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EFFECT OF HOT-BONED PORK ON THE KEEPING QUALITY OF FRESH SAUSAGES

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A number of investigations have demonstrated the advantages in using hot-boned (pre-rigor) meat with respect to processing characteristics such as improved water holding capacity (Cuthbertson, 1980), higher emulsifying capacity (Trautman, 1964) and lower cooking losses (Ray et al., 1980), among others. As the processing characteristics of hot-boned meat are closely related to the initial ATP level of the muscle (Hamm, 1980), it is desirable to maintain this level in meat for sausage making. Hamm (1982) described some methods to keep this high ATP level in minced beef. Several studies have considered the effect of a carbon dioxide environment in fresh meat products (Kraft and Ayres, 1952; Ledward, 1970; Taylor, 1971; Silliker et al., 1977). In addition, some authors (Walters, 1975; Carpenter et al., 1975) have reported the use of dry ice as a way of creating an atmosphere rich in carbon dioxide. The objective of the first part of this study was to evaluate the retail storage life of fresh pork sausage patties made with hot-bored meat supplemented with four different levels of dry ice. In the second experiment, the retail storage life of fresh pork sausage links made with different proportions of hot-boned meat was evaluated.

Experiment 1: Proportions of ham and shoulder of a carcass of a 18 month old, non-pregnant sow, weighing 75 kg (Canada index 103) were excised at random within 45 minutes after exsanguination and fabricated into patties. The patties were made with 75% pork trimmings (25% fat, 13.5% protein, 60.5% moisture) 10% pork fat, 13% ice, 1.5% salt, 0.25% rubbed sage and 0.25% ground pepper. Finely ground dry ice was added in proportions of 10, 20, 30 and 40% of the meat block. Patties approximately 2 cm thick and 6 cm in diameter were made from the mixture, vacuum packaged in plastic bags (0.75 mil nylon/2mil polyethylene)(DRG Packaging Ltd., Toronto) using a Multivac unit model AG500 (Multivac Export AG, Switzerland) and stored at 4 C in the dark under cool white fluorescent light (2260 lux). The total study period was 16 days. The samples were analysed every fourth day for the following response variables: hue, hardness and cohesiveness, fat oxidation and water holding capacity. Hue was measured using a Hunter Lab colour difference meter, model D25-2. A white tile was used as standard (L=94.5, a=-1.0, b=1.9). An Agtron cup of 6 cm diameter and 4 cm height was filled with raw meat, and placed in the illuminated opening of the equipment. The colour coordinates were transformed into hue (Little, 1975). It was assumed that a desirable sample had more red colour (lower hue values). Hardness and cohesiveness were measured through a texture profile analysis performed upon cooked samples. Squared pieces of 1.5 cm were placed in the load cell of an Instron Universal Testing machine (model 1122). A two-compression cycle was applied to each sample in order to produce a force-distance diagram describing the rheological behaviour of the material, as reported by Bourne (1978). The deformation of the sample was 50% of its total height. The crosshead speed was 20 mm/min, the chart speed was 50 mm/min with full scale of the recorder of 98 N. Fat oxidation was analysed by measuring the 2-thiobarbituric acid (TBA) values of the samples, according to the method described by Ockerman (1980). Although the point of rancidity is arbitrary, this author considered that TBA values of 1 or higher are unacceptable in fresh meat products. The water holding capacity (WHC) was obtained by using a modification of the centrifugation method described by Wardlaw et al. (1973). The model consisted of a 4x5 factorial with 4 levels of dry ice and 5 levels of study time. Data analyses consistedof multiple regression to provide a response surface. The predicted values were plotted by the use of an Apple Plot program.

Experiment II: Fresh pork sausage links were made from meat excised from different locations of a pork carcass weighing 75 kg (Canada index 103) within 45 minutes after exsanguination, and from regular chilled pork trimmings. Three formulations were prepared using hot-boned meat levels of 0, 50 and 100%. The complementary percentages to 100% were made from regular chilled pork. Each formulation was subjected to three Treatments and three study times. Treatment 1 consisted of meat ground through a 125 mm plate. It was then placed in trays at a depth of 2 cm and left overnight at -28 C. The meat for Treatment 2 was cut into 5 cm pieces and sprinkled with salt at a rate of 140 g per 9 kg of meat. The meat was then subjected to the same grinding and freezing sequences as the previous Treatment. Meat for Treatment 3 was cut into 5 cm pieces and sprinkled with salt at the same rate as above. The meat was then ground while 3 kg of finely ground dry ice were added for each 9 kg of meat. After this operations, the mixture was placed in trays and stored overnight at 4 C. Immediately following overnight storage, the meat was fabricated into sausages. The meat from Treatment 1 and 2 was chopped in a Hobart silent chopper while frozen. To each 9 kg batch was added 1 kg of fat, 29 g of spice mixture (nutmeg, ginger, ground pepper and rubbed sage), 500 g of cracker crumbs as binder and 500 g of water. In the frozen meat (Treatment 1), where no salt was added before freezing, 140 g of salt were added during chopping at high speed in a Hobart silent chopper. Once all ingredients were thoroughly mixed, the meat was stuffed into regenerated collagen casings of approximately 15 mm diameter. The sausages (13% protein, 38% fat, 45% moisture) were

placed into semirigid plastic containers of aproximately 454 g (16 sausages). The packaged sausages were stored under cool white fluorescent light of 807 lux at 5 C. The total study time was 14 days. Samples were analysed at 0, 7 and 14 days of storage for the following response variables: flavour and overall acceptability, microbial counts, hue, hardness, cohesiveness, fat oxidation and water holding capacity. Samples for sensory evaluation were cooked in a convection oven at 200 C for 15 minutes. They were evaluated by 3 panels of 8 untrained judges, each judge evaluated 3 Treatments. The panels evaluated for flavour and overall acceptability following the method described by Stone et al. (1974) using a fifteen centimeter unstructured scale and placing a vertical mark accross line at the point which best reflected the magnitude of his or her perceived intensity of that attribute of flavour and overall acceptability, where 0 was unacceptable and 15 was acceptable. The lines were measured from the left (0 cm) to each panelist's vertical mark on the line and recorded to the nearest tenth of a centimeter for subsequent statistical analysis. Coliforms and Total Plate Count (TPC) were evaluated by means of standard techniques (APHA, 1976). Hue, hardness, cohesiveness fat oxidation and water holding capacity were analysed as described in Experiment I. The experiment consisted of a complete 3 (Formulation) x 3 (Treatments) x 3 (study time) factorial. The data were subjected to multiple regression analyses to provide a response surface (Cochran and Cox, 1957). The predicted values were plotted by the use of an Apple Plot program.

RESULTS AND DISCUSSION.

Experiment I: Hot-boned meat patties showed little variation in fat oxidation throughout the study time within each carbon dioxide level, which agreed with the results reported by Drerup et al. (1981). However, TBA values decreased as the amount of solid carbon dioxide was increased due to fast freezing of parts of the sample in contact with dry ice. At such a low temperature, oxidation reactions are very unlikely to occur (Caldironi and Bazan, 1982). The more the dry ice added, the larger the amount of the sample frozen and hence the lower the TBA value obtained. The water holding capacity increased with increasing percentages of dry ice from 0 to 20%. This was probably due to a mechanical disruption of filaments, produced by the ice crystals. It resulted in a swelling effect of myofibrills and a larger amount of water could be adsorbed. Presence of salt also contributed to this swelling effect. However, there was a lower water holding capacity in samples addedwith 40% of dry ice as compared to those added with 10 and 20%. The trend for 40% level of dry ice is to increase as the study time also increased. Oppositely, the other dry ice levels showed a peak at 8 to 12 days of study. It was also observed that dry ice shifted the hue to yellow, This was due probably to pigment deterioration by oxidative reactions initiated by light, according to the results reported by Hansen and Sereika (1969). In addition, carbon dioxide was present in the package in proportions much larger than oxygen. Therefore, myoglobin remained in the reduced state and oxymyoglobin was practically absent with the results of a higher hue value. Increased solid dry ice level were observed to have a hardening effect whereas cohesiveness decreased. This was more marked when dry ice levels were of 20 to 40%. The decrease in cohesiveness could be associated with lower extractability of myofibrillar proteins in the frozen portion of the sample (Deatherage and Hamm, 1969). Thus when 20 to 40% solid carbon dioxide was added, a larger proportion of the sample was frozen, therefore less protein was extracted. In general, 30 to 40% dry ice added to the meat increased the water holding capacity of the samples up to 12 days of storage. This percentages also decreased the fat oxidation. However, some negative effects were observed such as hardening of the samples, reduction in cohesiveness and increased colour fading.

Experiment II. In this experiment, flavour and acceptability of sausages improved from 0 to 7 days of study time. Due that at 14 days the samples were highly contaminated, sensory evaluation analyses were not performed at thisstudy time. In salted Formulations (2 and 3), flavour of the samples with 100% hot-boned meat became less acceptable towards the end of the study period. In this case, salt may have promoted some oxidation resulting in a rancid flavour (Watts, 1961). This observation was supported by the increasing TBA values in these two formulations. Salting before grinding could start oxidation reactions that continued during sausage manufacture and storage. The hue was more yellow (higher) in samples with 100% hot-boned meat as compared with 0 and 50% hot-boned meat. This was no doubt related with higher metmyoglobin formation due to oxidation reactions, to which hot-boned meat showed to be more sensitive (Pisula, 1981). In addition, not salted and frozen samples had the lowest hue values as a result of the absence of prooxidants such as salt, as well as fast freezing decreased any oxidative change caused by atmospheric oxygen (Calvelo, 1981). Fresh pork sausages made with 50 to 100% hot-boned meat had higher microbial counts in Treatments 2 and 3. This was in agreement with results reported by Cornish and Mandigo (1974) and Henrickson (1968), which showed that hot-boned meat products were more easily contaminated if proper precautions are not taken. Oppositely, Treatment 1 gave similar microbial counts for the three Formulations. Samples made with 100% hot-boned meat were harder than those made with 0 and 50% in Treatment 2. It has bee observed by some authors (Kastner et al, 1973; Jacobs and Sebranek, 1980; Ray et al., 1980) that hot-boned meat shows an increased toughness as compared with chilled meat which undergoes enzymatic proteolysis during aging. This contributes to a tenderizing effect, which does not happen in the hot-boned meat process. Our results agreed with these reports in Treatment 2, where the meat was salted and frozen before fabrication. However, Treatments 1 and 3 showed a different trend decreasing the hardness values as hot-boned meat percentage increased. Addition of dry ice also gave on the average, lower extractability of myofibrillar proteins due to freezing of sections of the meat block. As a result, cohesiveness values were also lower. Oppositely, salting increased cohesiveness due to extraction of proteins by the mechanisms discussed by Hamm (1982). Although the water holding capacity of the sample increased with the amount of hot-boned meat in the formulation, this variable shows lower values towards the end of the 14 days study period, probably as a consequence of the increase in microbial population which was very marked from 7 to 14 days of study.

The highest water holding capacity was observed in salted and frozen samples, where swelling of myofibrills caused by salt addition, together with frozen storage gave up to 75% of water retention in samples made with 100% hot-boned meat. These results agreed with those reported by Hamm (1960). The water holding capacity was considerably reduced when dry ice was added to the Formulation. It was due in part to some degree of cold shortening occurred during chilled storage.

CONCLUSIONS

There were only slight differences among the three Treatments used (not salted and frozen, salted and frozen and addition of dry ice). Although salting increased TBA values and decreased flavour and hue, salting and freezing increased water holding capacity and cohesiveness. When all variables were considered, it was concluded that although 100% hot-boned meat had improved attributes such as water holding capacity and cohesiveness, it exhibited higher microbial counts, more facility to undergo fat oxidation and faster colour fading. In addition, sausages made from 100% regular-chilled meat had lower water holding capacity, and flavour and overall acceptability scores. Therefore, samples made with 50% hot-boned meat and 50% chilled meat had the most acceptable quality during longer retail storage life.

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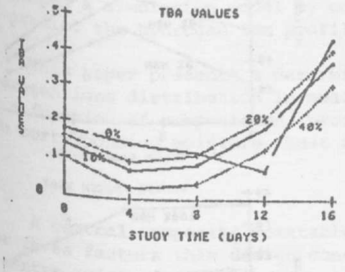
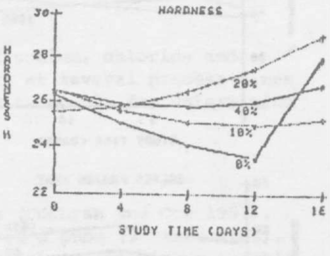


Experiment 1: TBA values



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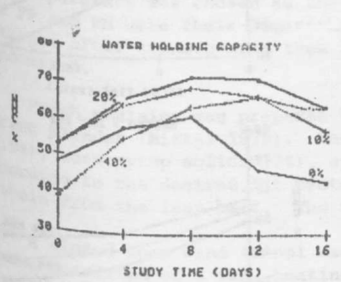
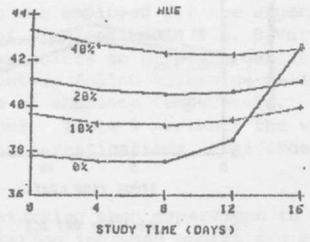
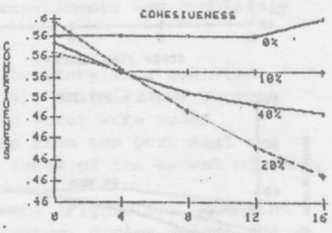


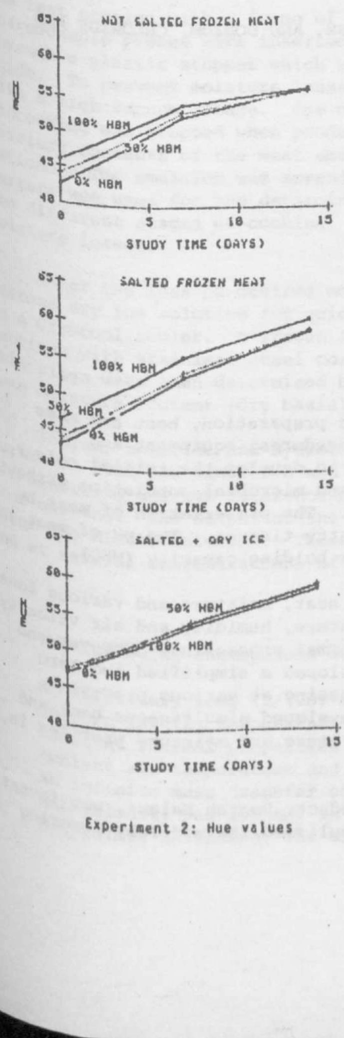
Experiment 1: Water holding capacity



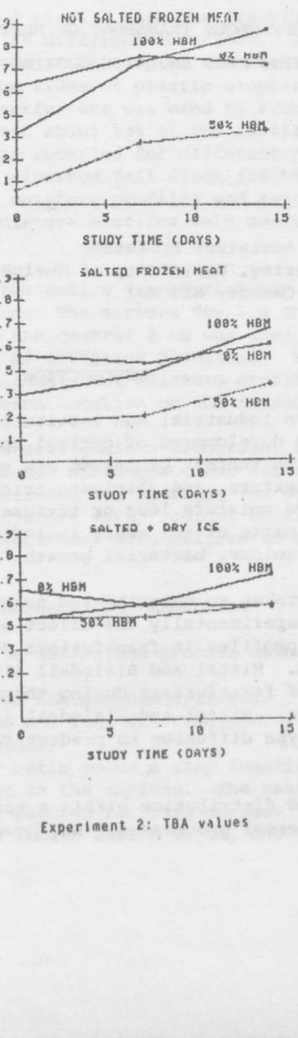
Experiment 1: Hue values



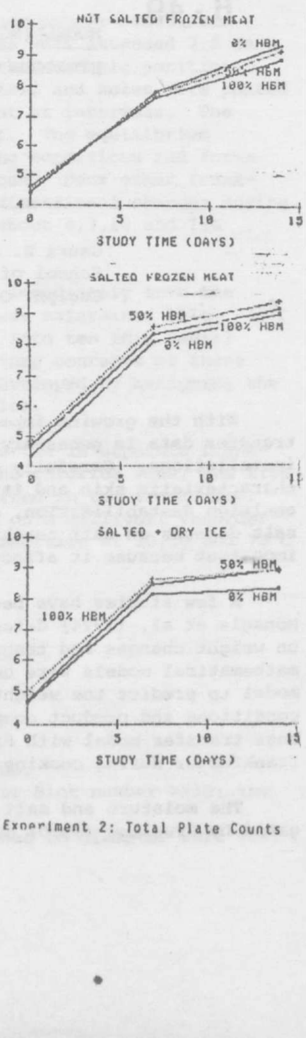
Experiment 1: Cohesiveness



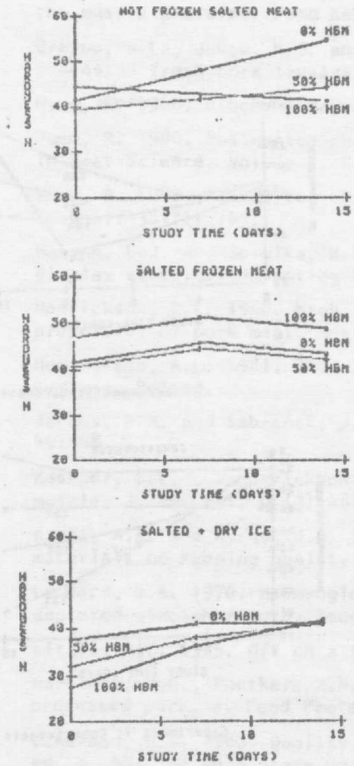
Experiment 2: Hue values



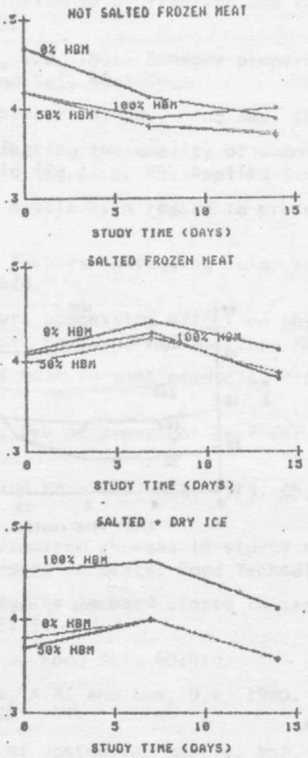
Experiment 2: TBA values



Experiment 2: Total Plate Counts



Experiment 2: Hardness



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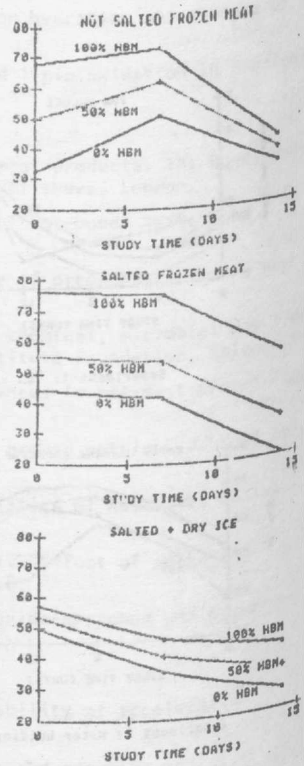

Experiment 2: Water Holding Capacity