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SPONTANEOUS HEATING AND IGNITION OF FISHMEAL

by

P. C. Bowes

Summary

A review has been prepared of literature on the spontaneous heating and ignition of fishmeal, and some laboratory tests of the heating have been carried out.

The necessary conditions for the storage and carriage of bagged fishmeal without risk of spontaneous heating appear to be, first, drying the meal to a moisture content of between six and twelve per cent and, second, adequate curing of the freshly prepared meal.

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INTRODUCTION

In response to an enquiry on the occurrence of spontaneous heating and ignition in fishmeal a review has been prepared of information available in the literature. An account is given also of some simple laboratory tests of the spontaneous heating of fishmeal.

REVIEW

Fishmeal is the dried and ground residue of whole fish, or fish scrap, that has been cooked and has had the oil extracted. The meal is recognized in the industry as liable to heat spontaneously, and even ignite, if stored in bulk immediately after preparation. The heating is attributed to oxidation of the residue of oil that is present in the meal in amounts that may vary from five to twelve per cent. Fish oils are usually capable of being readily and extensively oxidized.

Harrison [1] gives an account of the manufacture of fishmeal and states that it is normal practice for the material from the drier to be spread out on a floor for 24 to 48 hours. After being cured in this way the material is ground and put in bags. The bags are then allowed to stand loosely stacked for 24 to 48 hours before final close stacking. Alternatively, the raw material is ground and bagged immediately after drying and the bags are allowed to stand for 24 to 72 hours before stacking.

During the first six to twelve hours the temperature in the centre of a bag of meal may rise by 50-100°F (28-56°C). Harrison [1] has published curves showing a temperature rise of this order in herring meal and sardine meal in burlap bags. The degree of heating in the fresh meal depends on the type of fish from which it has been prepared; the heating is less for less oily fish but no comparative temperature measurements have been published. It appears that spontaneous heating due to oxidation in the freshly prepared meal can be reduced, or even prevented, by packing the meal in multiwall paper bags instead of in the usual bags of jute fabric (burlap) [1, 2, 3].

According to the rules of the Ministry of Transport [4] for the carriage of substances liable to spontaneous combustion, fishmeal carried in jute bags or double-walled paper bags must contain at least six per cent and not more than twelve per cent of moisture. Fishmeal containing less than six per cent or more than twelve per cent moisture must be contained in hermetically sealed metal-lined boxes or in airtight metal containers. The basis for the above moisture limits is not stated but they are presumably related to practical experience. It is noteworthy that the National Fire Protection Association [5] give the same moisture limits for the storage of bagged fishmeal and, moreover, state that the meal is dangerous if over-dried or packaged over 100°F. It is possible that meal that has been over-dried will, at the same time, have been heated to a higher temperature than usual and will therefore be undergoing oxidation, and evolving heat, at a higher rate than usual.

Published results of experimental investigations on the effect of moisture on the spontaneous heating of fishmeal are very scanty. Results of tests by Lewis [6] so far reported, do not show any definite relationship between the self-heating due to oxidation and the moisture content of the meal. Observations of self-heating in bags of cured pilchard meals with moisture contents of fourteen and twenty-two per cent have been reported [7]. Increases of temperature occurred in the

bags within twelve hours and again after six days as follows:-

Moisture content (per cent)	Temperature rise (°F)	
	12 hours	6 days
14	9	7
22	20	56

The initial temperatures are not stated and no explanation of the results is advanced.

SPONTANEOUS HEATING TESTS ON FISHMEAL

The following tests for spontaneous heating were carried out on a sample of fishmeal that was known to be at least six weeks old. The nature of the fish composing the meal was not known.

A test of the Mackey type with controlled air flow [8] was carried out to detect any tendency of the meal to undergo spontaneous heating by oxidation. In this test a specimen of the material is supported in a ventilated enclosure with walls maintained at 100°C; spontaneous heating in the material is indicated if the temperature of the specimen, observed by a thermometer inserted in the centre, rises to a value greater than 100°C.

Specimens of the meal were packed at densities of 0·49 - 0·64 g/cm^3 in paper cylinders 3·5 cm diameter and with a packing length of 7 - 8 cm. The air flow was 300 cm^3/min. The first test carried out showed that self-heating either did not occur or it reached completion at a slow rate during the initial heating of the specimen to the temperature of the enclosure, 100°C. In further tests therefore the initial heating up to 94 - 96°C in three hours was carried out in an atmosphere of nitrogen; air was then passed through for a further four hours. In all cases the temperature continued to rise slowly to a steady value of 98 - 99°C and there was no sign of self-heating.

From the failure to detect any tendency of the fishmeal to heat spontaneously in the above test it is concluded that oxidation of the meal had approached completion in the period between preparation and testing.

A sample of the meal (140 g) was next moistened with sufficient water to increase its moisture content to twenty per cent (from its initial value of eight per cent) and stored in a pint-size dewar flask in a constant-temperature room at 25·5°C. The temperature of the meal behaved in the manner shown in Figure 1. Except for variations which were related to variations in the room temperature (due to unusually high day temperatures) the temperature remained virtually stationary for four days and then rose to 42·5°C in a period of twenty-four hours. It then fell slowly but remained above 40°C for two days before falling more rapidly to near room temperature by the tenth day. At the end of the test the fish meal was mouldy throughout and had an average moisture content of nineteen per cent.

It may be regarded as reasonably certain that the heating of the moistened fishmeal was due to the activity of microorganisms - bacteria and fungi. The behaviour of the temperature of the meal is similar to that encountered in moist vegetable matter that is undergoing spontaneous heating through microbiological activity. In moist vegetable

matter it is possible for the temperature to rise to about 75°C as thermophilic bacteria become active, but the passage to this stage usually requires smaller heat losses or, what is in effect the same thing, larger masses of material than are possible in an experiment on the dewar flask scale. The present test could not therefore be expected to show whether temperatures as high as 75°C could be reached by biological activity in the fishmeal.

CONCLUSIONS

It appears that there are two mechanisms by which fishmeal can heat spontaneously. The first occurs in freshly prepared meal, and is almost certainly oxidation. The second resembles the microbiological heating of moist vegetable matter and occurs in the presence of excess moisture; it can occur in meal in which heating by oxidation is not possible. Oxidation of the fresh meal might cause a rise in temperature up to ignition; but it is not known whether the spontaneous heating of moist, fully oxidized, meal can proceed up to or beyond the maximum temperature attainable in microbiological heating, (about 75°C).

It appears that the necessary conditions for the storage and shipment of fishmeal in jute bags without risk of spontaneous heating are,

(i) the meal should be dried to a moisture content of between six and twelve per cent,

(ii) the meal should be protected from wetting thereafter,

(iii) the freshly prepared meal should be adequately cured to allow the oxidation process to approach completion.

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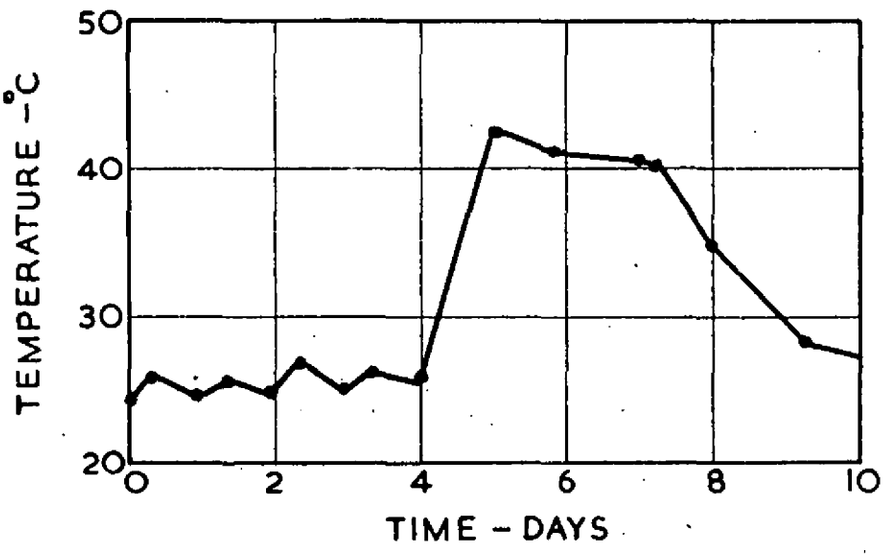

FIG.I. SELF HEATING OF MOIST FISH MEAL