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THE EFFECTS OF SALT, SODIUM TRIPOLYPHOSPHATE AND FROZEN STORAGE ON FLAKED, CURED PORK

by

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The Effects of Salt, Sodium Tripolyphosphate and

Frozen Storage on Flaked, Cured Pork

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INTRODUCTION

Over the last few decades the art of meat processing has evolved into a highly scientific field of study. Such concepts as hot boning of pork, continuous smokehouse operations and utilization of animal by-products serve as examples of new technology. The University of Nebraska, in cooperation with the National Pork Producers Council, has developed and continues to evaluate the concept of restructured pork. Work done by Chesney (1973), Popenhagen (1973), Belohlavy (1975) and Schwartz (1975) evaluated such parameters as flake size, flaking temperature, mixing time, salt levels and sodium tripolyphosphate concentrations on fresh pork products. It was not until this project, however, that a flaked, cured pork product was evaluated.

With the findings of the previous works in mind, this project was designed to fulfill the following objectives:

1) Evaluate the concept of flaking and curing pork to develop a product which might compete with Canadian Style Bacon either as a breakfast food or a pizza topping, and other cured and smoked pork products.
2) Determine the effect of sodium tripolyphosphate, salt and the combined effect of both on the physical, chemical and palatability attributes of a flaked, cured pork product.
3) Evaluate the effects of frozen storage on flaked, cured pork as it is affected by levels and combinations of sodium tripolyphosphate and salt.

REVIEW OF LITERATURE

For several years there has been increased interest in the area of restructured meat products, and thus technology has continued to improve and evolve. This project was developed to more fully evaluate the restructured concept on flaked, cured pork by evaluating the effects of salt, sodium tripolyphosphate (STP) and frozen storage. The review of literature which follows is addressed to a discussion of the flaking process and the effects of the treatments applied.

PROCESSING

Saffle (1968) described equipment which would cut meat into "shaved-like" particles rather than grind meat in the conventional manner. Barratt (1970) told of compressed meat products, such as steaks, which had been produced from ground meat. These products met with limited success. He continued by saying that a new development in this area is flaked meat rather than ground meat. Flaking produces products which retain their shape during and after cooking, even when stewed.

Actually, the technique of cutting thin slices of meat from inexpensive cuts and compressing them into solid pieces was introduced in the 1940's but abandoned as uneconomical (Ashton, 1973). A new machine, the Urschel Comitrol, operates on the principle of high speed centrifugal cutting. Meat, poultry or sea food is impelled at high speed across stationary, precision honed shearing edges. An agitator and feed screw provide continuous feed to the impeller where minute

heat rise and maximum retention of the meat juices can be obtained. The flakes are then blended, tempered and can be machine pressed or extruded into uniform logs (Food in Canada, 1971; Urschel Laboratories, 1973).

Work by Hansen (1960) and Anonymous (1971) indicated that such parameters as particle size and the temperature of the meat were important for the final product quality. Popenhagen (1973) studied the effects of flake size and temperature on restructured pork. He reported that flakes having passed through a 6.9 mm opening were superior to either a 3.0 mm or 12.7 mm flake at -5.6°C. At a flaking temperature of 22°C both the 6.9 mm and 12.7 mm flakes were better. When evaluating the effects of flaking temperature with the effects of flake size removed, Popenhagen (1973) found that the -5.6°C flakes had greater cooking losses than those flaked at 22°C. He concluded that warm, small flakes had the least cooking loss, were juicer, had better cohesion and in general had better overall acceptability. This work agreed with work done by Evans (1971) and Acton (1972) who showed that as the size of the flake was increased, cohesion and overall acceptability decreased.

Chesney (1973) studied the effects of flake size and found that as the size of the flake varied, proximate analysis data remained constant. He found that as the size of the flake decreased, cooking loss also decreased. Taste panels indicated a preference for products made

from small flakes, but as the size of the flake increased, juiciness and tenderness values increased. Warner-Bratzler shear values did not change with size. Chesney and Mandigo (1972) reported that water-holding capacity was not affected by flake size but was affected by flaking temperature. They concluded that small flakes (6.9 mm) manufactured at low flaking temperatures (2.2°C) yielded products with superior water-holding capacity. In reporting on the effects of flaking temperature, Chesney (1973) showed that as the temperature was altered, the percent of water, fat and ash were not significantly changed. Protein decreased as the flaking temperature was reduced. As the temperature decreased, water-holding values and shear values decreased while cooking loss increased. Chesney (1973) recommended that while products manufactured from meat flaked at 32.2°C had a better overall appearance, products made at 2.2°C were ideal.

Work done by Hansen and Mandigo (1972) showed that as the percent of warm flaked meat was increased as a percent of the meat block, the percent fat decreased. This was attributed to the increased fat adherence to the mixer as the percent of warm meat increased. They also found that as the percent of warm meat was increased, cooking loss decreased, but Warner-Bratzler shear values were not altered. As the percent of warm meat was increased, panel color scores, tenderness and overall acceptability increased. Urschel Laboratories (1973) recommend flaking temperatures between -4°C to 4°C which

is in agreement with the above work. Flaking temperatures below -4°C result in what is referred to as fractured flakes or snow.

As protein, and more importantly, protein extractibility are very critical in the quality of the final product, a very brief review of emulsion work is in order. Saffle and Galbreath (1964) showed that as the temperature of meat was lowered, the amount of protein extracted decreased. However, Acton and Saffle (1967) reported that the amount of extracted protein was not significantly affected by temperature. They also reported that the salt soluble proteins from frozen meat had a lower emulsion capacity than fresh meat. Maesso et al. (1970) showed that mixing time increased the amount of protein made available for product binding. Thus mixing is an intricate part of the restructuring process. During the mixing operation various spices and ingredients could be added, lending variability to the product. Blending increased the viscosity of a product, yielding better bind and textural properties (Swift et al. 1961 and Fenters and Ziemba, 1971). Belohlavy and Mandigo (1974) found in a study on mixing times, that shear values, firmness and proximate analysis did not change with increased time. Water-holding values increased with increased mixing time and were attributed to the increased migration of protein.

SALT

Tauber (1970) reported that salt has many uses in meat systems. Among them are such things as the extension of shelf life, flavor

development, protein solubility, fat emulsification and entrapment of small quantities of air. He also stated that salt markedly affects the textural qualities of sausage.

Amerine et al. (1965), stated that salt (saline) is one of the four basic tastes and that taste perceptions vary with individuals. The daily salt requirement for adults is about 0.5 g and the average intake is around 5.0 g (Wistreich, 1972). As Wistreich (1972) related his work to that of Amerine et al. (1965), he reported that due to the various levels of salt perceptiveness among individuals, it is better to use panel averages as an indicator of a product's saltiness. In their reporting of taste panel work, Kramlich (1971) and Wistreich (1972) showed that in products with equal concentrations of salt, coarse products appear less salty than those finely comminuted. This work was in agreement with work done by Ohashi et al. (1972b) who reported that salt was very important in the development of flavor.

Fabian and Blum (1943) reported that the threshold at which one detects salt in a given product is due, at least in part, to a cation-anion interplay. Later work by Johansson et al. (1973) proved women to have a lower salt threshold than men but concluded that taste perceptions vary with all individuals. Some work has been done which indicates detection thresholds for salt and Mandigo et al. (1972) showed that panelists consistentently preferred pork products containing 1.0% salt to those containing none. Pearson et al. (1962) reported that

2.5% salt in a cured ham was best while Marquardt et al. (1963) stated that panelists showed no preference for cured products containing from 1.5 to 3.0% salt.

Work by Wierbicki et al. (1957), Sulzbacher et al. (1960) and Karmas and Dimarco (1970) produced similar results by showing that as the concentration of salt was increased, water-holding capacity values and the amount of drip loss decreased. Swift et al. (1961), Swift and Sulzbacher (1963) and Trautman (1964) showed that water soluble proteins became more effective as emulsifiers when the concentration of salt was increased. They also pointed out that as the amount of salt was increased, more salt soluble proteins were made available to interact with water and fat.

The combined effects of salt and sodium tripolyphosphate (STP) have formed the basis of several research projects. One such piece of work was conducted by Ohashi and Sugano (1973) whereby a centrifugal method of water-holding capacity analysis was used to investigate the effects of salt and STP on beef, pork, chicken and rabbit. When these meats were treated with 0.3% STP in the presence of 2.0% salt, the water-holding capacity increased markedly. Flesch and Bauer (1965) found similar results but reported that when STP and salt were used together, the water-holding capacity increased beyond that seen with either of the two ingredients separately. Ohashi and Ando (1967) explained

the above findings by showing that 2.0% salt and 0.3% STP yielded products with the highest water-holding capacity.

Hamm (1963) showed that protein solubility and swelling was affected by the chlorine ion of salt which weakened the salt linkages in muscle protein allowing them to take up water. As the isoelectric point was displaced upward by the addition of salt, Hamm (1962) reported the anion becomes more firmly bound to the basic group of muscle proteins. This resulted in swelling and additional water uptake. Work done by Ohashi et al. (1972a) further explained why the water-holding capacity of meat increased with salt by studying beef. As salt concentrations were increased, water-holding capacity increased but the amount of muscle proteins in solution and the amount of free carboxyl groups containing these proteins also increased. Therefore, it was concluded that water-holding capacity increased with salt because of the liberation of metal ions which loosened the microstructure of the muscle proteins.

Maesso et al. (1970) studied the effect of salt and phosphates and found that combinations of 1 - 2% salt and 0.3% phosphate resulted in products with superior bind. They attributed this phenomenon to the increased solubility of muscle proteins and the structural rearrangement of the muscle constituents due to the presence of salt and phosphate. Patents by Hopkins and Zumont (1959) and Schlamb (1970) incorporated

the above technology whereby small pieces of poultry meat are coated with a mixture of salt and STP to minimize drip and maximize bind.

As the amount of salt is increased in a meat mixture, the stability of that mixture to heat stress is increased in a proportional manner (Vold and Groot, 1963). Work by Swift and Sulzbacher (1963) showed that the emulsion capacity and emulsion stability of water soluble proteins increased with increasing concentrations of salt and the emulsion capacity was at its maximum at pH 5.2. They also found that eliminating or restricting the amount of water in salted meat reduced the effectiveness of the salt and thus the emulsifying capacity of the meat.

Schnell et al. (1970) used cooking losses as an indication of bind. They found that as both salt and STP were increased the cooking loss was decreased and all binding properties were increased. They also showed that STP caused a decrease in the amount of protein expressed in the fluid drip while salt did not. Salt, however, caused an increase in the amount of expressed nucleic acids which were only slightly affected by STP.

Work by Kramlich (1971) agrees with the above by showing that as salt was increased, the emulsion capacity and stability were attributed to the increased solubility of actin and myosin. Trautman (1964) reported that work done at Oscar Mayer and Co. showed that as the salt concentration was increased to 10% of the aqueous phase of

the emulsion, an increase in soluble proteins and thus emulsion stability was observed. Also, as the temperature of the emulsion was raised, protein extraction was enhanced.

Salt has been shown to enhance oxidative rancidity and thus yield unacceptable products (Wistreich, 1972). Chang and Watts (1950) showed with their work on meat systems that less than 5% salt in a recipe actually inhibited rancidity. Concentrations above 15%, however, accelerated the development of rancid products. They explained these phenomena with the statement that as the concentration of salt was increased, the percentage of water was decreased. The decrease in water allows the fat to be attacked by oxygen and thus an increase in rancidity. Similar results were obtained by Moskovits and Kielsmeir (1960) where salt was found to act as a catalyst after only twenty-two hours of cooler storage. Cured meats also showed signs of salt catalyzed rancidity according to Watts (1961) and Ellis et al. (1968). They stated that catalyzed oxidation takes place in the triglycerides of frozen meat but only in the phospholipids of cooked meat. Compared with unsalted tissues, the addition of 3.0% salt to ground muscle sharply decreased the hydrolytic degradation of the muscle glycogen, significantly inhibited the autolytic decomposition of ATP and increased the solubility of the proteins of the actomyosin complex without altering the pH of the system (Pavlouskii, 1960).

SODIUM TRIPOLYPHOSPHATE

Ellinger (1972) reported that the use of several phosphates, either by themselves or in combination with one another, was feasible for use in the meat industry. Mahon and Schneider (1968) had previously shown that sodium tripolyphosphate (STP) was the best for meat. Their work took in such evaluations as water-holding capacity, emulsion stability, solubility and overall ease of use.

The U.S.D.A. (1975) allows the use of STP at a level of 0.5% for flavor protection in beef products which are to be frozen. The same level of STP is also allowed in cured pork products to decrease cook out.

Kowalewski and Dosiba (1967) reported that the consumption of polyphosphates was harmless to human health, provided that the amount consumed daily did not exceed 2.5 g of P_2O_5. They also noted that polyphosphates with a straight line configuration, of which STP is one, are safe for human consumption, but ring polyphosphates are highly toxic.

Generally, phosphates are used to improve the water-holding properties of sausage type meat products (Welhelm, 1948). They can be a single polymeric phosphate or a mixture of sodium, potassium or ammonia. Also, levels of 0.1 - 2.0% can be used to upgrade poor quality meats. In reviews by Sherman (1961b) and Oluski and Modic (1968), phosphates were shown to affect the water-holding ability of meat products but their effect on emulsifying capacity was limited.

Work completed since the time of Sherman 's (1961b) report has shown phosphates to greatly enhance the emulsifying capacity of meat. In an emulsion containing 4% coconut oil and emulsifiers, Vakaleris and Sabharwal (1970) found the addition of phosphates to increase emulsion capacity and stability. Also, Grau (1961) reported that as phosphates were increased, the water-holding capacity of sausage products increased in a like manner.

Phosphates have been used extensively in the poultry industry. Work by Kihara et al. (1971) reported on broiler meat which had been immersed in either 1.0, 3.0 or 5.0% solutions of STP for 6 hours, frozen and stored at -20°C. Drip loss decreased and water-holding capacity improved with increased concentrations of STP. No deterioration of muscle protein or fat was observed during storage which was attributed to STP. The presence of STP had no influence on digestibility, color or muscle structure. Froning (1965) soaked chicken meat rolls in a solution of 6% STP for 15 hours and found decreased cooking loss, increased moisture retention and increased tear strength in the treated rolls. He concluded that the binding properties of chicken meat were improved by adding STP. Landes (1972) found the moisture uptake of broilers to increase with increased concentration of STP. The cooking yield, juiciness and tenderness were also higher for the broilers which had been treated with up to a 12% concentration of STP. Raw deboned

turkey, coated with a 0.5% (by weight) STP slurry was firmer, showed less external gelatinization and less loss after cooking when compared to the untreated turkey rolls (Calgon Corp., 1965 and Mahon et al., 1970).

When fish fillets were dipped in a 8°C aqueous solution containing a single sodium or potassium phosphate prior to freezing at -18°C, the weight of the fluid lost on thawing after 85 days was decreased (Calgon Corp., 1965). The most effective dipping solution was found to be either 12.5% STP or 12.5% STP plus 4.0% salt.

A synergistic effect between salt and STP has been known for several years as reported by Mahon (1950) in his report on cured meat systems. Bendall (1954) saw decreased cooking loss with increased STP but noted that the loss was depressed additionally with the addition of salt. Tims and Watts (1958) and Sherman (1961a) also showed that a synergism existed between salt and STP. Their work showed that as salt and STP were added to a product, the cooking loss decreased and the water-holding capacity increased beyond the point seen with equal levels of either additive.

While continuing earlier work, Mahon (1960) and Mahon and Schlamb (1970) showed that as salt and STP were increased, their effects were additive in emulsifying fat and increasing water-holding capacity. Maesso et al. (1970) found that if a product was mixed for three minutes with salt and STP, the highest "product bind" resulted. Recent work

by Shultz and Wierbicki (1973) showed that concentrations of 0.25 - 0.5% STP reduced cooking loss. They concluded that a concentration of 0.3% STP with salt was most advantageous.

It has been shown (Hellendoorn, 1962) that phosphates significantly alter the pH of meat products. Since a direct relationship between water-holding capacity and pH exists, a review of this area is warranted (Motoc and Banu, 1967). Sherman (1961a) and Brendl and Klein (1970) reported that as the pH of a meat product was increased, the water-holding capacity of the system increased in a highly dependent manner. Work by Hamdy (1958) indicated that increased pH caused higher water-holding capacities resulting in better flavor and color evaluations. The dependency of a muscle system on pH was further demonstrated by Sayre et al. (1964). In their study, the pH at the onset and completion of rigor mortis was highly correlated with cooking loss, cooking rate and tenderness of the muscle.

Miller et al. (1968) found that the water-holding capacity of meat systems was significantly lower at pH 5.5 than at a higher pH. No significant differences in water-holding capacity were found in the pH range of 6.0 to 6.5. The water-holding capacity was the greatest in the 6.0 to 6.5 range. Significant differences were found among pre-rigor, post rigor and frozen meat samples for the water-holding capacity as determined by both the centrifuge and cooking procedures. Water-holding

capacity decreased as the fat level of the meat was increased due to the increase in the moisture/protein ratio. In meat cooked to an internal temperature of 65°C, Bouton et al. (1971) showed that cooking losses decreased in a linear fashion over the entire pH range of either raw or cooked meat. Cooking losses at 95°C showed little change until pH 5.9 (raw) or 6.2 (cooked). They then decreased linearly with increased pH. Juiciness, expressed in terms of cooking loss, and centrifugally expressed fluid, generally increased with increased pH.

In studies on the effects of various phosphates on the pH of raw beef, Shultz et al. (1972) found tetra-sodium pyrophosphate to be the most effective in raising the pH while sodium metaphosphate had practically no effect. Hexametaphosphate also had little effect, and STP affected pH slightly less than did tetra-sodium pyrophosphate. The relative effects of the phosphates on meat swelling were comparable to their effects on pH. Tetra-sodium pyrophosphate appeared to be the most useful phosphate for meats in which binding of added water was important. In the absence of salt, tetra-sodium pyrophosphate had the strongest effect on water binding; however, the ability of STP to act synergisticly with salt made it the best phosphate to use in meat systems.

Inklaar (1967) initiated studies to determine whether added STP complexed with Calcium (Ca) in meat, and to determine the amounts of Ca and Magnesium (Mg) bound to meat proteins. He found that STP did not complex with Ca bound to meat proteins. Approximately 60% of the