Influence of Salt Concentration in Animal Products on Human Health and Safety

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INTRODUCTION

Salt is commonly added in processing of meat, poultry, and fish products. It lowers the water activity (a_w), which helps in preventing growth of both spoilage and pathogenic microorganisms. Salt intake, however, has some adverse health effects, more particularly upon hypertension, which has been related to an increased incidence of coronary heart disease (CHD) and stroke.

OBJECTIVES

In this paper we will review the advantages of salt in preventing growth of pathogenic and spoilage organisms on the safety of processed meat, poultry, and fish products. We then will discuss the rationale for reducing salt intake and its beneficial effects on human health. Finally, we will point out the importance of considering safety and human health together in balancing the equation on salt levels in animal products.

SAFETY AND REDUCTION IN SPOILAGE

Muscle foods in the raw unprocessed condition are ideal media for the growth of both food pathogens and spoilage organisms. They must either be used promptly, held under carefully controlled refrigerated temperatures, or else be preserved by addition of salt and/or heat. In many underdeveloped countries of the world refrigeration is not available, so salt and/or heat are used to lower the a_w and preserve muscle foods. The a_w of muscle foods is about 0.98, which renders them highly perishable. Addition of salt and/or drying rapidly lowers the a_w to 0.90 or lower (0.60), which is equivalent to a relative humidity of 90 to 60%, respectively (Leistner, 1987). Some cured products can be held at ambient temperatures without spoilage or in most cases without growth of pathogenic microorganisms. Most countries produce some characteristic intermediate-moisture (IM) products as discussed by Chang et al. (1996). Salt accelerates drying and lowers the a_w, which aids in preventing both spoilage and food poisoning (Leistner, 1987). Williams (1997) has discussed the role of salt in preservation of meat, poultry, and fish products and some procedures for reducing amounts used in processing.

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ROLE OF SALT IN THE DIET

Salt (sodium) is an essential nutrient that the body requires but does not retain in any appreciable stores. Thus, a certain minimum dietary intake is necessary to maintain normal body functions as summarized by Sebranek et al. (1983). Sodium provides the proper osmotic balance in the extracellular fluid. Extracellular sodium and intracellular potassium act in concert to create the cell membrane environment that is needed for transmission of nerve impulses, muscle function, and cellular utilization of many different metabolic products. The most obvious effect of sodium, however, is its effect on extracellular fluid volume, which has led to its implication in the etiology of hypertension. The sodium concentration in the extracellular fluid is regulated by a number of renal, neural, and hormonal mechanisms as summarized by Pearson and Wolzak (1982).

REQUIREMENTS FOR SODIUM AND DIETARY INTAKE

Svetsky et al. (1996) concluded that the physiological requirements for sodium are between 0.2 and 0.5 g/day, while average intake in U.S. adults amounts to about 3.5 g/day (Dietary Guidelines Advisory Committee, 1995). The Food and Drug Administration (FDA) has established the daily reference value for sodium as being 2.5 g/day, which means intake far exceeds requirements and the recommended value (Federal Register, 1991).

Sodium in the diet is derived from three sources: (1) the amount that is naturally present in food and water; (2) the amount added in processing; and (3) that added at the table by the consumer. The first two sources are classified as "nondiscretionary," since the individual has little choice if he/she eats the foods, while the latter is called "discretionary" since the consumer completely controls the amount of salt added. With the advent of low salt products, however, one has some choice in consuming or not eating processed products.

SODIUM AND HYPERTENSION

Epidemiological evidence presented by Altschul and Grommet (1980) suggests that physiological needs for sodium are quite low, with consumption in some nonindustrialized cultures being extremely low. These populations are apparently very efficient in recycling sodium, which accounts for their efficiency and low dietary requirements. These groups also are characterized by having a low incidence of hypertension. It should be remembered, however, that epidemiological data should not be construed as being optimum. On the other hand, it is known that salt consumption is positively correlated with hypertension and the incidence of coronary heart disease (CHD) and stroke as pointed out by Antonios and MacGregor (1997), who concluded that even a modest reduction in salt consumption may be beneficial in reducing hypertension and the closely related incidence of CHD and stroke.

INCIDENCE OF HYPERTENSION

Tobian (1979) reviewed the effects of sodium intake on blood pressure in normal and hypertensive individuals and concluded that 9-20% of the U.S. population is genetically susceptible to sodium-induced hypertension. This estimate is probably low because the incidence of hypertension increases with age, which is not taken into account by these data. For example, if the data were calculated for age 60 and older, it would likely show a coincidental increase along with blood pressure.

EFFECTS OF CALCIUM AND POTASSIUM IN COUNTERACTING HYPERTENSION

It is well known that the incidence of hypertension is lower in both humans and rats in geographic areas where the water has a high concentration of calcium and magnesium. Supplementation with calcium was shown by McCarron et al. (1982) to decrease blood pressure in both species. It was also observed that some patients with high blood pressure failed to respond to sodium restriction, whereas, addition of calcium resulted in a reduction to normal. The mechanism by which calcium exerts its influence may be through prostaglandin synthesis, which enhances both renal excretion of sodium and vasodilation.

The role of potassium in reducing hypertension has been discussed by Antonios and MacGregor (1997), who pointed out a substantial body of evidence suggests that potassium intake tends to lower blood pressure. The mechanism appears to be by counteracting the action of sodium in the extracellular fluid by the greater amount of potassium in the intracellular compartment. There are, however, limits to this mechanism so that reduction of sodium is still necessary.

INFLUENCE OF SALT ON CALCIUM EXCRETION AND OSTEOPOROSIS

Antonios and MacGregor (1997) concluded there is a substantial body of evidence that high salt intake contributes to an increase in urinary calcium excretion. The end result can be bone demineralization and osteoporosis. A recent report from Australia followed 100 postmenopausal women for two years and found that those consuming the most sodium lost the most calcium in their urine, which was accompanied by greater bone loss in their hips and ankles (Nordin et al., 1993). This translates into a requirement for about an additional 1,700 mg of calcium per day. Their calculations indicate that reduction of sodium intake by 1200 mg/day would lower the daily calcium requirement by 200 mg/day.

OTHER ADVERSE EFFECTS OF HIGH SALT INTAKE

Antonios and MacGregor (1997) have summarized information on other negative effects of high salt intake on human health. There is some evidence, although not conclusive, that high salt intake is a powerful independent risk factor for congestive heart failure, coronary artery disease and sudden death (Kannel et al., 1969). This may be related to left ventricular hypertrophy, which seems to be independent of the effects of blood pressure (Antonios and MacGregor, 1997). Excess salt intake may also be related to renal injury, bronchial asthma, and cancer (Antonios and MacGregor, 1997). Puolanne (1995) has reviewed labeling requirements for salt content in cooked Finnish sausages aimed at reducing sodium intake in view of its adverse health effects.

EFFECTS OF SALT ON OXIDATION OF ANIMAL PRODUCTS

Salt is added to processed meat for its sensory, functional, and preservative properties. It is widely recognized that salt may initiate undesirable color and flavor changes in meat. Possible mechanisms by which salt could initiate prooxidant activity include activation of lipoxygenase enzymes, displacement of iron from macromolecules by the sodium ions, alterations in the reactivity of iron by the chloride anion, and salt-induced changes in cellular organization. These proposed mechanisms have been reviewed by Gray and Crackel (1994) and Kanner (1994) who concluded that the effect of salt on the catalysis of lipid oxidation in foods, especially in muscle foods, needs further clarification.

SUMMARY

Salt added in processing of meat, poultry, and fish products lowers the a_w to 0.95 or below, which decreases the incidence of spoilage and aids in preventing growth of food poisoning microorganisms. Added salt, however, increases hypertension in salt sensitive individuals, which comprise from 10-20% of the population—an estimate that is probably too low. High salt intake also increases urinary calcium excretion, which can lead to bone loss and development of osteoporosis. Excessive salt consumption also may contribute to cardiac hypertrophy, renal disease, bronchial asthma, and cancer, although the evidence is not conclusive. Salt also is a prooxidant and contributes to oxidation of muscle foods. Overall there are sound health reasons to decrease the concentration of salt in animal products, as even moderate reductions are beneficial. The health benefits, however, must be balanced against greater safety and reduction in spoilage.

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