# Use of Cryoprotectants for Mechanically Deboned Pork

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**ASL-R1427**

### Summary and Implications

Mechanically deboned pork (MDP) is used a great deal in further processed products as an economical lean meat ingredient. Because it must be frozen to prevent rapid spoilage, loss of protein functionality occurs due to freezing and frozen storage. The use of maltodextrins and corn syrup solids was shown in this study to protect proteins in MDP from freezing damage and increase the functionality of the proteins during processing. Because these cryoprotectants easily are incorporated into MDP before freezing, the use of cryoprotectants offers the industry a significant potential improvement in quality of MDP.

### Introduction

Mechanical deboned pork (MDP) has been used extensively in processed meats in recent years because it greatly contributes to the production of low-cost meat products. This has been especially true since 1995 when the USDA changed labeling requirements for products with MDP. Use of MDP in processed meats now can be labeled as "pork" rather than "mechanically separated pork" as was the case prior to January, 1995. However, the comminuted nature of MDP makes this product prone to rapid quality deterioration if not handled and/or stored properly. Spoilage caused by microbial growth is a problem in non frozen MDP, whereas oxidative rancidity is the major cause of deterioration in frozen MDP. Because microbial control is absolutely essential, MDP is frozen to insure microbial quality. Thus, it is well recognized that MDP is highly susceptible to lipid oxidation, which leads to loss of protein functionality during frozen storage.

To improve the functionality of frozen meats as ingredients in processed meat products, preventing or inhibiting freeze-induced denaturation and/or aggregation of proteins is an important consideration. Cryoprotectants, added to meat before freezing, have been shown to improve long-term storage stability of proteins during frozen storage. This, in turn, assures good functionality of the material in the subsequent manufacture of meat products. High molecular weight carbohydrates have been shown to "cryostabilize" proteins during frozen storage.

Mechanically deboned meat is very finely comminuted as a result of the deboning process and cryoprotectants could easily be added prior to freezing if shown to be effective. The purpose of this study was to investigate and compare the effects of readily available carbohydrates such as maltodextrins and corn syrup solids on the freeze thaw stability and quality characteristics of mechanically deboned pork during frozen storage. The effects of these cryoprotectants on quality of pork sausage with frozen MDP also was evaluated.

### Materials and Methods

Fresh mechanically deboned pork (MDP) was obtained from a commercial source, directly off the processing line. The study was designed to include seven treatments: control, 4% and 8% each of five DE and 10 DE maltodextrins, as well as 20 DE corn syrup solids. The MDP (27.3 kg) was mixed immediately after collection with maltodextrins or corn syrup solids by using a bowl chopper at low speed under vacuum for one minute. The maltodextrins and corn syrup solids were provided by the Grain Processing Corporation (Muscatine, Iowa). The MDP was then divided into seven 2.27 kg. batches and placed in two-gallon freezer bags. Half the bags were frozen in an air-blast freezer at -40°C (Vollrath Refrigeration, Inc., River Falls, Wisconsin) while the other half were frozen in the still-air freezer at -10°C. After three days, all the samples were moved into a freezer at -28°C (Vollrath Refrigeration Inc., River Falls, Wisconsin). Samples were evaluated on the day of preparation of the mixtures (non frozen) and after 2, 60, 120, 180, and 240 days of frozen storage for both the air-blast and still-air frozen samples.

Evaluation of the MDP with cryoprotectants included thaw drip losses, protein solubility, protein gel strength and emulsifying capacity. Pork sausage also was manufactured with the frozen MDP and product quality was assessed.

### Results and Discussion

The drip loss (moisture loss) during thawing was greater for slow-frozen MDP, as expected, but the cryoprotectants had no effect on amount of drip loss (data not shown). The maltodextrins and corn syrup solids were effective for controlling the development of rancidity (TBA values) as shown in table 1. The difference was not significant, however, until after 240 days of frozen storage. While rancidity is a major concern for MDP, the freezing and frozen storage conditions may be more important for controlling rancidity than the cryoprotectants. It can be observed in table 1 that slow freezing, for example, resulted in significantly greater TBA values within two days of the freezing treatment.

One of the most important processing properties of meat ingredients is protein solubility, and the cryoprotectants resulted in a very significant effect on

solubility (table 2). Protein solubility normally is decreased by freezing and frozen storage, and maintaining proteins in soluble form represents a very important contribution to maintaining product quality.

The heat-set gel strength of proteins from the MDP also was better maintained by addition of the maltodextrins and corn syrup solids (table 3). There is a decreased gel strength in all cases during frozen storage but less so with the addition of the cryoprotectants.

Emulsifying capacity, which is a function of protein quality, also is maintained more completely during frozen storage by addition of the cryoprotectants (table 4). As with the other properties measured, the 10 DE maltodextrin and 20 DE corn syrup solids appear to be more effective than the 5 DE. This may well be because the dextrose equivalent (DE), which represents the reducing sugar groups, could be an important contributor to stabilizing proteins. Also, the 8% level was more effective than 4% in many cases and these differences can be observed at the 120 to 240 day storage times in table 4.

Pork sausage manufactured with the frozen MDP reflected the results observed during storage of MDP. For example, TBA values were improved after extended (180 days) frozen storage (table 5). This means that rancid, off-flavors will not be developing as quickly in products in which the cryoprotectants are used.

Sensory panel flavor scores were not different in this study (data not shown) but tenderness was scored higher for products with the cryoprotectants (table 6). This may be the result of protein stabilization and less protein change from oxidation reactions.

The results of this study show that incorporation of 10 DE maltodextrin or 20 DE corn syrup solids has potential to improve quality of frozen MDP for further processing. The results are greater after extended frozen storage time (three months or more). Because these cryoprotectants are easy to include with MDP prior to freezing, they offer significant potential to maintain quality of MDP during frozen storage.

**Table 1. Effect of maltodextrins and corn syrup solids on the thiobarbituric acid (TBA) values in mechanically deboned pork.**

| | Days of frozen storage | | | | | |
|---|---|---|---|---|---|---|
| Treatments | 0 | 2 | 60 | 120 | 180 | 240 |
| Control | 1.71[a] | 1.92[a] | 4.21[a] | 4.98[a] | 6.04[a] | 6.41[a] |
| 4% 5 DE[1] | 1.23[a] | 1.45[a] | 3.76[a] | 4.95[a] | 3.48[a] | 4.50[b] |
| 8% 5 DE | 1.80[a] | 2.01[a] | 5.13[a] | 5.35[a] | 4.28[a] | 4.82[a,b] |
| 4% 10 DE | 1.52[a] | 1.64[a] | 3.98[a] | 4.54[a] | 3.71[a] | 4.54[b] |
| 8% 10 DE | 1.61[a] | 1.64[a] | 5.64[a] | 4.98[a] | 4.12[a] | 4.76[a,b] |
| 4% 20 DE | 1.12[a] | 1.38[a] | 3.46[a] | 5.30[a] | 4.61[a] | 3.80[b] |
| 8% 20 DE | 0.85[a] | 1.16[a] | 2.49[a] | 3.22[a] | 3.44[a] | 3.34[b] |
| SEM[2] | 0.36 | 0.48 | 0.99 | 0.81 | 0.61 | 0.54 |
| Freezing Method | | | | | | |
| Rapid freezing | — | 0.95[b] | 3.40[b] | 4.29[b] | 3.44[b] | 4.38[a] |
| Slow freezing | — | 2.24[a] | 4.78[a] | 5.23[a] | 4.44[a] | 4.12[a] |
| SEM[2] | — | 0.25 | 0.52 | 0.43 | 0.32 | 0.29 |

[1] Dextrose equivalent.
[2] Standard error of the mean.
[a,b] Means with differeent letters within the same column are significantly different (P<0.05).

**Table 2. Effect of maltodextrins and corn syrup solids on the protein solubility (%) in mechanically deboned pork.**

| | Days of frozen storage | | | | | |
|---|---|---|---|---|---|---|
| Treatments | 0 | 2 | 60 | 120 | 180 | 240 |
| Control | 34.80[a] | 38.47[b,c] | 26.41[b] | 22.53[b] | — | — |
| 4% 5 DE[1] | 33.33[a] | 38.22[b,c] | 35.37[a] | 38.02[a] | 37.09[a] | — |
| 8% 5 DE | 38.27[a] | 42.09[a] | 37.31[a] | 40.62[a] | 40.03[a] | 34.11[a] |
| 4% 10 DE | 32.95[a] | 40.85[a,b] | 37.07[a] | 38.94[a] | 37.99[a] | 33.65[a] |
| 8% 10 DE | 34.23[a] | 39.12[a,b] | 34.95[a,b] | 38.86[a] | 36.43[a] | 31.52[a] |
| 4% 20 DE | 38.45[a] | 41.92[a] | 38.55[a] | 41.76[a] | 35.98[a] | 31.48[a] |
| 8% 20 DE | 36.13[a] | 35.36[c] | 33.50[a,b] | 41.44[a] | 38.28[a] | 26.23[a] |
| SEM[2] | 2.03 | 1.10 | 2.84 | 1.86 | 1.68 | 4.28 |
| Freezing Method | | | | | | |
| Rapid freezing | — | 39.26[a] | 35.57[a] | 38.35[a] | 37.52[a] | 34.72[a] |
| Slow freezing | — | 39.60[a] | 33.91[a] | 36.56[a] | 37.74[a] | 28.07[a] |
| SEM[2] | — | 0.59 | 1.52 | 0.10 | 0.97 | 2.71 |

[1] Dextrose equivalent.
[2] Standard error of the mean.
[a,b,c] Means with differeent letters within the same column are significantly different (P<0.05).
— = not extracted.

**Table 3. Effect of maltodextrins and corn syrup solids on the gel strength[1] (N) of protein extracts from mechanically deboned pork.**

| | Days of frozen storage | | | | | |
|---|---|---|---|---|---|---|
| Treatments | 0 | 2 | 60 | 120 | 180 | 240 |
| Control | 8.94[a] | 5.05[a] | 1.98[c] | 1.91[b] | — | — |
| 4% 5 DE[2] | 5.66[a] | 4.87[a] | 2.28[b,c] | 2.55[a,b] | 2.36[a] | — |
| 8% 5 DE | 6.59[a] | 4.41[a] | 2.61[a,b,c] | 2.52[a,b] | 2.24[a] | 2.13[a] |
| 4% 10 DE | 8.13[a] | 4.00[a] | 2.57[a,b,c] | 2.69[a,b] | 2.16[a] | 2.18[a] |
| 8% 10 DE | 7.46[a] | 4.79[a] | 3.50[a] | 3.25[a] | 2.31[a] | 2.46[a] |
| 4% 20 DE | 8.54[a] | 4.37[a] | 2.44[a,b,c] | 2.55[a,b] | 2.01[a] | 2.06[a] |
| 8% 20 DE | 8.35[a] | 4.49[a] | 3.34[a,b] | 2.66[a,b] | 2.37[a] | 2.17[a] |
| SEM[3] | 1.37 | 0.70 | 0.39 | 0.31 | 0.81 | 0.19 |
| Freezing Method | | | | | | |
| Rapid freezing | — | 4.85[a] | 2.95[a] | 2.67[a] | 2.36[a] | 2.54[a] |
| Slow freezing | — | 4.29[a] | 2.39[a] | 2.50[a] | 2.12[a] | 1.86[b] |
| SEM[3] | — | 0.37 | 0.21 | 0.16 | 0.10 | 0.12 |

[1] Protein concentration of the extract was adjusted to 35 mg./ml. N= Newtons.
[2] Dextrose equivalent.
[3] Standard error of the mean.
[a,b,c] Means with different letters within the same column are significantly different (P<0.05).
— = not extracted.

**Table 4. Effect of maltodextrins and corn syrup solids on the emulsifying capacity[1] (ml. of oil) of protein extracts from mechanically deboned pork.**

| | Days of frozen storage | | | | | |
|---|---|---|---|---|---|---|
| Treatments | 0 | 2 | 60 | 120 | 180 | 240 |
| Control | 131.50[a] | 138.75[a] | 109.25[f] | 97.00[f] | — | — |
| 4% 5 DE[2] | 143.00[a] | 142.50[a] | 123.00[e] | 110.25[e] | 94.50[d] | — |
| 8% 5 DE | 132.75[a] | 139.63[a] | 137.25[c] | 126.00[c] | 100.50[c,d] | 85.00[c] |
| 4% 10 DE | 144.50[a] | 139.00[a] | 128.75[d] | 116.00[d] | 103.00[b,c] | 88.25[b,c] |
| 8% 10 DE | 136.00[a] | 146.50[a] | 163.25[a] | 147.25[a] | 110.00[a,b] | 94.50[a] |
| 4% 20 DE | 146.25[a] | 145.38[a] | 127.75[d,e] | 117.50[d] | 102.00[c] | 89.00[b] |
| 8% 20 DE | 145.25[a] | 144.13[a] | 155.75[b] | 138.75[b] | 112.00[a] | 96.25[a] |
| SEM[3] | 6.74 | 2.76 | 1.75 | 1.85 | 2.37 | 1.19 |
| Freezing Method | | | | | | |
| Rapid freezing | — | 141.54[a] | 140.36[a] | 125.86[a] | 106.33[a] | 93.80[a] |
| Slow freezing | — | 143.00[a] | 129.64[b] | 117.79[b] | 101.00[b] | 87.40[b] |
| SEM[3] | — | 1.47 | 0.93 | 0.99 | 1.37 | 0.75 |

[1] Emulsifying capacity was measured for 10 ml. of the adjusted (35 mg./ml.) protein extract.
[2] Dextrose equivalent.
[3] Standard error of the mean.
[a,b,c,d,e] Means with differeent letters within the same column are significantly different (P<0.05).
— = not extracted.

**Table 5. Thiobarbituric acid (TBA) values in pork sausage manufactured with mechanically deboned pork previously treated with maltodextrins and corn syrup solids.**

| | Days of frozen storage of MDP | | | |
|---|---|---|---|---|
| Treatments | 14 | 60 | 120 | 180 |
| Control | 1.39[a,b] | 1.14[b] | 1.68[b] | 2.34[a] |
| 4% 5 DE[1] | 1.55[a] | 1.90[a] | 2.77[a] | 2.46[a] |
| 8% 5 DE | 1.35[a,b] | 1.06[b,c] | 1.39[b] | 1.60[b] |
| 4% 10 DE | 1.42[a,b] | 1.21[b] | 1.28[b] | 2.29[a] |
| 8% 10 DE | 1.04[b] | 1.06[b,c] | 1.16[b] | 1.67[b] |
| 4% 20 DE | 0.98[b] | 1.22[b] | 1.22[b] | 1.63[b] |
| 8% 20 DE | 0.80[b] | 0.88[c] | 0.94[b] | 1.32[b] |
| SEM[2] | 0.15 | 0.07 | 0.26 | 0.16 |
| Freezing Method | | | | |
| Rapid freezing | 1.17[a] | 1.22[a] | 1.43[a] | 1.53[b] |
| Slow freezing | 1.64[a] | 1.19[a] | 1.56[a] | 2.27[a] |
| SEM[2] | 0.08 | 0.04 | 0.14 | 0.08 |

[1] Dextrose equivalent.
[2] Standard error of the mean.
[a,b,c] Means with differeent letters within the same column are significantly different (P<0.05).

**Table 6. Tenderness scores[1] for pork sausage manufactured with mechanically deboned pork previously treated with maltodextrins and corn syrup solids.**

| | Days of frozen storage | | | |
|---|---|---|---|---|
| Treatments | 14 | 60 | 120 | 180 |
| Control | 2.29[a] | 3.01[a] | 3.29[a] | 3.48[a] |
| 4% 5 DE[2] | 2.10[a] | 2.31[b] | 2.69[b] | 2.39[b] |
| 8% 5 DE | 2.14[a] | 2.46[b] | 2.29[b] | 2.11[b] |
| 4% 10 DE | 2.02[a] | 2.17[b] | 2.26[b] | 2.26[b] |
| 8% 10 DE | 1.95[a] | 2.23[b] | 2.39[b] | 2.33[b] |
| 4% 20 DE | 2.04[a] | 2.66[b] | 2.49[b] | 2.48[b] |
| 8% 20 DE | 2.04[a] | 2.25[b] | 2.46[b] | 2.03[b] |
| SEM[3] | 0.21 | 0.29 | 0.17 | 0.21 |
| Freezing Method | | | | |
| Rapid freezing | 2.04[a] | 2.36[a] | 2.41[b] | 2.14[a] |
| Slow freezing | 2.13[a] | 2.51[a] | 2.69[a] | 2.43[a] |
| SEM[3] | 0.11 | 0.15 | 0.09 | 0.11 |

[1] Tenderness scores based on a 7-point hedonic scale.
Tenderness 1=extremely tender, 7=extremely tough.
[2] Dextrose equivalent.
[3] Standard error of the mean.
[a,b.] Means with differeent letters within the same column are significantly different ($P<0.05$).