will heat, owing to the same cause, a series of plant tests were conducted to determine the effectiveness of an oil antioxidant in preventing heating in bulk-stored herring meal.

Santoquin (6 ethoxy-1, 2-dihydro-2, 2,4-trimethylquinoline) was selected as the antioxidant to use in the plant test because of its effectiveness as an oil antioxidant. It is an oily substance and was used as an oil-in-water emulsion in order to spread the small amounts required over a large quantity of material. The Santoquin-water emulsion was applied by spraying it on the press cake, or on the meal passing in a conveyor (fig. 3). The antioxidant was added at two levels: 0.08 percent and 0.01 percent by weight of dried meal. Preliminary laboratory experiments indicated that these levels would bracket the desirable application rate if the use of antioxidants were accepted.

Intimate contact between the antioxidant and the oil on the meal is necessary for the antioxidant to become of maximum usefulness. The antioxidant, therefore, first was added as early in the process as possible--to the press cake--in order to achieve maximum mixing in existing plant equipment. Because the advantage gained by intimate mixing in the drier might be offset by destruction in the drier, a second test was made adding the antioxidant to the meal just after it was discharged from the drier. The only mixing that the antioxidant and meal received under the latter conditions was in the 50-foot conveyor and in the meal grinder.

The extent of the spontaneous heating of the herring meal and the effect of the antioxidant at different concentrations and when added at different stages in the process were measured by storing the meal in cubicle bins 4 feet on a side. The heating curves of the meal, treated with two concentrations of antioxidant added either to the press cake, or just after discharge from the drier, are presented in figure 4. The heating curves of untreated meal are presented in figure 5. The heating observed in the antioxidant-treated meal was less and reached a maximum sooner than in the untreated meal.

Fig. 3 - Adding oil antioxident to herring scrap leaving drier.

BULK DENSITY: Bulk density is an important factor in determining shipping costs because the density controls the amount of meal that a barge of given size can carry. It also was suspected that meals with a high bulk density--those that were tightly packed--would show different heating characteristics from meals with a low bulk density. To determine the effect of bulk density on heating, we poured normal production meal into two test bins. The meal in one bin, however, was tamped until it had a bulk density of 38 pounds per cubic foot. The loosely-filled bin had a bulk density of only 30 pounds per cubic foot. The heating curves of these meals are shown in figure 5. The lower-density meal heated slightly more rapidly than did the higher-density meal, but after 80 hours of storage, the temperatures in both bins were essentially the same.

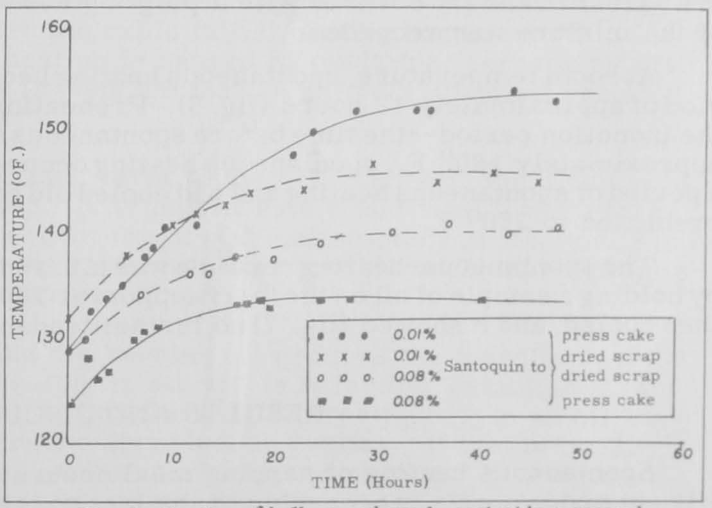

Fig. 4 - Heating of bulk stored meal--antioxidant-treated.

The bulk densities of unpacked herring meal observed at three different herring plants at one time during their operating season were 30.0, 32.5, and 34.2 pounds per cubic foot. The differences among the meals might be explained by differences in the moisture content of the meal and in the herring from which the meal was prepared. The density of the meal sacked in the hold of the barge was estimated to be 35 pounds per cubic foot. This is an estimated 5 to 10 percent less than the density of a sack of meal but 15 percent greater than loosely-filled bulk meal.

LABORATORY EXPERIMENTS

The plant-production variables of sacking temperature, moisture content, and bulk density of the meal seemed to affect the extent and the rate of heating of the herring meal. Laboratory experiments were set up to help explain the observed effects of these variables. In the laboratory experiments it was assumed that the major cause of heating was the oxidation of the oil.

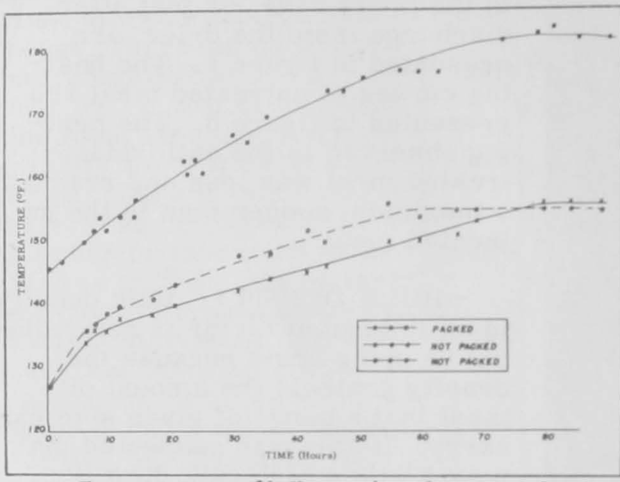

Fig. 5 - Heating of bulk-stored meal--untreated.

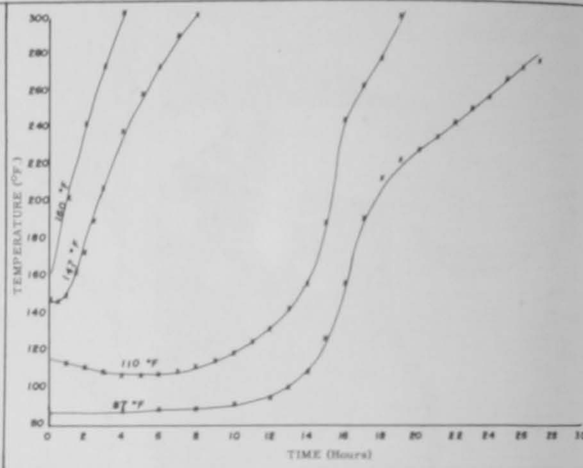

Fig. 6 - The effect of preheating on induction period of herring oil.

This oxidation was simulated in the laboratory by mixing herring oil with an inert support material that would expose a large surface of the oil to the air. The inert support used in the tests described here was composed of two parts by weight of silica gel and one part of the filter aid "Hyflow Super Cel." The oil was dissolved in four volumes of petroleum ether and then mixed so as to wet the support uniformly. The petroleum ether was removed by evaporation at room temperature (70° F.). Seventy-five milliliters of oil were used with 340 grams of the support. The oil-coated support was then placed in a vacuum flask and covered with a plug of glass wool, and the temperature in the center of the mixture was recorded.

At room temperature, spontaneous heating became apparent after an induction period of approximately 12 hours (fig. 6). Preheating the oil on the inert support reduced the induction period--the time before spontaneous heating becomes apparent--until, at approximately 160° F., spontaneous heating occurred at once. Oil that had gone through a period of spontaneous heating and had cooled did not heat again spontaneously even when preheated to 230° F.

The spontaneous-heating reaction was allowed to occur under controlled conditions by holding a sample of oil on the inert support at 180° F. for 4 hours. This sample was then cooled, and it showed (fig. 7) no further tendency to heat spontaneously.

RESULTS AND DISCUSSIONS

Spontaneous heating of herring meal occurs as soon as the meal leaves the drier (fig. 2) and probably is occurring in the last part of the drier where the moisture content of the scrap is almost as low as at the discharge. The spontaneous heating before sacking does not have an opportunity to cause a temperature rise in the meal because, under the procedures in herring plants, the heat is dissipated faster than it is formed. The spontaneous-heating reaction continues in the sacked meal where, because of the insulating characteristics of the meal, the temperature in the center of a sack of meal, under some conditions, rises to 170° F. or higher (fig. 2). Where the sacks are stored in small piles (four high) and in cool warehouses (50° to 60° F.), rapid dissipation of the heat occurs, and the spontaneous reaction is soon slowed to a rate that allows the heat to dissipate faster than it is formed.

Meal stored in bulk in test bins 4 feet on a side, however, dissipated heat more slowly and therefore exhibited a higher temperature than did sacked meal piled four sacks high (fig. 2 and 5). It is to be expected that the temperature of meal in the center of larger piles would rise to higher temperatures than those experienced in the test bins.

The addition of the antioxidant to herring meal did not reduce the initial rate of heat formation below that of the untreated meal. After the first 8 to 16 hours, however, the rate of heating of the antioxidant-treated samples fell much below that of the untreated meal, with one exception. This exception was the sample treated with 0.01 percent antioxidant added to the press cake. The fact that a large percentage of the very small amount of antioxidant added to this particular sample was undoubtedly destroyed in the drier may account for this difference in reaction. The maximum observed temperature of all the treated meals was less than that of any of the untreated meals. The difference in maximum temperatures was dependent on treatment of the meal, on its initial storage temperature, and undoubtedly also on other operating variables.

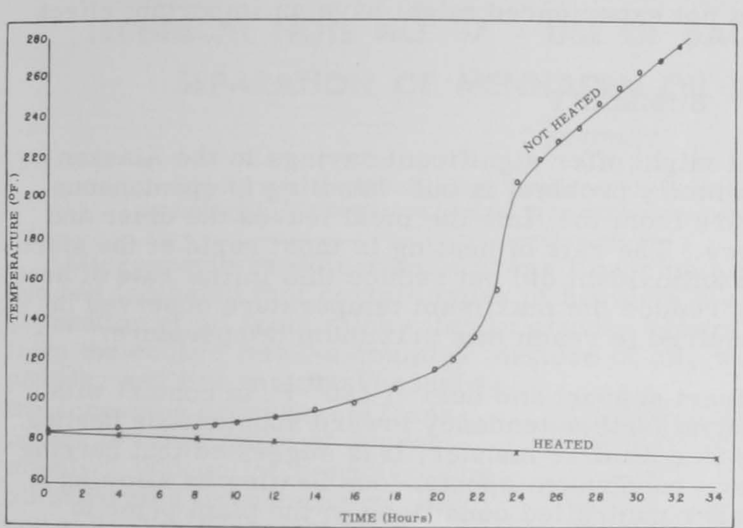

Fig. 7 - The effect of heating herring oil dispersed on support medium to 180° F. for 4 hours on subsequent spontaneous heating.

The antioxidant was effective in reducing both the maximum temperature rise of the bulk-stored meal and the time to reach maximum temperature. Its action appeared to be one of inhibiting or stopping further oxidation after the rapid initial heating had occurred. Although it is suspected that the first heating is caused by oxidation, perhaps by that oil not mixed with the antioxidant, it is possible that an entirely different reaction is taking place.

Antioxidant added at the 0.01-percent level to the scrap leaving the drier gave protection against spontaneous heating. It is thus possible that even lower rates of addition of antioxidant than 0.01 percent might give satisfactory protection. Santoquin is convenient to apply as an oil-in-water emulsion and, as such, can be applied by spraying the meal passing on a conveyor.

It is shown (fig. 6) that preheating the herring oil reduced the induction period (the time required for spontaneous heating to start). It is further established that spontaneous heating does not reoccur, within the limits investigated, in an oil-support mixture which has already undergone spontaneous heating. If the oil on the meal reacts in a manner similar to oil on an inert support medium, herring meal might be stored without the occurrence of spontaneous heating by allowing the meal to go through an initial heating before storage. It is possible that an additional processing unit might be installed to permit the rapid initial reaction to take place under controlled conditions before storage. An antioxidant might further reduce the possibility of subsequent heating.

The addition of antioxidants delays the formation, from the oil, of products not easily digestible. The nutritional value of a meal so treated might be significantly higher than that of untreated meal, particularly after prolonged storage. Samples of the treated meals from these experiments have been sent to the University of California for evaluation in poultry nutrition to test the validity of these assumptions.

Because of the lower density of bulk herring meal, the barges now used to carry the meal from Alaska production points to such distribution points as Seattle, Wash., would hold about 15 percent less than when loaded with sacked meal, unless the meal were packed in the hold of the barge. This might be a significant factor in determining the economic desirability of bulk handling.

These observations and conclusions are based on limited tests during a short period in one operating season. Although it is believed that the data are representative, it is possible other variables not experienced might have an important effect on the results.

SUMMARY

Bulk handling of herring meal might offer significant savings to the Alaskan producer of herring meal. The primary problem in bulk handling is spontaneous heating. Spontaneous heating occurs from the time the meal leaves the drier and continues for 6 to 80 hours or more. The rate of heating is most rapid at the start. The addition of 0.01 percent of an antioxidant did not reduce this initial rate of heating significantly. It did, however, reduce the maximum temperature observed in bulk-stored meal and the time required to reach this maximum temperature.

Herring oil dispersed on an inert support and held at 180° F. in contact with air for 4 hours then cooled showed no further tendency toward spontaneous heating. If the oil in herring meal behaves in a similar manner, it is suggested that herring meal could be stored in bulk without subsequent spontaneous heating by allowing it to go through its intital heating under controlled conditions in the plant prior to storage.

ANTIBIOTIC ICE FOR FISH

"From what we hear on the scientific grapevine, antibiotic ice for fish may not be too far away," D. M. Haywood of Los Angeles, Calif., told delegates to the 12th annual convention of the National Fisheries Institute during the week of April 28 to May 1 in Chicago, Ill. "When we are permitted to use antibiotic ice," he went on to say, "a lot of our headaches will be behind us. Shipments of fresh fish from California to Maine will be commonplace."

Haywood, the first speaker of the Monday morning session of Customers Day, pointed out that "The very fresh fish we trade in, like all perishable commodities, makes us vulnerable." "We either keep up with modern trends and patterns, or else we don't stay in business very long. Our economy has changed from a 'need' economy to a 'want' economy. Fish sticks have given us a much-needed shot in the arm and--more important--have proved to us that the 'want' economy will work for fish as well as other products. Find out what the public wants, produce it, advertise it, and promote it."