STUDIES ON PRESERVATION OF POULTRY MEAT BY CURING

By

NAGENDRA SHARMA

B. V. Sc. & A. H.

Post-Graduate College of Animal Sciences,

INDIAN VETERINARY RESEARCH INSTITUTE,

IZATNAGAR (U. P.)

THESIS

Submitted to the Agra University, Agra

in partial fulfilment of the requirements for the degree of

MASTER OF VETERINARY SCIENCE

IN

(POULTRY SCIENCE)

Izatnagar

April 1972

Dr. T.D. Mahadevan,
B.Sc., Ph.D.,
JUNIOR POULTRY TECHNOLOGIST,

Division of Poultry Research
Indian Veterinary Research Institute
Izatnagar (U.P.).

This is to certify that the thesis entitled "Studies on Preservation of Poultry Meat by Curing", embodies the result of work actually carried out by Shri Nagendra Sharma, Research Fellow (I.C.A.R.), under my supervision and guidance for the award of the Degree of Master of Veterinary Science (Poultry Science) of Agra University, Agra, during 1971-72.

(T.D. MAHADEVAN) 15/4/72

Izatnagar
Dated 15th April, 1972.

***

I. V. R. I. Izatnagar (Agra University)

THE AUTHOR GRATEFULLY ACKNOWLEDGES THE FINANCIAL ASSISTANCE GIVEN BY THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH, KRISHI BHAVAN, NEW DELHI, BY WAY OF AWARD OF A JUNIOR FELLOWSHIP DURING THE ENTIRE PERIOD OF MY STUDY.

I. V. S. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

ACKNOWLEDGEMENT

The author acknowledges the invaluable help, enlightened guidance, constant advise and encouragement received from Dr. T.D. Mahadevan, Junior Poultry Technologist, Division of Poultry Research, Indian Veterinary Research Institute, Izatnagar (U.P.), during the course of this study and also in the preparation of the manuscript.

The author is greatful to Dr. B. Panda, Head, Division of Poultry Research, Indian Veterinary Research Institute, Izatnagar for suggesting the present problem and the interest taken and the laboratory facilities provided for undertaking this course of work. But for his unstinted support it might have been difficult to complete this problem.

The author expresses his gratitude to Dr. C.H. Singh, DIRECTOR, Indian Veterinary Research Institute, Izatnagar (U.P.), and Dr. G.L. Sharma, Principal-cum-Jt. Director, Indian Veterinary Research Institute, Izatnagar, for providing necessary facilities to conduct the present study.

The author takes the opportunity to extend his sincere indebtedness to Dr. S.C. Mohapatra, Professor of Poultry Science and Dr. V.R. Sadagopan, Assistant Professor of Poultry Science, for their help and criticism in course of present investigation.

Dr. A.S. Narula, Assistant Bacteriologist, Dr. M.Y. Khan, Asstt. Lecturer H.V.C., Dr. R.C. Katiyar, Junior Animal Nutritionist

and Shri S.S. Verma, Assistant Poultry Technologist, have been of great help and assistance in the study of bacteriological and biochemical aspect of this problem. Their assistance and ungrudging cooperation are thankfully acknowledged.

Mention must be made of the constant help given to me by Shri T. Kotaih, Shri R.R. Pandeya and to my sister Mrs. Kanti Sharma.

I am also thankful to Shri B.S. Sharma, Junior Statistician for his valuable help in the statistical analysis of the data.

Last but not the least I am thankful to Dr. H.S. Sinha, Research Officer, Genetics, Bihar, who has encouraged me for undertaking the post-graduate study.

I am thankful to my villager Shri Ramanuj Prasad Singh and Shri Chandra Bhusan Prasad Singh, for their help to me and affection shown to me and my family members during my absence.

My thanks are due to the Officers and Staff of the Poultry Research Division. Laboratory Assistant - Shri Sabundas and Lab. Attendant- Shri Mahesha Nand Dhyani of Technology Laboratory, require special mention for their constant help and assistance during my study.

I am thankful to the Director, Animal Husbandry, Bihar, for providing me extra-ordinary leave during this study period.

I. V. R. I. Izatnagar (Agra University)

CONTENTS

			Page
CHAPTER I			
Introduction	...	...	1-4
CHAPTER II			
Review of Literature	...	...	5-25
CHAPTER III			
Material and Methods	...	...	26-39
CHAPTER IV			
Result	...	...	40-62
CHAPTER V			
Discussion	...	...	63-73
CHAPTER VI			
Summary and Conclusion	...	...	74-78
BIBLIOGRAPHY	...	...	79-92

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

CHAPTER I

Introduction

I N T R O D U C T I O N

"If a problem confronts us, we should face it, study it in all its aspects and never evade it until it is solved"

--------Morgan "Keeping a sound mind"

The major problem confronting human race is the population explosion. The enormous increase in human population with inadequate space required to grow sufficient foods is causing great stress on the progress of the human race. The problem now confronting us is to give more and more concentrated food so that the demands made by the body are adequately met and this brings in what is known as protein Hunger.

Protein from animal source is certainly superior in quality to plant sources. Poultry meat is very useful in helping to meet the nutritional needs of increasing under-nourished population. Poultry have a shorter life cycle and are much more prolific than larger livestock. Poultry are also relatively easy to raise, are adaptable to wide range of climatic conditions and high altitudes. It is one of the best converters of poor quality cereals and other agro-industrial byproducts into high quality protein feeds.

In developing and breeding new strains of poultry for meat production, there has been an increasing appreciation of the need

I. V. R. I. Izatnagar (Agra University)

for devoting more attention to processing, preserving and handling of the meat for market. For an efficient production programme to continue and for economical return for the producer, it is necessary to have a proper marketing procedure and technique; otherwise a good job done by producing high quality product often breaks down due to want of proper marketing system. Poultry meat like any other meat is highly perishable due to its high biological value. It must be expertly and efficiently processed for marketing. Since there has been significant increase in poultry production in India in the last decade (Panda 1966), marketing poultry products is facing many problems due to inadequate refrigeration facilities. In the absence of well developed refrigeration facilities some suitable methods should be evolved to facilitate the preservation, transportation and marketing of poultry meat which can avoid loss of this highly valuable feed.

In marketing of poultry meat, preservation, transportation appearance and condition of the meat are very vital factors. Poultry meat technology has to take into consideration the point of view of the consumer to maintain quality factors and give proper returns to the producer so that it gives him proper incentive and encouragement.

Bacteria are the main causative agents for spoilage of poultry meat. Poultry meat contains an abundance of all nutrients require for growth of bacteria.

I. V. R. I. Izatnagar (Agra University)

Many methods have been developed to check, if not prevent or destroy these bacteria from goowing. Some of them are drying, curing and smoking, storing under low temperature, canning, application of some chemicals and irradiation.

Curing of meat is a very old method and it has been tried by many workers abroad for preservation of poultry meat - Basley and Marsden (1941), Miner and Marsden (1961), Hindman et al (1963) have reported from U.S.A. Curing of ducks is a common method of preservation in Philippines. In India, Chatterjee et al (1971) have also tried curing and smoking for preservation of poultry meat.

Curing of meat is carried out with the prime object of enhancing its keeping quality and flavour. Cured meat is the product obtained by subjecting meat to a process of salting. Salt is used either in dried condition or as brine, Other chemicals are also added to complement salt used for curing. Most common curing additives are sodium nitrate, sodium nitrite, sugar, sodium polyphosphate, monosodium-glutamate and other spices. After curing, meat is smoked in hard wood smoke which acts as a complement to curing.

Research workers have tried the use of antibiotics and irradiation. But an importanct objection to antibiotics is that harmful effects may result from long term inclusion of antibiotics in the diet. Wide spread use of antibiotics in feed may encourage the appearance of antibiotic resistant strains among pathogenic bacteria present in gut.

I. V. R. I. Izatnagar (Agra University)

Irradiation of meat and meat products have not proved very successful as the finished products have lost much of its colour, taste and flavour, when large doses of irradiation is used. Smaller doses of irradiation have not been sufficient to kill the micro-organisms in the meat. However, irradiation above 10 mev (million electron volts) intensity induced radioactivity in the final products.

Low temperature is the best method for preservation of poultry meat. Since refrigeration facilities are not easily available in India, this method is not of much use. As such other methods can be easily used by producer and at the same time not harmful to the consumer.

Keeping in view all these facts, an attempt has been made to cure and smoke poultry meat for extending its shelf life in ambient temperature and to facilitate its easy handling and transportation from centre of production to the point of consumption.

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izetnagar (Agra University)

CHAPTER II

Review of Literature

I. V. R. I. Izatnagar (Agra University)

CHAPTER II

REVIEW OF LITERATURE

MICROBIAL SPOILAGE OF POULTRY

Presumably 8,000 years ago, man first encountered problems of spoilage of meat due to improper storage. 'A Kircher' - (1958) was perhaps the first man to suggest the role of microorganisms in spoilage of food. He thought them as 'worms' invisible to the naked eye (cited by Jay, 1970). L Pasteur (1837) for the first time appreciated and understood the presence and role of microorganisms in food spoilage.

Spoilage of poultry meat is mainly due to the presence of microorganisms on the body surface. Primary spoilage organisms at lower temperature belongs to the genus Pseudomonas (Ayres et al. 1950, Nagal et al. 1960), Barnerand Impey, 1968). Gunderson et al(1954) after his two years of investigation of poultry and poultry products tabulated these species - Achromobacter, Aerobacter, Alcaligenes, Escherichia, Bacillus, Flavobacterium, Micrococcus Paracolobactrum, Proteus, Pseudomonas, Staphylococcus, Corynebacterium and Salmonella. Woodburn et al (1966) observed the presence of coliforms and Enterococci in considerable numbers on ready-to-cook frying chicken which was collected from 10 different retail stores in four seasons.

On the skin surface of live birds approximately 1,500 organisms per sq.cm. are present and about 35,000 per sq.cm. on skin of freshly processed birds have been reported by Walker and Ayres (1956). According to Ayres et al (1950) microbial count on cut up poultry was higher than whole carcasses but Woodburn et al (1966) found cut up birds were not significantly different from whole birds in

number of viable organisms.

Gunderson et al (1946 and 1947) and Nagal et al (1956) observed very many sources of contamination of poultry meat during processing procedures. They observed scald tank water as continuous source of bacterial contamination in poultry processing plants. They advocated constant change of scald water. They also noted that through vent, faecal material was a great source of bacterial contamination of dressed chicken.

Edwards (1939) considered poultry to be the largest single reservoir of salmonella infection in U.S.A. Wilson et al (1961) reported about 15 percent incidence of salmonella from market birds of Ohio area. Woodburn (1964) reported incidence of salmonella in dressed broiler fryer chicken in 27 percent cases examined.

Offodour and sliminess is an evident sign in poultry spoilage. While working with eviscerated cut up poultry Ayres et al (1950) observed an sliminess when the bacterial load was 10^8 per sq.cm. May et al (1961) and Clark (1970) reported that Psychrotolerant pseudomonads and Achromobacter grew faster on skin than other muscle tissues.

Adamcic et al (1970) were of opinion that the pigmented variety of pseudo-monas are more proteolytic among the common psychrotolerant types of bacteria. They also have noted that collagenase is present in pigmented group of bacteria. They have shown that after offodour had developed in the meat, there is an increase in free and total extractable proline and hydroxyproline indicating thereby that collagenous proteins were attacked at the time of putrefaction. Shelef and Jay (1969) observed that in the first phase of spoilage of meat at lower temperatures the source of nutrient to microflora

I. V. R. I. Izatnagar (Agra University)

consists mostly of soluble non-protein substances specifically lactic acids, glucose and others free aminoacids and the nucleotids are also utilised. The above authors also noted that the bad odour in spoiling meat was mostly due to production of H_2S from sulfur containing acids, NH_4 from many aminoacids and other related compounds and indol from tryptophan. The primary proteins of meat are probably not attacked until the supply of simpler constituents has been exhausted (Larke et al (1963).

In spoilage of cured meat the role of Pseudomonas is not important due to inhibiting effect of salt. Pseudomonas in this case is replaced by micrococcus (Ingram and Dainty, 1971).

Hansen (1960) and Cavetta (1962) observed that when cured meat is packed in oxygen impermeable, wrapper, the oxygen that is present in the wrapper is rapidly utilised by the tissues and microflora present for their respiration. With the change in atmosphere in the wrapper, oxygen being replaced by carbon-dioxide, the type of bacteria also change; enterococci succeed in developing intially but ultimately lactic acid bacteria predominate.

Ross (1965) reported from few clostridia (clostridium putrefaciens) capable of growing at intermediate temperature in cured meat. This species produces not putrefaction but highly characteristic sweet/sour odour, the nature of which is unknown. Ham spoiled in this way produced no ill effect when eaten after cooking(Ingram,1971)

Jay (1970) observed that smoked cured meat becomes relatively less susceptible to spoilage by bacteria. The most common form of spoilage in smoked-cured meat is caused by molds, which may be aspergellus, mucor, botrytis, penicillus, albernaria and other molds.

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

SALT AND SUGAR

Between 3000 B.C. and 1200 B.C., the Jews employed salt from the dead sea for the preservation of various foods. The Chinese and Greeks used salted fish in their diets aroung this time and are credited with passing this practice to the Romans, who included pickled meat in their diet. Since long, salt was used as a preservative for meat and meat products. But its application was just a rule of thumb, Rockwell and Eberts (1924) concluded that at least five factors are involved in the preserving action of sodium chloride. According to them they are (a) Dehydration (b) Director effect of chloride a ions (c) Removal of oxygen (d) Sensitization to carbon-dioxide and (e) Interference with rapid action of proteolytic enzymes.

Hamm (1957), Hamm and Grau (1958) and Grau (1961) observed that if salt is added to ground meat, two effects were markedly observed - (1) the pH value of meat decreases with increasing amount of salt content and (2) addition of salt (5-6%) has a large effect on water binding capacity of muscle. Change in pH and increase in water binding capacity of meat is due to the change of the electrostatic changes of meat proteins. The binding of water brings about a disruption of peptide chains resulting in swelling of muscle proteins. The increase water binding capacity, due to sodium chloride is effective even when meat heated up to 70°C has been reported by Wierbicki et al (1957). They observed that when NaCl was added to meat prior to freezing, less drip was obtained on

thawing. Hamm and Iwata (1962) reported that when meat is heated at 50°C for 60 minutes in the presence of NaCl there is an increase in water retention for the time being but gradually the water binding capacity decreases with increase in pH. But no change was observed at 30°C.

Grau (1961) reported that when the salt concentration is very much increased water binding capacity of meat decreased and meat starts to shrink. Many water soluble components of meat such as proteins, carbohydrates, minerals, enzymes and vitamins show their presence in the pickle solution.

Sherman (1962) observed that water retention capacity of meat is linearly related to concentration of salt ions absorbed.

Beeley and Marsden (1941), while working with curing of turkey meat, reported that when tendon from leg was removed penetration of salt into drumstick muscle was increased. Further they found that penetration of salt in to muscle depends on concentration of salt in pickle and keeping time of muscle under curing pickle.

Smith et al (1951) found little difference in penetration of salt between coarse and fine grained salt.

Grau and Bohm (1958) observed no difference in speed of penetration of different grades of kitchen salt in the meat.

I. V. R. I. Izatnagar (Agra University)

Wistreich et al (1959) found that by increasing the temperature penetration of salt is increased but there is no linear relation between temperature and penetration.

Chatterjee et al (1971) reported, cured smoked chicken kept at higher temperature was having higher salt content in both dark and light meat than those stored at lower temperature. They also mentioned that this finding agrees with observations of Moulton and Lewis (1940) that salt diffuses rapidly at higher temperature.

Pantaleon (1959) as cited by Grau (1961) observed that penetration of salt into meat is through diffusion due to changed osmatic pressure of systems and reaction between salt and proteins.

Chatterjee (1968), Borys et al (1969) and Starzenski et al (1969) observed that salt penetration depends on nature of tissues and anatomical characteristics of the tissue.

Contamination of salt with Ca and Mg reduces penetration as per Bulgarian Workers and cited by Grau (1961), but other group of workers from the same country contradict this. According to the latter workers hard water increases penetration of salt, whereas soft and distilled water retards it (cited by Grau, 1961).

Shewan (1955) suggested that salt contaminated with cooper causes Maillard reaction and Browning of cord muscle during curing.

Ingram (1949), Grau (1951) and Tilgner (1956) found that a raw salted meat was having less salty taste than a cooked salted

I. V. R. I. Izatnagar (Agra University)

meat under the same condition of water and salt content. They further observed that cooked ham of lower pH value had a more salty taste than one having higher pH, both having the same salt content (cited by Grau, 1961).

Osmanjones (1949) reported about bacterial inhibition property of salt and was of opinion that there was no growth of microorganisms in concentration exceeding 13 per cent of salt in meat.

Liston and Shewan (1958) reported that during curing the gram negative groups specially the Pseudomonas and Flavobacter species decrease in concentration at the expense of grampositive type (micrococci and coryneforms).

Cavett (1962) obtained result indicating that both salt concentration and temperature have an effect on the spoilage flora of vaccum packed bacon.

Genigeorgis et al (1966) reported that as salt concentration increased, a higher pH level is needed for growth of staphylococci.

Pivnic and Thatcher (1968) showed that meat containing 10^6 spores/gram remained non-toxic for 18 months at 30°C if it contained 6.2 percent salt but became toxic if less salt was added. They also found that NaCl with $NaNo_2$ have a synergestic effect on inhibition of toxin producing bacteria.

Mclean et al (1968) observed that the level of NaCl above 2-3 percent had been found to inhibit production of entro-toxin B. But Genigeorgis et al (1966) reported that strain S^6 produced entrotoxin with cured ham under anaerobic conditions with brine

I. V. R. I. Izatnagar (Agra University)

containing 9.2 percent NaCl. These workers further reported that no anaerobic production of entrotoxin occured below pH 5.30 at 30°C or below pH 5.58 at 10°C.

Bem et al (1969) reported that there was no increase in bacteria during quick curing.

Ingram and Dainty (1971) reported that sodium chloride at a concentration of 5 percent partly inhibited and at 7 percent totally inhibited the growth of putrifying Pseudomonads in fresh meat. They also indicated that the ability of salt may either be due to the inhibition of the proteolytic power of pseudomonas or interfere with the metabolism of amino acids which leads to the production of evil smelling compounds or both.

Fournaud et al (1971) reported that one commercial red salt was having as much effective bacteriocidal property as nitrite.

Kondereski (1971) reported that Aerobic spore forming bacteria, Clostridia, were more sensitive to inhibitory effect of cooking salt than cocci.

Greenwood et al (1940) noted that sugar contributes to setting up of a reducing condition during curing. According to Horowitz-wlassowa (1941) bacteria of subtilis group form acetylomethyl carbinol from sugar. This compound is easily oxidized and so it protects nitrite from oxidation.

Grau (1955) observed that small amounts of sugar in curing solution have advantageous effect, as it increases flavour, tenderness, colour change etc. Over and above, sugar contributes to the maintenance of optimum pH.

I. V. R. I. Izatnagar (Agra University)

Marshall (1963) reported that the use of light brown sugar with sodium nitrate and salt in pickle solution was ideal for fryers (cited by Chatterjee *et al*, 1971).

Mihalyi (1969) came to the conclusion that ham treated with starch syrup or with saccharin had the best taste.

***

I. V. R. I. Izatnagar (Agra University)

NITRATE AND NITRITE

Under modern marketing system dressed poultry is sold pre-packed in transparentwrapper and sales depend on the visual appearance of the product. Nitrate and nitrite are added in curing of meat for colour fixation and for its bactericidal property.

Bassly and Marsden (1941), Malcolm et al (1957) and Hiner and Marsden (1961) have described the use of saltpeter in turkey curing. Chatterjee et al (1971) reported the use of sodium nitrate and nitrite in chicken curing.

It was shown by Haldane (1901) that the characteristic colour of cured meat is due to nitrosylmyglobin, a complex in which nitric oxide has combined with reduced of the muscle pigment.

Brooks (1937) showed that sodium nitrite reacted with haemoglobin to yield exclusively nitrosylhaemoglobin only in the presence of a reducing agent such as dithionite.

Jensen and Hess (1941) found that nitrate was reduced to nitrite and nitrite was further reduced to hydroxylamine.

Tarr (2944) showed that in lingcodflesh stored for 3 days at 10°C sodium nitrate was reduced to nitrite and nitrite was further reduced.

Castall (1949) reported that a very large proportion of bacteria on cod fillets reduced nitrate to nitrite.

Eddy and Ingram (1956) found that nitrous oxide and nitrogen were produced from nitrate by Bacilus species which was isolated from a blown can of bacon.

I. V. R. I. Izatnagar (Agra University)

Niinivaara and Pohja (1957) observed various species of micrococci, Bacilli, Sarcina, alkaligens and aerobacter reduced nitrate to nitrite and thus contributed to the formation of red colour of cured meat.

Eddy (1958) and Patterson (1963) found that most micrococci which develop on cured meat are capable of reducing nitrate to nitrite and if their number became large, this reduction may lead to the production of undesirably high concentration of nitrite.

Eddy et al (1960) remarked that loss of nitrate does not occur if the growth of bacteria on the surface of meat is reduced by swabbing with a solution of formaldehyde.

Buttiaux (1963) reported that bacteria which bring about satisfactory reduction of NO_3 to NO_2 in a pickling medium belongs to the group, vibrio.

Chatterjee (1968) observed that in a curing mixture only nitrate was added but in cured has nitrite was present in substantial amount which must have come ffom reduction of nitrate by bacterial process.

Walter and Tayler (1963) reported that nitrite but not nitrate, can be metabolised anaerobically by enzyme system persisting in postmortem muscle tissue without the necessity for bacterial interventions; nitric oxide is a product of the metabolic action.

Tayler and Walter (1967) confirmed that under anaerobic conditions skeletal muscle mitochondria can utilise nitrite with the formation of nitric oxide. Bacterial flora of curing pickle,

I. V. R. I. Izatnagar (Agra University)

though active in the utilisation of nitrate and nitrite, do not produce nitric oxide. They further state that tissue enzyme cytochrome oxidase, appear to be the sole agents for producing nitric oxide and production of cured meat colour and not bacteria.

Takagi (1971) reported that during short curing (1-7 days) reduction of nitrate to nitrite by nitrate reducing bacteria is so small that it is difficult to develop cooked cured meat colour. Further he observed that nitrate was reduced more slowly in the presence of nitrite then in its absence during short curing.

About bacterial inhibitory action of nitrite, Richardson (1970), Quastal and Wooldridge (1927) thought that nitrite may be able to inactivate bacterial enzyme by combining with aminogroups.

Tarr (1941a and 1942a) reported that both in fish muscle as well as in culture media, bacteriostatic effect of sodium nitrite was critically affected by pH. The bactericidal activity of sodium nitrite was feeble or absent at pH 6.5 or above. He further found that growth of clostridia was inhibited at 200 ppm of sodium nitrite at low pH.

Bernheim (1943) suggested that nitrous acid, produced from nitrite, having bactericidal effect combines with amino groups of certain enzymes.

Sciariniand Nord (1944) obtained evidence in support of the fact that nitrous acid combines with amino groups of Grboxylase causing inhibition and that a diazo compound is formed.

I. V. R. I. Izatnagar (Agra University)

Bose et al (1954) found that ice containing both sodium nitrite and sodium chloride were more effective in preserving fresh water fish than those containing nitrite alone.

Castellani and Niven (1955) reported that the antibacterial activity of nitrite increases as pH is lowered within acid range. This effect is accompanied by an overall increase in the undissociated HNO_2. Further he found that microbial inhibition is reversed by the addition of sulfhydryl compounds such as thioglycolic acid and cystine. This finding suggests that nitrite or one of its breakdown products interferes with the sulfur nutrition of susceptible microorganism.

Pivnick and Bird (1965) observed that moderate increase of sodium chloride along with 62 ppm of sodium nitrite prevents the toxigenesis by clostridium batulinum type A, B and E to a remarkable extent in cooked, vaccum packed meat in plastic pouches.

Maclean et al (1968) reported that production of staphylococcal entrotoxin B could be inhibited by 2-3 percent salt but nitrite at the concentration allowed in cured meat have no effect on production of this entrotoxin.

Bullerman et al (1969) revealed that during aging of salami and cured ham specially in the presence of pepper, sodium nitrite tends to reduce the amount of aflotixins.

Dyer (1949), Dyer and Castell (1949) observed that nitrite was reduced on storage.

I. V. R. I. Izatnagar (Agra University)

Shewan (1950) reported significant reduction in nitrite content of iced cod fish during storage. He found achromobacter species which perhaps reduced nitrite to free nitrogen and a little ammonia.

Eddy et al (1960) observed that substantial quantity of nitrate can be lost from maturing bacon without any corresponding accumulation of nitrite. They feel that some nitrite may disappear through purely chemical reaction with meat constituent i.e. heme products and amino compounds.

Pivnic et al (1967) reported that nitrite is not completely stable during cooking and subsequent storage. Temperature and storage are very important factors. They found that nitrite was lost 2 to 3 times more at 30°C than at 20°C.

Hordin (1969) remarked that the rate of nitrite loss was proportional to its concentration and increased with temperature or lowering of pH. At room temperature a surprisingly rapid loss in nitrite was found, caused by bacterial consumption unless the product was sterilised.

Takagi et al (1970) concluded that the composition of nitrite in cured meat was affected by curing periods, cooking temperature, cooking time, pH of meat, period of storage and raw meat used.

I. V. R. I. Izatnagar (Agra University)

Wieckerham (1957), Ingram and Dainty(1971) reported that yeast may be responsible for the fall of nitrite concentration which commonly occures in the latter stages of storage.

Cho and Fratzler (1970) observed the flavouring effect of nitrite. Pork cured with sodium nitrite when roasted had more cured pork flavour than only salt cured pork. Even smoke did not mask this flavour.

***

I. V. R. I. Izatnagar (Agra University)

OTHER ADDITIVES (MSG, ASCORBIC ACID AND TRIPOLYPHOSPHATE)

Barry (1949) reported that discovery of monosodium glutamate (MSG) was made by Ikadak in 1909 in the course of his investigations on the protein constituent of a sea weed (Laminaria japonica-renamed Pleurophycus japonica). He mentioned that the pure substance had little or no taste when taken in a medically clean mouth, but if protein is present its natural flavour is accentuated.

Kraybile (1955) found high degree of preference when monosodium glutamate was added in bacon curing.

Neukom (1956) also observed that monosodium glutamate is practically tasteless but it intensifies the flavours of certain foods.

Hodger (1956) and Chatterjee et al (1971) have also reported about the use of MSG in chicken meat. Heurickson et al (1956) reported that curing pickle containing ascorbic acid and sodium ascorbate had a deeper colour in the finished product, which is not desirable whereas brine containing MSG and ascarbic acid had a high grey pink colour, more characteristics of cured ham.

Merry (1968) noted a unique characteristics of MSG in that it increased salivation. He further observed that when more saliva is present in the mouth, there are better chances for appreciating the delicate aroma components while eating, though there is still no widely accepted physiological explanation for this property. Neither cooking nor processing nore even freezing can entirely stop this natural flavours of MSG.

I. V. R. I. Izetnagar (Agra University)

Finji (1970) indicated that MSG may be causing Chinese restaurant disease where it is served frequently in meat dishes (the symptoms being dullness, itching in shoulder nervousness and feeling light). But Morselli and Garattinis (1970) reported that there was no evidence of Chinese restaurant syndrome after injection of MSG even in higher doses.

Annon (1970) found that the oral dose of glutamic acid improves mental function. It may cause brain damage if injected in large doses.

Mohler and Raible (1959), Lavrova et al (1968), Grau (1969) and Jacquest et al (1969) reported that ascarbic acid alongwith sodium nitrite hastened colour production and helped in retention of colour of cured meat as well as reduced free nitrite in the finished products.

Elliott et al (1964) reported chemically and commercially pure polyphosphates inhibits the growth of non-fluorescent strains of bacteria in synthetic media. Inhibition may be due to chelation of essential metal ions such as Mg.

Katz and Dawson (1964), Forning (1965, 1966) and Chatterjee et al (1971) reported use of tri sodiumpolyphosphate in the curing of meat and found that Polyphosphates sufficiently reduces cooking losses and increases water binding capacity of meat.

***

I. V. R. I. Izatnagar (Agra University)

Finji (1970) indicated that MSG may be causing Chinese restaurant disease where it is served frequently in meat dishes (the symptoms being dullness, itching in shoulder nervousness and feeling light). But Morselli and Garattinis (1970) reported that there was no evidence of Chinese restaurant syndrome after injection of MSG even in higher doses.

Annon (1970) found that the oral dose of glutamic acid improves mental function. It may cause brain damage if injected in large doses.

Mohler and Rmible (1959), Lavrova et al (1968), Grau (1969) and Jacquent et al (1969) reported that ascarbic acid alongwith sodium nitrite hastened colour production and helped in retention of colour of cured meat as well as reduced free nitrite in the finished products.

Elliott et al (1964) reported chemically and commercially pure polyphosphates inhibits the growth of non-fluorescent strains of bacteria in synthetic media. Inhibition may be due to chelation of essential metal ions such as Mg.

Katz and Dawson (1964), Forning (1965, 1966) and Chatterjee et al (1971) reported use of tri sodiumpolyphosphate in the curing of meat and found that Polyphosphates sufficiently reduces cooking losses and increases water binding capacity of meat.

***

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

SMOKING

Since prehistoric times people have known the value of smoking of meat. It not only improves flavour but helps in preservation.

Bugge (1927) reported that when wood is heated a wide range of compounds are generated. The chemical constitution of smoke depends on many factors such as the type of wood used, the temperature of smoke chamber etc., etc.

Lea (1933), Watts and Faulkner (1954) observed that the surface of bacon is protected against rancidity when smoked. They feel that this was due to antioxident properties of smoke constituents.

Suter (1941) found that methyl and prophyl isomer of guaicsol and other smoke phenol components have very high phenol value against S. aureus and E. typhi.

Jensen (1943) noted that smoke constituents were chiefly responsible for wellknown bactericidal effect of smoke.

Shewan (1949) found that cold smoking at 28-30°C produced a 95% reduction in viable bacterial count and bactericidal action depends on phenolic compounds present in smoke and smoking time.

Cutting (1952), Spanyar et al (1966) have reported that smoke contains simple organic compounds such as aldehyes, acetone, the lower alcohols, formic, acetic and higher fatty acids as well as phenol and tar. All these products are produced by incomplete combustion. The absorption of these antiseptics is considered more effective than superficial drying action.

Gibbons et al (1954) demonstrated that smoke constituents are responsible for bacteriokdal effect of the combined smoking, heating and drying process.

Watts (1956) reported that cured pork containing ascorbate and further subjected to smoke helped in the development of rancidity to a great extent.

Hussaini and Coper (1957) have observed that phenolic compounds are of great importance in smoke flavour, other compounds in smoke undoubtedly play an important but secondary role in the flavour of smoke meat.

Tilgner (1957) found that fish smoked at 65°C to 75°C a had most of the psychrophilic bacteria in them destroyed and only the more resistant mesophiles might be expected to survice.

Foster and Simpson (1961 I and II) observed that the various constituents of wood smoke are distributed between two phases - one is liquid phase, i.e. tiny smoke particles and other is dipersing gas phase i.e., invisible smoke vapours. Smoke particles containing a relatively low portion of volatile compounds and a high proportion of nonvolatile smoke components. Further they concluded that smoking of meat might evolve vapour absorption rather than particle deposition. Direct deposition of smoke particles makes a negligible contribution within normal range of smoking temperature (32-82°C). They also found that the rate of deposition of phenols was about 20 times high for wet surface as compared to dry surface.

I. V. R. I. Izatnagar (Agra University)

Ziemba (1962) is of opinion that considerable colour formation after smoking involves protein and phenal interactions. Reaction between smoke components and tissues involving aldehydes and amino groups could be taking place in colour formation.

Draudt (1963) reported that colour development on the surface of meat depends on the components of wood resin. He further found that smoke does more than provide the desirable colour and flavour of smoked products. It contributes substantially to preservation by acting as an effective antioxidant and bacteriostatic and bactericidal agent, as well as it provides a protective film on the surface of smoked products.

Kitchell and Ingram (1966) observed that if bacon is smoked, there are perceptable alteration both in number and types of bacteria. Immediate effect of smoking was to reduce the total numbers of microorganisms by atleast 90 percent, the more intense the smoke treatment the greater was reduction in bacterial numbers and spoilage was delayed.

Randal (1969), Randall and Bretzler (1970) indicated that smoke constituents react with the functional group of meat proteins and causes decrease in pH. This change is probably caused by the penetration of smoke components such as organic acids into the meat.

Breclaw and Dawson (1970) reported higher preference for smoked chicken rolls by taste a panel than non-smoked ones. Smoked sample was found to have less moisture than unsmoked rolls.

I. V. R. I. Izatnagar (Agra University)

Light meat was preferred to dark although dark meat was having less moisture than white meat, still dark meat was rated as more juicy.

Kunishev (1970) conducted experiments to assess the inhibitory effect of liquid smoke preparation on development of lactic acid bacteria and it was found to have inhibitory effect on lactic acid bacteria.

Brummendorf (1970) reported th about smoke producing tablet which contain mixture of sawdust and spices or other flavouring materials. These were dried to a moisture content of 7-9 percent and compressed to form tablets and are supposed to be very good for use in meat smoking.

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

CHAPTER III

Material and Methods

CHAPTER III

MATERIALS AND METHODS

Meat can be cured either by wet curing or by dry curing. In wet curing a solution has to be prepared which has the various ingredients in weighed quantity dissolved in a measured volume of water. The water to be used has to be mineral free so that the dissolved metal ions in tap water may not interfere with the action of the curing agents at the time of curing. In dry curing the various chemicals are mixed in the dry state and then applied to the meat surface in the dry condition. Due to osmosis the chemicals are drawn inside.

In all the experiments reported here only wet curing was tried.

Preparation of Curing Solution

The following ingredients were used for preparation of curing solution.

Commercial table salt (A.R.)	-	5.44 Kg
Cane sugar	-	2.72 Kg
Sodium nitrate (A.R.)	-	85.0 grams
Sodium nitrite (A.R.)	-	112.0 grams
Monosodium glutamate (A.R.)	-	20 gms

Dissolved approximately in 40 litre mineral free water giving salinometer reading of 60 at 20°C. This pickle solution contains approximately 13.6 percent salt and 0.21 percent nitrate and 0.28 percent nitrite.

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

Curing Method

The drawn chicken were packed carefully close together in non-corrosive stainless steel barrels. The barrels then were filled with pickle solution, care being taken to keep at least 10 to 15 cms of solution above the topmost layer of birds. The barrels were kept at 5-6°C with relative humidity of 80-90 percent for 72 hours in cold storage room. After 24 hours of curing the birds were re-arranged in the pickle so that the top birds were pushed deeper and bottom birds came to the top and it was made sure that all the birds remained dipped under the curing solution. Birds were rearranged every 24 hours. After 72 hours birds were taken out and were thoroughly washed in tap water to remove excess salt present on the surface. Birds were kept for 2 hours on racks for draining.

Smoking

Cured birds after draining were put in smoke chamber and were directly subjected to cold, hard, wood smoke. Cured birds were hung by their legs in such a way as to provide maximum exposure of skin surface as well as the visceral cavity of the dressed birds. The temperature of the smoke chamber was maintained between 40°-45°C with the help of a thermometer hung at the level of the birds. The birds were kept in the smoke chamber for atleast 4 hours. The birds were removed from smoke chamber. They were vacuum packed individually in polyethylene bags after they cooled to room temperature.

I. V. R. I. Izatnagar (Agra University)

Chemical Analysis

Under chemical analysis chloride and nitrite were given emphasis but other proximate analysis for moisture, protein, fat and ash were also performed in both white and dark muscles. For all chemical analysis A.O.A.C. method was adopted.

Moisture andAsh

About 10 grams of meat was accurately weighed in a chemical balance in a dry weighed silica dish and kept in air oven at 100°-120°C for 16-18 hours. The silica dish was removed from oven, cooled in dessiccator and weighed. Weight lost was taken as moisture content of the sample and calculated on 100 grams of meat.

For ash estimation silica basin with the dry sample was heated until the sample was well carbonised and then with the help of a tongs it was transferred to a muffle furnace at temperature 550°C. Silica basin was removed with white ash and after cooling in dessicator final weight was taken.

Ether Extract

3 grams of minced meat sample was taken into a thimble. Meat was mixed with a small amount of asbestos powder. Thimble was kept in a beaker and dried in oven for six hours at 100°C. After this the thimble was transferred to the Soxhlet extraction apparatus. Petroleum ether (60-80°F) was taken in a dried weighed flask of the extraction apparatus, and was fitted to the extraction apparatus and allowed to run for about 4 hours. The flask was removed and the last traces of solvent evaporated on the water bath.

After drying the extraction flask for about 30 minutes at 100°C, in drying oven, it was transferred to a dessicator and weighed to the nearest 0.001 gram after the flask had cooled to room temperature.

Calculation

$$M_2 - M_1 \times \frac{100}{MO} = \% \text{ fat}$$

whereas MO = weight of meat

M_1 = weight of empty extraction flask

M_2 = final weight of Flask with fat.

Protein - Principle

All the nitrogen compound of meat were converted to Ammonium sulphate by boiling with concentrated H_2SO_4. Subsequently the ammonium sulphate was hydrolysed by strong alkali. By steam distillation, the liberated ammonia was collected in boric acid solution containing Toshiro's indicator (King and Wooton, 1956). Ammonia with boric acid formed Ammonium borate which was then tirated against standard H_2SO_4.

Toshiro's indicator

Exactly 80 mgms of methyl red and 20 mgms of bromo cresol green were dissolved in 100 ml of methyl alcohol. 10 ml of this indicator were added to 1 litre of 2% boric acid solution.

Estimation

Micro Kjeldahl method was followed for the estimation of total nitrogen. 2 grams well minced meat was digested with 20 ml of H_2SO_4. A pinch of catalyst (a mixture of cooper sulphate and sodium sulphate) was added to hasten the digestion. The digested

I. V. R. I. Izatnagar (Agra University)

sample was quantitatively transferred into 250 ml volumetric flask and volume was made upto 250 ml. Aliquote sample of 10 ml was taken into Micro Kjeldahl's distillation set for distillation. The liberated ammonia, upon addition of 40 percent sodium hydroxide, was absorbed by boric acid solution containing Toshiro's indicator and titrated against N/70 H_2SO_4.

Calculation

"A"X 0.0002 X 25 X 6.25 X 50 = grams protein/100 grams of fresh meat

whereas "A" is burette reading of N/70 H_2SO_4.

Chloride - Principle

More than enough 0.5 N silver nitrate (Ag No.$_3$) was added to a solution precipitate all chloride as silver chloride and the remaining excess silver nitrate was titrated with 0.5 N ammonium thiocynate (N H_4SCN) solution.

Reagent required

1. 0.5 N silver nitrate solution
2. 0.5 N Ammonium thiocynate solution
3. Ferric Alum Indicator (Saturated solution of (Fe N H_4(So$_4$)$_2$12H_2o)

Estimation

3 grams of minced meat was taken in a conical flask. It was moistened with 10 ml of 0.5 N Ag No$_3$ solution. 15 ml of conc. H No$_3$ was also added and boiled for 10 minutes, care was taken to dissolve all meat. Conc. KMno$_4$ solution was added in small portions and it was again boiled, after each addition, until KMnO$_4$ colour disappeared and the solution became nearly colourless.

I. V. R. I. Izatnagar (Agra University)

25 ml of H_2O was added and boiled and diluted to approximately 150 ml. 25 ml ether was added and flask was shaken. Afterwards 5 ml of ferric alum indicator was added and was titrated with 0.5 N NH_4SCN solution until colour was changed to permanent light brown.

Calculation

ml of 0.5 N ammonium thiocynate solution used was substracted from ml of 0.5 N Ag No_3 solution added and was calculated on the basis of 10 gms samples

1 ml of 0.1 N Ag No_3 = 0.058 % NaCl.

Nitrite- Principle

The nitrite concentration was determined through the formation of reddish purple diazodye produced at pH 2.0 - 2.5 by the coupling of diazotished sulphanilic acid with naphthylamine hydrochloride.

1. Reagent

Modified Griess reagent: 45 ml of glacial acetic acid was taken in a measuring cylinder and volume was made upto 300 ml with double distilled water. 0.5 gram of sulphanilic acid and 0.125 gm naphthylamine hydrochloride were ~~ska~~ taken separately in two beakers. They were dissolved in above prepared solution. Then both were mixed together and kept in amber glass bottle.

2. Nitrite Standard Solution

1.1 gram of silver nitrite was dissolved in approximately 150 ml of double distilled water in a 1 litre volumetric flask. Concentrated Nacl solution was added in it till precipitation was

I. V. R. I. Izatnagar (Agra University)

completed. Volumetric flask was kept in dark for some time to settle the ppt., then volume was made upto 1 litre. 100 ml of supernatant fluid from this flask was transferred to another 1 littre flask and volume was made upto one litre. 10 ml from second flask was transferred to third 1 litre volumetric flask and volume was made upto to mark.

3. 1 ml of final solution = 0.0001 mg N.

3. <u>Saturated solution of mercuric chloride</u>

<u>Preparation of standard curve:</u> Suitable volumes(series of 10 ml to 50 ml) of standard nitrite solution was taken in 50 ml volumetric flasks and volume was accurately made upto mark in all cases. 2 ml of modified Griess reagent was added in all five flasks. After one hour of colour development, reading were taken in colorimeter at wave length of 520 m μ, setting instrument to zero absorbance with blank of 50 ml H_2O plus 2 ml reagent and a curve was drawn with obtained reading which was in a straight line upto 5 μg N in final solution.

<u>Estimation</u>

5 gram minced meat was taken in 50 ml beaker. Approximately 40 ml H_2O was added and heated to 80°C and was mixed with a glass rod. Care was taken to break up all the lumps. Then it was transferred to 500 ml volumetric flask. Approximately 250 ml hot H_2O was added and flask was transferred to steam bath for 2 hours. Flask was removed and 5 ml of saturated $HgCl_2$ solution was added and mixed. It was cooled to room temperature and volume was made upto 500 ml with H_2O. It was filtered and suitable amount was taken in 50 ml flask and volume was correctly made up. 2 ml of

I. V. R. I. Izatnagar (Agra University)

reagent was added and made to remain for 1 hour for colour development. In the colorimeter tube a suitable amount was taken and reading was taken at 520 m µ setting instrument to zero absorbance with blank. Concentration of No_2 was calculated from standard curve.

Calculation

$$\text{ppm Nitrite N} = \frac{\text{Ug nitrogen nitrite from graph X dilution}}{\text{ml of sample taken X Wt. of sample taken}}$$

ppm Nitrite = ppm nitrite N X 3.29

Bacteriological studies

Swab method for bacteriological examination was used throughout the experiments as described by McVicker et al (1959) Kotula (1966). Absorbent cotton was twisted firmly on a wooden 3/4" long applicator to form a swab about 1/16" in diameter. The swabs were sterilized in hot air oven at 160°C for 1 hour. Each swab were moistened in sterile saline then pressed to make free of excess moisture. The skin surface (approx. 6 cm.sq.) at different places, i.e. breast, back and thigh, was swabbed three times in each direction, rotating the swab in the process. The applicator stick was broken aseptically about 1/2" above the swab and the swab was placed in a test tube containing 10 ml of sterile saline. The tube was vigorously shaken by rotating it in between the palms to disperse the cotton. Serial dilutions were made from diluent and plated 1 ml in each petridishes. All petridishes, test tubes and pipettes were sterilized in dry heat. Nutrient agar media was poured in each inoculated plate near the flame and plates were incubated at 37°C for 48 hours. Total colonies were counted on Quebec colony counter. The composition of nutrient aga used was

I. V. R. I. Izatnagar (Agra University)

as follows:-

Composition for 1 litre nutrient agar.

Meat extract	-	1 litre
Alkali	-	4%
Peptone (oxide)	-	1%
Treptone (Difco)	-	1%
Sodium chloride ~~glucose~~	-	0.5%
Glucose	-	0.4%
Agar	-	3%

All the ingredients, except glucose, were dissolved in distilled water and meat extract. pH was adjusted to 7.4 and autoclaved at 15 lbs for 20 minutes. Glucose was added separately which was also sterilised.

Organoleptic Tests

After one week of preservation, birds were steam cooked at 10 lbs pressure for 10 minutes. Fresh bird also cooked under identical conditions and were also kept before taste panel judges. The meat was presented in plates. The identity of plates were not disclosed to judges but they were explained about the type of experiment. They were requested to make their opinion of the quality of meat in the proforma given on next page. All the organoleptic tests were made in the afternoon between 3.00 to 4.00 p.m. and no spices were added at the time of cooking or eating so the natural meat taste is evaluated. A total of 9 judges took part in each organoleptic test.

I. V. R. I. Izatnagar (Agra University)

Statistical Methods

Mean and SE were calculated by standard statistical method. Analysis of variance of three way classification with equal number of observations per subclass was performed as per Snedecor (1968). Where treatment effects were found significant the Duncan multiple range test was applied for pairwise comparison of treatment means as Federer (1967). Though result has been expressed in percentage but mean and variance were not correlated, so transformation was not applied in analysis of variance.

I. V. R. I. Izatnagar (Agra University)

MEAT QUALITY EVALUATION SHEET

1. Name of the taster: (A panel of atleast 5 to 10 members).
2. Date
3. Time of Evaluation (Preferably half to one hour before or after meals).
4. Method of Cooking: i) Steam cooking (10 to 15 lb pressure for 15 to 10 minutes, respectively).
5. Age of the birds - 10 weeks.
6. Test for meat components:-

(a) Meat is ☐ Tender ☐ moist

☐ Dry ☐ Fatty ☐ Tough

☐ Stringy ☐ other please specify.

(b) Describe flavour, if any.

Extremely poor poor fair

good very good excellent

(c) Colour Poor Fair Good Excellent

(d) Rate saltiness, if required

Very much undesirable | Much undesirable. | Undesirable | Desirable.

In the above tastings, please mark (box(es) and other points which nearly describe the component.

7. Acceptance Score Sheet

	Points
Like very much	7
Like moderately	6
Like slightly	5
Neither like nor dislike	4
Dislike slightly	3
Dislike moderately	2
Dislike very much	1

Please circle the point at which you rate the quality (Use reverse side for additional remakrs).

I. V. R. I. Izatnagar (Agra University)

EXPERIMENTAL PROCEDURE

Twenty five birds were taken in each trial from the experimental poultry farm of the Institute. Due to non-availability of same type of birds there was slight variation in age, breed and other nutritional and managemental conditions among the birds from trial to trial. In all the trials the birds were of the age ranging from six to nine months.

The birds were killed by the improved Kosher method i.e. by cutting the jugular vein and carotid artery without damaging the trachea and gullet. The birds were allowed to bleed for about 2½ minutes and then scalded at a temperature of 54.5°C for about 90 seconds and were defeathered by the feather picking machine. The birds were eviscerated and were washed. Giblet and neck were not used in the experiments. These eviscerated birds were cooled in cold water to a temperature of 40°F to 45°F for one hour to reduce the body heat. The birds were then kept on draining rack for draining of the excess of water. After that weight of individual birds were taken upto 10 grams accuracy.

One bird was taken at random and was used for approximate chemical analysis. From remaining twenty four birds, bacterial load was taken in six birds. Two birds were kept as control, one at room temperature (25°-27°C) and the other at refrigeration temperature (5°-6°C). Rest of the four birds of known bacterial count (with individual identification marks) were dipped in cuffing solution along with other remaining eighteen birds.

I. V. R. I. Izatnagar (Agra University)

After 72 hours of cur-ing process at 5°C, birds were taken out from curing solution. Again bacterial count from those 4 birds were then taken and then all birds were washed in fresh water and were weighed after about 1 hour draining.

2 birds were analysed chemically for moisture, protein, fat, ash, chloride and nitrite content. Two birds of known bacterial count were wrapped in poletheline pack and one kept at room temperature and other at refrigeration temperature.

Remaining 18 birds were randomly grouped into two, one of 8 and the other of 10. All the eight birds of the first group were vacuum packed in pälyethylene bags and the four of them were kept at room temperature and other four at refrigeration temperature.

The other group of 10 birds were smoked for 4 hours at 40-45°C. After taking individual weight of all the smoked birds, one was used for chemical analysis. From two birds bacterial load were taken and simultaneously one kept at room and other at refrigeration temperatures. Remaining seven birds were vacuum packed in polyethylene bags. Three of them were stored at room temperature and 4 at refrigeration temperature.

Bacterial load from all previously identified birds were taken at interval of 48 hours till they became unfit for human consumption.

I. V. R. I. Izatnagar (Agra University)

One bird from each group was used on 4th day and 8th day of storage for chemical analysis. On 8th day one bird from each group was cooked at 10 lbs pressure for 10 minutes at a temperature of 116°C. Samples from cooked birds were chemically analysed and were kept for organoleptic evaluation before the judges.

The whole experiment was repeated thrice.

I. V. R. I. Izatnagar (Agra University)

L. Y. S. I. Izatnagar (Agra University)

CHAPTER IV

RESULTS

I. V. R. I. Izatnagar (Agra University)

CHAPTER IV

Result

CHAPTER IV

R E S U L T

The following factors were studied to evaluate the effect of curing and curing-smoking for preservation of poultry meat.

Weight Changes: It was observed that there was only 6.51 percent gain in total weight of birds after curing process for 72 hours at 5°C. During smoking at 40-45°C for 4 hours there was 5.95% shrinkage in apparent weight of birds when calculated on dressed weight and 11.72 percent shrinkage when calculated on cured weight.

Chemical Analysis: Both dark and white meats were used for chemical analysis. Means and standard error for moisture, protein, fat, ash chloride and nitrite content of the meat subjected to different treatments, temperatures and storage periods are presented in Table I. For statistical analysis of the data they were divided into three parts, depending upon the length of storage and temperature i.e. 0 to 4 days; 4 to 8 days and 8 days to the time of cooking.

Moisture: The moisture content of fresh chilled chicken was found to be about 70 percent. The moisture content in cured meat increased significantly by 1.68 percent (Table I). There was no significant loss in moisture content of the cured chicken when stored at room temperature (25° to 26°C) for four days (Table III). When cured meat was stored at refrigeration temperature (5 to 6°C) for four days it lost 2.14 percent moisture. Cured meat after one week of storage at refrigeration temperature lost 4.92 percent moisture (Table I). Cured meat could not be stored for more than four days at room temperature (25° to 26°C).

I. V. R. I. Izatnagar (Agra University)

1 Cured meat on subsequent smoking for four hours at 40 to 45°C lost 5.53 percent moisture compared to fresh, and 7.30 percent when compared to cured meat. In cured-smoked meat on fourth day of storage, there was no significant loss of moisture at room temperature as shown in Table III.

Similarly treated birds when stored at refrigeration temperature, there was 2.58 percent loss of moisture on fourth day of storage and 3.75 percent loss after one week of storage. At room temperature even after one week of storage there was no significant loss in moisture content of both dark and white meat as shown in Table V.

On perusal of data presented in Table I it is seen that there was a higher moisture loss from cured meat at refrigeration temperature after storage for one week as compared to cured-smoked chicken under identical storage condition.

On eighth day when meat was cooked at 10 lbs pressure for 10 minutes, there was a significant loss of moisture content from all treatments as is evident in analysis of variance, Table VI. Cured chicken stored at refrigeration temperature had lost 13.38 percent moisture after cooking. Cured-smoked chicken stored at room temperature and at refrigeration temperature had lost 10.58 percent and 11.64 percent moisture respectively. There was no significant difference in moisture content of dark and white meat samples in any treatment (Anova Table IV and VI).

I. V. R. I. Izatnagar (Agra University)

1 Cured meat on subsequent smoking for four hours at 40 to 45°C lost 5.53 percent moisture compared to fresh, and 7.30 percent when compared to cured meat. In cured-smoked meat on fourth day of storage, there was no significant loss of moisture at room temperature as shown in Table III.

Similarly treated birds when stored at refrigeration temperature, there was 2.58 percent loss of moisture on fourth day of storage and 3.75 percent loss after one week of storage. At room temperature even after one week of storage there was no significant loss in moisture content of both dark and white meat as shown in Table V.

On perusal of data presented in Table I it is seen that there was a higher moisture loss from cured meat at refrigeration temperature after storage for one week as compared to cured-smoked chicken under identical storage condition.

On eighth day when meat was cooked at 10 lbs pressure for 10 minutes, there was a significant loss of moisture content from all treatments as is evident in analysis of variance, Table VI. Cured chicken stored at refrigeration temperature had lost 13.38 percent moisture after cooking. Cured-smoked chicken stored at room temperature and at refrigeration temperature had lost 10.58 percent and 11.64 percent moisture respectively. There was no significant difference in moisture content of dark and white meat samples in any treatment (Anova Table IV and VI).

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

Protein and Fat: The protein content of fresh chicken meat was 21.61 percent. There was significant change in protein content of meat stored for different days under various storage conditions. There was no significant difference in protein content of dark and white meat at any level of treatment or days of storage which can be seen in analysis of variance Table II, IV and VI. There was a significant decrease in protein content of cured chicken when taken out from curing solution. After smoking of cured meat and on subsequent storage the protein content has significantly increased which is correlated to the moisture content of the meat.

A significant difference in fat content of dark and white meat was observed (Amova Table II, IV and VI). On perusal of Table I, it is found that breast meat was having a higher fat content than dark meat. There was significant decrease in fat content of meat when taken out from curing solution after 72 hours of curing process. But in subsequent storage upto one week at room and refrigeration temperatures there was no significant difference in fat content of chicken meat. Table III also shows that fresh birds are having significantly high fat content (6.51%) whereas rest of the other treatments are not significant to each other as far as fat content is concerned. From data on Table I, it seems that there was loss of fat during cooking process but when data was statistically analysed, non-significant difference was observed (Table VI).

Ash and Chloride: Cured meat has shown significant increase in chloride content from that of the fresh meat. Immediately after smoking and on storage of cured-smoked meat at room temperature

there was a significant increase in the chloride level.

Meat stored at refrigeration temperature irrespective of treatment was having lower chloride content as shown in Table I.

Chloride and ash content in cured and cured-smoked chicken seems to be correlated as there was simultaneous increase in both chloride and ash content.

After one week of storage both at room temperature as well as at refrigeration temperature when meat was cooked at 10 lb pressure for 10 minutes there was significant decrease in chloride and ash content of cooked chicken (Table I).

There was also significant difference in ash and chloride contents of dark and white meat sample (Analysis of Variance Table II, IV and VI). On comparison of mean from Table I, dark meat was found to have higher chloride and ash content than white meat.

<u>Nitrite:</u> There was no nitrite in fresh meat. On curing it increased significantly upto 281 ppm. On subsequent smoking, the level of nitrite was reduced to 225 ppm from 281 ppm. But again on storage for 4 days both at room temperature as well as refrigeration temperature, nitrite content significantly increased in cured and cured-smoked chicken. On perusal of Table I it is evident that the highest increase in nitrite level was observed in cured refrigerated meat, 41 percent. This can also be seen in Figure IV. On 4th day of storage irrespective of the treatment the highest level of nitrite was again seen in meat stored at refrigeration temperature than at room temperature.

I. V. R. I. Izatnagar (Agra University)

On 8th day of storage there was significant decrease in nitrite level both at refrigeration and at room temperature, but the loss of nitrite at room temperature was higher than at refrigeration temperature (Figure IV).

When meat was cooked after one week of storage, stored at both temperatures at 10 lb pressure for 10 minutes, there was significant loss of nitrite level in all treatments (Table I, Fig. IV).

On perusal of dat, it is seen that cured meat kept at room temperature for 4 days showed in increase of 23 percent nitrite over that immediately after curing. After 5 days the cured meat stored at room temperature had to be discarded as such the nitrite content could not be estimated.

When cured-smoked meat was stored at room temperature for 4 days, the nitrite level had increased by only about 6.6 percent over that immediately after curing and smoking. But on storage for 8 days at the same temperature the nitrite content of cured-smoked meat had dropped by 37 percent than that obtained at the end of 4 days.

When similar observations were made at refrigeration temperature, the nitrite content of cured meat stored for 4 days had increased by 41 percent over the level immediately after curing. As observed at room temperature, the nitrite concentrates after 8 days of storage had dropped down by 35 percent over that observed after 4 days of preservation.

I. V. R. I. Izatnagar (Agra University)

When poultry meat was stored at refrigeration temperature after curing and smoking, there was an increase of nitrite level by 25 percent after 4 days of storage but continuing the storage period for 8 days the nitrite level again dropped by 33 percent over that observed after 4 days of storage.

There was significant difference in nitrite content of dark and white samples (Table II, IV, VI). The dark meat was having higher nitrite level than that of white at both temperatures of preservation and after curing and curing and smoking and even after cooking.

***

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

BACTERIOLOGICAL STUDY

Experimental data on bacteriological studies in trial I, II and III are presented in Table VIII, IX and X, respectively. Only total count was made and no effort was made to identify the species. This shows the effect of curing and smoking and subsequent storage at room and refrigeration temperatures, on bacterial growth. Untreated control chicken kept at room temperature showed an enormous bacterial growth and had become unfit for human consumption within 24 hours. But when birds were given curing treatment for 72 hours a significant decrease in bacterial load (Table VIII, IX and X) was noted. Further when cured chicken was subjected to smoking at (40-45°C) for 4 hours, the bacterial load still got reduced. (Table VIII, IX and X).

Table VIII, IX and X show that cured chicken at room temperature could be successfully maintained in good edible condition upto 4 days. But there was unpleasant smell on 5th day when the bacterial load had increased above by log 6.34 Sq.cm. The initial load after curing was log 4.98/Sq.cm. But when temperature of storage was reduced to 5°C the rate of bacterial multiplication was also reduced and length of preservation period was proportionally increased upto 16th days, whereas untreated control could be kept only upto 10th days at refrigeration temperature. From Table VIII, IX and X it is evident that smoking the cured meat further reduced the bacterial multiplication than the cured meat itself. This was true in both at room temperature as well as at refrigeration temperature (Fig.VII and VIII).

But when birds were stored at refrigeration temperature the rate of multiplication of bacteria was rather steady and there was no sudden spurt as observed in case of those stored at room temperature (Fig. VII and VIII).

Bacterial growth on cured-smoked chicken at refrigeration temperature was very slow upto 20th days after which a rapid growth was noticed (Fig. VIII).

One interesting observation made in the Ist trial was that fungus growth was noticed on the smoked chicken on 6th day when stored at room temperature, as also on 20th day when stored at refrigeration temperature (Table VIII). Though there was no foul smell, bacteriological studies were discontinued from the time mould spores were observed on the meat as such meat cannot be marketed. The mould spores were observed only on the skin surface. But when 10 ppm of mycostatin was added in pickle solution during IInd and IIIrd trials, the fungus growth was not seen upto 14th days of storage at room temperature and 30th day at refrigeration temperature (Table IX and X). Cured-smoked chicken were found in very good edible condition upto 14th days at room temperature and one month at refrigeration temperature.

***

I. V. R. I. Izatnagar (Agra University)

ORGANOLEPTIC EVALUATION

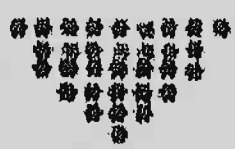
Means and standard error for acceptance score are presented in Table XI. Analysis of data for acceptance score indicated highly significant difference between treatments, between judges, treatment and judges interaction and between trials.

Cured refrigerated meat and cured-smoked refrigerated meat had the highest preference followed by cured-smoked meat kept at room temperature. But there was no significant difference between cured-smoked meat stored for one week at room and refrigeration temperatures (Table XII).

At the time of organoleptic evaluation it was found that cured-smoked chicken kept on room temperature was rated a little more salty in taste in comparison with meat treated similarly and stored at refrigerated temperature. But taste panel judges did not observe any undesirable salty taste. There was significant remark about flavour of smoked chicken which was entirely different from cured and fresh ones. Colour of cured chicken stored at refrigeration temperature was more acceptable.

In respect of tenderness and juiciness there was no significant difference in between room temperature and refrigeration temperature stored meat.

This indicates that curing and smoking of poultry meat can be successfully used to prolong the shelf life of dressed chicken and avoid the transit loss at high temperatures.



I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

Treatment Code No.	Details of treatments
1	- Fresh chilled chicken - O-Day
2	- Cured chicken (after 72 hours of curing treatment at 5°C).
3	- Cured and smoked chicken (just after smoking at 4°C for 4 hours).
4	- Cured chicken Room (25-26°C) on 4th day of storage.
5	- Cured chicken Refrigerated (5-6°C) on 4th day of storage.
6	- Cured and smoked chicken at Room(25-26°C) on 4th day of storage.
7	- cured-smoked chicken at Refrigerated (5-6°C) on 4th day of storage.
8	- Cured meat refrigerated (5-6°C) on 8th day of storage.
9	- Cured and smoked chicken at Room (25-26°C) on 8th day of storage.
10	- Cured and smoked chicken Refrigeration (5-6°C) on 8th day of storage.
11	- Cured chicken refrigerated (5-6°C) when cooked on 8th day at 10 lb pressure for 10 minutes.
12	- Cured and smoked chicken Room (25-26°C) when cooked on 8th day at 10 lb pressure for 10 minutes.
13	- Cured and smoked chicken Refrigerated (5-6°C) when cooked on 8th day at 10 lb pressure for 10 minutes.

(Since the treatment are large in numbers and the full name will occupy too much space, the treatments are coded as shown above and are referred to by the code number in the text).

TABLE I

Means ($\bar{X}$) and standard effors (S.E.) for moisture, protein, fat ash chloride and nitrite content of meat subjected to different types of treatments, temperature and storage.

Storage time and temperature	Sample	Moisture %	Protein %	Fat %	Ash %	Chloride %	Nitrite p.p.m.
T 1 Fresh chilled chicken on 0-Day	Dark	69.82 ± 1.11	21.72 ± 0.61	6.48 ± 1.58	1.29 ±0.00	0.80 ± 0.04	0.00 ± 0.00
	White	70.01 ± 1.07	21.50 ± 0.66	6.53 ± 1.77	1.26 ± 0.04	0.75 ± 0.08	0.00 ± 0.00
T 2 Cured chicken (after 72 hrs.cof curing treatment at 50°)	Dark	71.60 ± 1.66	18.21 ± 0.12	5.68 ± 1.68	4.43 ± 0.12	3.93 ± 0.09	283 ± 2.41
	White	71.78 ± 1.55	18.17 ± 0.13	6.33 ± 1.51	4.21 ± 0.19	3.69 ± 0.17	279 ± 2.97
T 3 Cured-smoked chicken (just after smoking at 40°C for four hours.)	Dark	64.23 ± 0.86	24.79 ± 1.01	5.67 ± 1.77	4.67 ± 0.14	4.18 ± 0.12	227 ± 2.31
	White	64.55 ± 0.60	24.61 ± 1.19	5.79 ± 1.83	4.41 ± 0.23	3.94 ± 0.20	223 ± 1.78
ON 4th DAY OF STORAGE							
T 4 Cured chicken Room (25-26°C)	Dark	71.07 ± 1.76	18.25 ± 0.15	5.75 ± 1.69	4.88 ± 0.10	4.41 ± 0.12	349 ±0.71
	White	71.19 ± 1.69	18.24 ± 0.13	5.95 ± 1.57	4.69 ± 0.23	4.18 ± 0.23	345 ±0.91
T 5 Cured chicken at Refrigeration (5-6°C)	Dark	69.53 ± 1.78	20.34 ± 0.55	5.76 ± 1.70	4.55 ± 0.10	4.05 ± 0.08	396 ± 1.68
	White	69.57 ± 1.77	20.33 ± 0.55	5.93 ± 1.56	4.41 ± 0.16	3.83 ± 0.18	393 ± 1.78

Contd...

TABLE I (Contdd.)

Storage time and temperature	Sample	Moisture %	Protein %	Fat %	Ash %	Chloride %	Nitrite P.P.M.
T_6 Cured-smoked chicken at Room (25-26°C).	Dark	64.12 ± 0.85	24.81 ± 1.01	5.67 ±1.77	4.66 ± 0.17	4.23 ± 0.13	243 ±2.89
	White	64.43 ± 0.60	24.62 ± 1.21	5.85 ± 1.67	4.49 ± 0.21	4.02 ± 0.18	237 ±1.00
T_7 Cured-smoked chicken at Refrigeration(5-6°C)	Dark	62.69 ± 0.88	26.50 ± 0.98	5.66 ± 1.77	4.68 ± 0.14	4.19 ± 0.12	283 ±2.05
	White	62.93 ± 0.68	26.50 ± 0.94	5.85 ±1.67	4.43 ± 0.30	3.96 ± 0.29	279 ± 2.09
CURED MEAT AT ROOM TEMPERATURE (25-26°C) SPOILED ON 5TH DAY OF STORAGE							
8TH DAY OF STORAGE							
T_8 Cured meat at Refrigeration(5-6°C)	Dark	67.79 ± 1.86	21.88 ± 0.69	5.75 ±1.70	4.69 ±0.12	4.20 ±0.08	259 ± 2.97
	White	67.75 ± 1.84	21.89 ± 0.68	5.92 ± 1.57	4.49 ± 0.20	3.97 ±0.17	253 ± 3.35
T_9 Cured-smoked chicken at room temperature (25-26°C)	Dark	63.90 ±0.75	24.85 ± 1.03	5.67 ±1.78	4.85 ± 0.40	4.35 ±0.12	154 ± 1.87
	White	64.16 ±0.36	24.77 ± 1.15	5.85 ± 1.68	4.63 ± 0.21	4.16 ±0.18	150 ± 0.91
T_{10} Cured-smoked chicken at Refrigeration (5-6°C)	Dark	61.55 ± 0.90	24.74 ± 0.91	5.66 ±1.24	4.73 ±0.14	4.25 ±0.13	190 ± 1.00
	White	61.76 ± 0.71	27.60 ± 1.02	5.85 ±1.67	4.52 ±0.23	4.03 ±0.21	186 ±1.16

Contd....

TABLE I (Contd...)

Storage time and temperature	Sample	Moisture %	Protein %	Fat %	Ash %	Chloride %	Nitrite p.p.m.
8TH DAY AFTER COOKING (116°C under 10 lb pressure for 10 minutes.).							
11 Cured chicken stored at refrigeration(5-6°C)	Dark	58.30 ± 1.62	32.88 ± 0.62	4.75 ±1.82	3.58 ±0.14	3.09 ±0.09	116 ±1.87
	White	58.31 ±1.60	32.89 ± 0.63	5.08 ± 1.79	3.39 ±0.20	2.87 ±0.16	112 ±2.20
12 Cured-smoked chicken stored at room (25-26°C)	Dark	54.80 ±0.87	36.13 ±1.00	4.67 ±1.73	3.71 ±0.13	3.23 ±0.11	24 ±1.53
	White	54.81 ±0.76	36.13 ±1.01	4.75 ±1.77	3.54 ±0.19	3.05 ±0.15	22 ±2.05
13 Cured-smoked chicken stored at Refrigeration (5-6°C)	Dark	52.81 ±0.66	38.27 ±1.31	4.74 ±1.76	3.61 ±0.13	3.16 ± 0.09	28 ± 2.05
	White	52.68 ±0.75	38.26 ± 1.34	5.04 ±2.01	3.42 ± 0.16	2.94 ±0.16	25 ±2.35

RF F 351

TABLE- II

Analysis of Variance

Chemical analysis of cured, cured and smoked chicken when stored at different temperatures from 0 - 4th day of storage.

Source of variation.	Degree of freedom.	Mean Square					
		Moisture	Protein	Fat	Ash	Chloride	Nitrite
Between treatments	6	82.56**	66.42**	0.43**	9.26**	9.33**	95370.93**
Between samples	1	0.43	0.09	0.38	0.33*	0.36*	137.52
Treatment X Samples	6	0.01	0.015	0.003	0.01	0.02	5.41
Between trials	2	59.95**	13.43**	117.12	0.89*	0.65**	66.67**
Error	26	0.76	0.90	.045	0.018	0.02	4.18

*P $\angle$ 0.05 (Significant)

** P $\angle$ 0.01 (Highly significant)

I. V. R. I. Izatnagar (Agra University)

TABLE III

Duncan multiple range test for composition of treatment means from 0-4th day of storage.

MEAN IN ASCENDING ORDER

Moisture

Treatment	T7	T6	T3	T5	T1	T4	T2
Means -	62.81	64.28	64.39	69.55	69.92	71.13	71.69

Protein

Treatment	T2	T4	T5	T1	T3	T6	T7
Mean -	18.19	18.25	20.33	21.61	24.68	24.72	26.50

Fat

Treatment	T7	T6	T3	T5	T4	T2	T1
Mean	5.76	5.76	5.78	5.84	5.86	5.95	6.51

Ash

Treatment	T1	T2	T5	T3	T7	T6	T4
Mean	1.28	4.32	4.48	4.54	4.56	4.58	4.79

Chloride

Treatment	T1	T2	T5	T3	T7	T6	T4
Mean	0.78	3.81	3.94	4.06	4.08	4.13	4.30

Nitrite

Treatment	T1	T3	T6	T7	T2	T4	T5
Mean	0.00	225.17	240.17	281.17	281.33	347.33	394.17

Note:- Means under the same bar are not significantly different.

I. V. R. I. Izatnagar (Agra University)

TABLE IV

ANALYSIS OF VARIANCE

Chemical analysis of cured, cured and smoked chicken when stored at difference temperatures from 4th to 8th day of storage.

Source of variation	Degree of freedom	Mean Square					
		Moisture	Protein	Fat	Ash	Chloride	Nitrite
Between treatments	6	77.81**	69.80**	0.014	0.0700**	0.083**	43036.35**
Between samples	1	0.27	0.04	0.35**	0.40**	0.31**	214.58**
Treatment X Sample	6	0.023	0.083	0.000	0.0017	0.0017	1.65
Between trials	2	58.08**	19.46**	118.87**	1.28**	0.92**	78.50**
Error	26	.98	0.87	0.032	0.0092	0.0081	4.06

* $p < 0.05$ (Significant)

** $p < 0.01$ (Highly significant)

I. V. R. I. Izatnagar (Agra University)

TABLE-V

Duncan multiple range test for pairwise comparison of treatment means from 4th to 8th day of storage.

MEAN IN ASCENDING ORDERS

Moisture

Treatment	T10	T7	T9	T6	T8	T5	T4
Mean-	61.16	62.81	64.04	64.28	67.77	69.55	71.13

Protein

Treatment	T4	T5	T8	T6	T9	T7	T10
Mean -	18.25	20.33	21.89	24.72	24.81	26.50	27.67

Ash

Treatment	T5	T7	T6	T8	T10	T9	T4
Mean-	4.48	4.56	4.58	4.59	4.63	4.74	4.79

Salt

Treatment	T5	T7	T8	T6	T10	T9	T4
Mean -	3.94	4.08	4.09	4.13	4.14	4.26	4.30

Nitrite

Treatment	T9	T10	T6	T8	T7	T4	T5
Mean	152.33	188.00	240.17	256.33	241.17	347.33	394.17

Note:- Means under the same bar are not significantly different

I. V. R. I. Izatnagar (Agra University)

TABLE-VI

ANALYSIS OF VARIANCE

Chemical analysis of cured, cured and smoked chicken kept at different temperatures upto 8th day of storage and cooked under 10 lb pressure for 10 minutes.

Source of variation	Degree of freedom	Mean Square					
		Moisture	Protein	Fat	Ash	Chloride	Nitrite
Between treatments	5	194.22**	252.60**	1.65	2.24**	2.25**	50570.97**
Between samples	1	0.02	0.01	0.39	0.35**	0.41**	144.00**
Treatment X Samples	5	0.026	1.74*	0.012	0.002	0.00	2.46
Between trials	2	39.71**	27.89**	110.25**	0.95**	0.66**	21.44**
Error	22	0.83	0.53	1.089	0.0082	0.0041	2.77

* $p < 0.05$ (Significant)

** $p < 0.01$ (Highly significant)

I. V. R. I. Izatnagar (Agra University)

TABLE-VII

Duncan multiple range test for pairwise comparison of treatments on 8th day of storage and cooked at 10 lb pressure for 10 minutes.

MEANS IN ASCENDING ORDER

Moisture

Treatment	T13	T12	T11	T10	T9	T8
Mean:	52.75	54.81	58.31	61.66	64.04	67.77

Protein

Treatment	T8	T9	T10	T11	T12	T13
Mean	21.89	24.81	27.67	32.89	36.13	38.27

Ash

Treatment	T13	T12	T11	T10	T9	T8
Mean	3.52	3.64	3.85	4.63	4.74	5.59

Chloride

Treatment	T11	T13	T12	T8	T10	T9
Mean	2.98	3.05	3.14	4.09	4.14	4.26

Nitrite

Treatment	T12	T13	T11	T9	T10	T8
Mean	22.83	26.83	114.00	132.33	180.00	263.88

I. V. R. I. Izatnagar (Agra University)

TABLE-VIII

TRIAL I

Bacterial count in log unit per Sq.cm.

Days of Storage	Control		Cured Meat		Cured and smoked	
	Room (25-26°C)	Refgn. (5-6°C)	Room (25-26°C)	Refgn. (5-6°C)	Room (25-26°C)	Refgn. (5-6°C)
0 days	4.61	4.52	4.56	4.58	4.56	4.62
After 72 hrs of curing treatment	-	-	4.48	4.53	4.49	4.54
Just after smoking	-	-	-	-	3.78	3.76
2nd day of storage	Spoiled‡ not counted.	4.75	5.99	4.62	4.19	3.89
4th day		5.59	6.34	5.10	4.83	3.96
6th day		5.94	Started ‡ smelling	5.53	5.65	4.18
8th day		6.16		5.79	Not smelling but little fungus growth visible.	4.41
10th day		6.41 (Started smelling)		5.92		4.48
12th day				6.02		4.60
14th day				6.15		4.72
16th day				6.32		4.88
18th day				6.45 (Started smelling)		4.98
20th day						5.18 (Not smelling but fungus growth visible)

I. V. R. I. Izatnagar (Agra University)

TABLE-IX

TRIAL II

Bacterial count in log unit per sq.cm.

Days of storage	Control		Cured Meat		Cured-smoked	
	Room (25-26°C)	Refgn. (5-6°C)	Room (25-26°C)	Refgn. (5-6°C)	Room (25-26°C)	Refgn. (5-6°C)
0 day	4.76	4.67	4.56	4.58	4.61	4.63
After 72 hrs of curing treatment	-	-	4.48	4.53	4.54	4.56
Just after smoking	-	-	-	-	3.79	3.78
2nd day of storage	‡	4.78	5.99	4.62	4.21	3.90
4th day	-	5.58	6.34	5.10	4.83	3.97
6th day		5.95	‡	5.53	5.49	4.20
8th day		6.16		5.79	5.96	4.40
10th day		6.41		5.92	6.23	4.49
12th day		‡		6.02	6.45	4.60
14th day				6.15	6.54	4.74
16th day				6.32	XX	4.87
18th day				6.45		4.98
20th day				‡		5.21
22nd day						5.35
24th day						5.75
26th day						6.36
28th day						6.61
30th day						6.85
32nd day						XX

‡ Spoiled (started smelling) discarded as putrified. Further bacterial load not taken.

XX Not smelling but fungus growth visible. Further bacterial load not taken.

I. V. R. I. Izatnagar (Agra University)

TABLE-X

TRIAL III

Bacterial count in log unit per Sq. cm.

Days of Storage	Control		Cured Meat		Cured-smoked	
	Room (25-26°C)	Refgn. (5-6°C)	Room (25-26°C)	Refgn. (5-6°C)	Room (25-26°C)	Refgn. (5-6°C)
0 day	4.65	4.68	4.65	4.60	4.65	4.71
After 72 hrs. of curing treatment.	-	-	4.56	4.52	4.56	4.57
Just after smoking	-	-	-	-	3.81	3.80
2nd day of storage	‡	4.77	5.99	4.64	4.22	3.93
4th day		5.58	6.34	5.10	4.75	3.99
6th day		5.95	‡	5.53	4.48	4.23
8th day		6.16		5.76	5.96	4.39
10th day		6.41		5.93	6.23	4.50
12th day		‡		6.02	6.41	4.61
14th day				6.16	6.50	4.75
16th day				6.32	XX	4.87
18th day				6.45		4.99
20th day				‡		5.19
22nd day						5.36
24th day						5.75
26th day						6.34
28th day						6.61
30th day						6.84
32nd day						XX

‡ Spoiled (started smelling) discarded as putrified. Further bacterial load not taken.

XX Not smelling but fungus growth visible. Further bacterial load not taken.

I. V. R. I. Izatnagar (Agra University)

TABLE-XI

Mean ± Standard Error for acceptance Score of cured and cured-smoked cooked chicken stored under different conditions

Judges	Cured Refrigerated (5-6°C)	Cured-smoked refrigerated (5-6°C)	Cured-smoked room (25-26°C)	Fresh Meat
1	6.33 ± 0.34	5.66 ± 0.34	5.66 ± 0.34	6.00 ± 0.58
2	6.00 ± 0.00	6.66 ± 0.34	6.33 ± 0.34	4.00 ± 0.00
3	6.66 ± 0.34	5.33 ± 0.67	4.00 ± 0.34	4.00 ± 0.58
4	6.66 ± 0.34	5.33 ± 0.34	5.66 ± 0.34	5.33 ± 0.00
5	5.33 ± 0.67	6.00 ± 0.58	5.66 ± 0.88	4.66 ± 0.34
6	5.66 ± 0.34	5.00 ± 1.00	4.66 ± 0.88	6.33 ± 0.88
7	5.66 ± 0.34	6.00 ± 0.58	5.33 ± 0.34	4.33 ± 0.67
8	6.66 ± 0.34	6.66 ± 0.34	6.33 ± 0.34	5.33 ± 0.67
9	6.66 ± 0.34	6.33 ± 0.34	6.00 ± 0.58	5.33 ± 0.34

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

TABLE-XII

ANALYSIS OF VARIANCE

Acceptance score of cured and cured-smoked cooked chicken stored under different conditions.

Source of variation	D.F.	M S
Between treatment	3	9.44**
Between judges	8	2.04**
Treatment X judges	24	1.32*
Between trial	2	5.46**
Error	70	0.64

* $p < 0.05$ (Significant)

** $p < 0.01$ (Highly significant)

Duncan multiple range test for pairwise comparison of treatment means:

		Mean in Ascending order		
Treatment	T1	T12	T13	T11
Mean	4.81	5.52	5.89	6.19

Note:- Means under the same bar are not significantly different.

I. V. R. I. Izatnagar (Agra University)

CHAPTER V

Discussion

CHAPTER V

D I S C U S S I O N

Weight Changes:- There was a significant increase in weight of chicken during curing process. It was also seen that the increase in moisture content in both dark and white muscles after curing was also significant. This increase in moisture content of meat might be due to physical absorption of curing solution. This curing solution has higher concentration of sodium chloride. The increased water binding capacity of meat due to addition of chloride ion has also been reported by Hamm (1957) and Grau (1961). The increase in moisture content of both white and dark muscle (1.68%) alone cannot explain the significant gain in weight (6.51%). This might be due to increased chloride absorption along with with water which also add to the weight of cured chicken. Similar finding has been reported by Beeley and Marsden (1941). In this experiment only dark and white muscle were used for analysis. Water might have also been absorbed by many other loose tissues and bones of body which were not analysed.

After smoking the cured birds, there was a shrinakge of 5.95% and 11.72% when calculated on the basis of fresh and cured weights respectively. This proportion of loss in weight during smoking has also been reported by Hiner and Marsden (1961). However the shrinkage reported in this experiment is more than that reported by Chatterjee et al (1971). The lower losses in their report was claimed to be due to the addition of sodium polyphosphate which was not incorporated in the curing solution used by the author. Moisture analysis showed that both dark and

I. V. R. I. Izatnagar (Agra University)

white meat contributed to only 5.53 percent loss when compared to fresh and 7.30 percent when compared to cured. This shows that there was more moisture loss from some other parts also. Wings and other less fleshy parts which were nearer the heat during smoking might have lost more moisture than the other parts (Beasley and Marsden, 1941).

Moisture: The increase in moisture content of cured meat and loss of moisture in smoked chicken has been discussed under weight changes.

The higher moisture loss at refrigeration temperature than room temperature noticed in the study is in agreement with the report of Chatterjee et al (1971). This may be due to the fact that at 5°C the water holding capacity of air is low and that is why moisture gets condensed in the cooling coils etc., in the refrigerator. Since the birds were having more moisture than the surrounding atmosphere water might have escaped through the polyethylene bag. At 25°C the water holding capacity of air is quite good and so water did not escape through the polyethylene bag and hence the shrinkage was less.

The rate of moisture loss in cured meat was more than that of cured-smoked meat at refrigeration temperature. This may be due to the fact that the higher loss in cured meat might be due to higher moisture content and the lower loss in cured-smoked chicken might be due to the lower moisture content. At the time of smoking superficial drying takes place and due to the formation of a thin protective film of smoke on the surface of meat. This might have prevented surface evaporation which is

I. V. R. I. Izatnagar (Agra University)

corroborated by the findings of Draut (1963). No change of moisture content was observed when stored at room temperature and no difference of moisture content of dark and white meat was also noted and this is in agreement with the findings of Chatterjee et al (1971).

In this study a significant difference in moisture content has been observed between the three trials. This might be due to different age, breed and plain of nutrition of the birds used in different trials.

Protein and Fat: A slight decrease in protein and fat content of meat just after curing was noticed in the study. This might be due to increase in moisture content as the protein and fat were estimated on fresh sample basis. It might also be due to the fact that there is loss of a small amount of soluble nitrogen and fat into brine solution during the curing process. Fields and Dunker (1952) were also of the opinion that small amounts of nitrogen and fat are lost in wet curing process. Increase in protein content in smoked refrigerated and cooked meat was also proportional to decrease in moisture content.

After the initial loss of fat at the time of curing there was no further loss of fat either during smoking or at the time of preservation at either of the two temperatures. This may be due to the fact that chloride ions of sodium chloride might have prevented further oxidation of fat and the various constituents of smoke might have acted as antioxidants. This is in agreement with the findings of Rockwell and Eberts (1924) and Draudt (1963).

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

Chloride and Ash: In both cured and cured-smoked chicken there was a significant increase in chloride and ash content of birds stored at room temperature as compared to those kept at refrigeration temperature. This might be due to higher temperature in the room. Rapid diffusion of salt at higher temperature has also been reported earlier by Moulton and Lewis (1940) and Chatterjee et al (1971).

The higher chloride content in smoked meat might also be due to higher temperature within the smoking chamber. The dark meat was having significantly higher salt content than that of white meat, which might be due to anatomical differences of tissues. The dark meat contained low fat. Thus it seems that the concentration of salt in the tissue is inversely correlated to fat content. Borys et al (1969) has observed that lean bacon block took 7-11 hours at 50°C to reach 4 percent sodium chloride level whereas back fat took 128 hours to attain the same concentration at equal temperature. My findings are corroborated by the above observations.

Ash and salt was found low in cooked meat. This might be due to loss at the time of cooking when salt is exuded alongwith moisture. The juice when tested was salty.

Nitrite: During curing meat absorbs nitrite from curing pickle. So there is a significant increase in nitrite content of cured meat. But on subsequent smoking, cured meat has shown a significant decrease in nitrite content perhaps due to higher temperature of smoke chamber. Nitrite loss was 2 to 35 times more at 30°C than at 20°C has been reported by Pivnick et al (1967).

From table I and Fig.IV, it is clear that nitrite content of both cured and smoked meat stored at refrigeration was higher than that kept at room temperature. Cowanjones (1949) also reported similar findings.

After the initial take up of nitrate from the curing solution the nitrate might have been broken down to nitrite at the time of preservation by bacteria and also the moisture content of the meat has gone down and these factors might be responsible for the increase in the nitrite content of meat after storage both at room and at refrigeration temperature.

The nitrite content of meat stored both at refrigeration and room temperatures increased significantly at the end of 4th day of storage. But a significant decrease in nitrite content was evident on 8th day under the above storage conditions.

All the nitrate added during curing might have not been converted to nitrite during the short time curing process. A small quantity of nitrate might have been taken into the meat tissue, from the solutions, at the time of curing. The increase in nitrite content of meat upto 4th day might be due to the conversion of this residual nitrate to nitrite. Takagi et al (1970) also reported that a very small amount of nitrate was converted to nitrite by nitrate reducing bacteria during short curing process. The increase in nitrite level upto 4th day of storage was attributed to the increased nitrate reducing bacterial population in maturing bacon by Eddy et al (1960). An increase in nitrite content even to undesirable level due to increase in nitrate reducing micrococci was reported by Patterson (1963).

I. V. R. I. Izatnagar (Agra University)

The reduction of nitrite level from 4th to 8th day might be due to increase bacterial growth which might have started utilising nitrite since nitrate might have been exhausted. An increase in bacterial growth from 4 to 8th days was also recorded in this study (Fig.VII and VIII). The utilisation of nitrite by bacteria and breaking down of nitrite to subsequent end products by large numbers of bacteria was reported by Eddy et al (1960). The other possibility of nitrite reduction at later stages of storage might also be due to growth of yeast. This has been reported by Ingrem and Dainty (1971).

There was significantly more decrease of nitrite from 4 to 8th day at room temperature than refrigeration temperature. Nordin (1969) found surprising loss of nitrite in subsequent period of storage which was attributed to increased temperature and bacterial growth. Similarly in this experiment, also since room temperature was higher than refrigeration temperature the loss of nitrite was more at room temperature.

There was a higher reduction of nitrite content of meat after cooking. This finding is also in agreement with Pivnick et al (1967) and Takagi et al (1970), who reported a reduction of nitrite content to one third to one half on cooking at 70°C.

It is felt that this much of nitrate and nitrite need not be used for curing of chicken since the cured chicken was deep pink in colour. As chicken meat is considered white meat, consumers may not appreciate this much colour in the cured meat. Also nitrates need not be used when nitrite alone can give proper curing. But this would require further investigation.

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

BACTERIOLOGICAL STUDY

From the result (Table VIII, IX and X) it is evident that there has been a significant reduction in bacterial count, when meat was cured for 72 hours. This reduction of bacterial count might be due to inhibition of proteolytic bacteria by the salt, which was present at a concentration of 13 percent in the curing solution used. It might also be due to low pH. The pH of curing solution in the present experiment was 5.9. Similar type of finding was reported by Bee et al (1969). He observed that during rapid pickling method there was no increase in bacterial growth during curing. Ingram and Dainty (1971) reported that sodium chloride at 5 percent concentration partially and at 7 percent totally inhibited putrifying pseudomonas organisms. Since the concentration used in this study was 13 percent the bacterial growth might be very low.

There was only 4 percent salt in the meat immediately after curing (Table I). Even then there was not very much increase in bacterial load upto 4 days at room temperature and 18th days at refrigeration temperature (Fig. VII and VIII). This might be due to simultaneous presence of nitrite, nearly 300 ppm (Table I), along with sodium chloride, which might have also checked the bacterial multiplication. That sodium chloride along with nitrite has a synergestic inhibitory action on bacterial multiplication has also been reported by Pivnick and Thatcher (1968).

When cured chicken was smoked for 4 hours at 40-45°C it showed a remarkable decrease in bacterial population (Table VIII, IX and X). Similar type of finding has also been reported by Tilgner (1957). Kitchell and Ingram (1966) found that there was an immediate reduction in total number of bacteria by at least 90 percent on smoking of bacon. This inhibition of bacterial multiplication on smoking might be due to superficial drying action of heat during smoking which made water unavailable to bacteria or due to the formation of a thin film of smoke on the external surface of smoked chicken or both. It might also be due to bacteriocidal properties of the smoke constituents (Daudt, 1963). Randall (1969) found a decrease in pH of meat after smoking which he claimed to be due to absorption of smoke constituents into the meat. The reduced pH of the meat might have helped to check the bacterial growth of the smoked meat. The bacterial count of the meat stored at refrigeration temperature in all the treatments was always lower than those kept at room temperature. This might be due to complementary effect of refrigeration temperature to curing and smoking in suppressing the bacterial multiplication.

It was observed that at room and refrigeration temperatures mold growth was visible in cured-smoked meat after 6 and 10 days respectively and so mycostatin was added to suppress mold growth. When the birds were treated with 10 ppm mycostatin during II and III trials, the bacterial behaviour was similar as was observed in 1st trial. During 1st trial no mycostatin was added in the curing pickle.

I. V. R. I. Izatnagar (Agra University)

Since mycostatin have no antibacterial action, the bacterial growth was not at all affected but there was marked suppression on growth of mold and yeast at room temperature and at refrigeration temperature.

***

I. V. R. I. Izatnagar (Agra University)

ORGANOLEPTIC EVALUATION

The significant difference between treatments was not unexpected. Significant differences for other components of variation seems puzzling. Meat used for different trials were not of the same age and breed. This might have accounted for significant difference between trials.

Highly significant differences between judges and treatments and judges interaction was also observed. This may be due to the fact that judges in the taste panel to test the meat qualities were not specially trained for this. Further the type of cooking to which they are accustomed to is completely different from that used for the test. As such there was difficulty on the part of the judges to score and differentiate correctly the different samples. But when they got habituated, scoring pattern differed. These were probably the reasons for getting significant differences between judges and judges X treatment interaction.

Cured-smoked chicken stored at room temperature was rated slightly salty in taste when compared with refrigerated chicken. This has already been explained in chemical analysis where it has been shown that salt diffusion was more in meat stored at higher temperature than at lowere temperature. But the taste was not very much undesirable. Flavour of smoked chicken was very much distinct due to flavouring effect of smoke. But it was not liked by some of the judges, probably they were not accustomed to smoked meat.

I. V. R. I. Izatnagar (Agra University)

But the people who had previously tasted bacon or ham preferred cured-smoked chicken to cured or fresh chicken. Because many people like red meat the colour of cured meat was liked better, than other samples because of the slight pink colour.

Even though cured-smoked meat had lost moisture at the time of smoking, still the judges found it to be as tender and juicy as fresh meat.

****
*****
***
*

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

CHAPTER VI

Summary and Conclusion

I. V. R. I. Izatnagar (Agra University)

CHAPTER VI

SUMMARY AND CONCLUSION

Poultry Industry is making rapid strides in this country. This impetus can be maintained only if the eggs and poultry meat reach the consumer at a comparatively cheap and acceptable form. Since big poultry farms are mostly far away from the point of consumption, poultry meat has to be transported in such a way that neither nutritive value, nor palatability nor cooking proportion are to be adversely affected. Refrigeration and Deepfreeze may be available in the farms. But no refrigeration facilities are available either at the time of transport or during marketing. Hence experiments were undertaken to find out whether curing could be used for preservation of poultry meat.

In curing high concentration of salt is used to prevent bacteria from growing on meat and at the same time help in water binding capacity to prevent dehydration. Other chemicals like nitrite, nitrate and monosodium glutamate in low concentration were used. The addition of these chemicals helps to improve colour of meat and helps in marketing of the product.

Since chloride and nitrite may be injurious to consumers if used in large quantities, the amount of chloride and nitrite was estimated at various stages of preservation. Also the bacterial load was estimated at the time of dressing before immersion in curing solution and during the period of preservation.

Birds were preserved both at room temperature (25-26°C) and at refrigeration temperature (5-6°C). Birds were wrapped in polyethylene bags during the period of preservation.

To give a complementary effect to curing, the birds were smoked for 4 hours at 40-45°C after curing. Hard wood smoke was used. At the end of 8 days organoleptic evaluation of the meat was done using a panel of judges and the preserved meat was compared with fresh meat. Experimental birds and fresh controls were cooked at 10 lb pressure for 10 minutes before offering the birds to the judges.

It was found that -

(1) Fresh killed birds become unfit for human consumption within 24 hours at room temperature. But at refrigeration temperature, they remained edible for about 10 days.

(2) Poultry meat can be safely kept at room temperature for 4 days if they are cured for 72 hours in pickle solution used.

(3) At refrigeration temperature cured birds can be stored for about 14 days.

(4) Smoking acts a complement to curing, cured-smoked birds can be kept at ambient temperature for as long as 14 days without any adverse effect and at refrigeration temperature for 30 days.

(5) It was observed that the chloride content of meat increases after curing. But the chloride content of meat stored at room temperature is significantly more than that preserved

I. V. R. I. Izatnagar (Agra University)

at refrigeration temperature. This may be due to the fact that there is better penetration of salt within the tissues at higher temperature than at lowere temperature. This higher value of chloride ions in meat kept at room temperature is observed even after the meat is cooked.

(6) The nitrite content of cured and cured-smoked birds increases in the meat upto about 4 days. This is noticed in meat preserved both at room temperature and at refrigeration temperature. But by 8th day the nitrite content had again got sufficiently reduced that they can be safely used for human consumption. After cooking the nitrite concentration was so low in meat preserved at both the temperatures that the cured and cured-smoked meat will cause no harm if eaten. Against a recommeded dose of 200 ppm the nitrite content was only approximately 25 ppm after cooking in cured-smoked poultry meat meat and approximately 115 ppm in cured meat. Cured-smoked poultry meat can be safely preserved at room temperature (25-26°C) for 14 days and for one month at refrigeration temperature (5-6°C). Nitrite content increases initially perhaps due to the fact that bacteria were able to breakdown nitrates to nitrite but after sometime nitrite itself was used by the bacteria for their growth and multiplication and so the value got reduced.

(7) Bacterial load in cured meat went up slowly in the initial stages but after 4 days, the load became so high that meat could not be preserved for more than 4 days at room temperature.

I. V. R. I. Izatnagar (Agra University)

(8) Under similar treatments the bacterial load of meat stored at refrigeration temperature increased only at a slow pace. This may be due to the effect of low temperature on the growth of bacteria.

(9) In cured-smoked birds kept at room temperature the bacterial load initially came down but after 12 days the load became very high and so after 14 days the meat had to be rejected.

(10) Cured-smoked chicken preserved at refrigeration temperature had low bacterial load upto 20th day after that growth increased very rapidly. Still it was edible upto one month. This may be due to the effect of low temperature and curing and smoking.

(11) Organoleptic tests showed that consumers like cured meat as much as fresh birds. As a matter of fact many preferred cured meat to fresh meat because of the slight pink colour; since many consumers preferred red meat to white meat. Due to the slight smoke flavour taste panel Judges were less pr appreciative of the meat of cured-smoked birds. They were also able to appreciate slightly higher salt taste in cured birds stored at room temperature.

(12) All in all it can safely be said that cured poultry meat can be safely kept at room temperature (25-26°C) for 4 days and for 14 days at refrigeration temperature (5-6°C). Cured-smoked poultry meat can be safely preserved at room temperature (25-26°C) for 14 days and for one month at refrigeration temperature (5-6°C). Birds can be transported from one end

I. V. R. I. Izatnagar (Agra University)

of the country to the other without any refrigeration facility and without loss in nutritive value and cooking properties if they are processed by curing and curing and smoking at the point of production.

*****
****
***
*

I. V. R. I. Izatnagar (Agra University)

I. V. R. I. Izatnagar (Agra University)

BIBLIOGRAPHY

BIBLIOGRAPHY

Adamcia, M., Clark, D.S., Yoguchi, M. (1970).
Effect of Psychrotolerant bacteria on the aminoacid of chicken skin.
J. of Food Sci. 35: 272-75.

Annon (1970).
Monosodium glutamate studies on its possible effects on the C.N.S.
Nutrition Reviews 28, 124-29.

Ayres, J.C., Ogilvy, W.S. and Stewart G.F. (1950).
Postmortem changes in stored meat. Ist microorganisms associated with development of slime on eviscerated cut up poultry.
Food Tech - 4: 199-205.

Barnes, E.M. and Impey, C.S. (1968).
Psychrophilic spoilage bacteria of poultry.
J. Appl. Bact. - 31: 97-107.

Barry, T.H. (1949).
Glutamic Acid.
Food XVIII: 100-103.

Bem, Z., Stolic, D., Tomcov, D. (1969).
Effect of Technological procedures on microflora on cured and comminuted canned meat.
Proc. of the European Meeting of Meat Res. Workers, 15: 164-75.

Benheim, F. (1943).
The significance of the amino acids groups for the oxidation of various compounds by cholera vibrio (V.Comma).
Archives Biochem. J - 30: 394-411.

Beeley, A.K. and Marsden (1941).
A study of turkey curing and smoking.
Poultry Sci. 20: 496-506.

Borys, A., Riewe I and Strzezewski T (1969).
Gospodarka Miesna 21: 21-24.
Food Sci. Tech. Abst. 2: 297-1970.

I. V. R. I. Izatnagar (Agra University)

Bose, A.N., Dutt, J.M.A. and Saha, M. (1954).
Studies on extension of storage life of fish by chemical ice.
J. Indian Chem. Soc. 17: 30-34.

Brechaw, E.W., and Dawson, L.E. (1970).
Smoke flavoured chicken roals.
J. of Food Sci. 35: 379-82.

Brooks, J. (1937).
Proc. Roy. Soc. Lond. 123: 368.
Cited by Taylor. A. McM in final Tech. Report - Investigation of the Biochemical properties of pork muscle as they are related to pigment formation and colour fixation during curing.

Brummendorf, L. (1970).
Smoke producing tablets.
United State Patent. 3: 492: 134.

Bugge, G. (1927).
Studies of the smoking process for foods I. The importance of vapours.
J. Sci. Food Agric. 12: 364: 374.
(cited by Foster, W.W. and Simpson, T.H.,1961).

Bullerman, L.B., Hartman, P.A. and Ayres, J.C.(1969).
Aflatoxins production in meat II. Aged dry salmis and aged country cured hams.
Appl Microbiology 18: 718-22.

Buttiaux, R. (1965).
Nitrifying bacteria in pickled meats.
Rev Ferment, 18: 191-95.

Castell, C.H. (1949a).
Nitrite reducing bacteria on cod fillets.
Fisheries Res. Board Can- 7: 528-35.

Castell, C.H. (1949b).
Nitrite reducing bacteria on cod fillets.
Fisheries research Board Can. 7: 424-429.

Castellani, A.G. and Niven, C.F. Jr. (1955).
Factors affecting the bacteriostatic action of sodium nitrite.
Appl Microbial- 3: 154-59.

I. V. R. I. Izatnagar (Agra University)

-A 2633-

Cavett, J.J. (1962).

The microbiology of vacuum packed sliced bacon.
J. Appl. Bact. 25: 282.

Chatterjee, A.K. (1968).

A study on the effects of environmental condition on the migration of curing chemicals in ham.
Indian Jour. of Animal Health. 7: 219-24.

Chatterjee, A.K., Panda, B., Khabade, V.S. and Puttarajappha(1971).

Studies on curing and smoking of poultry.
Food Sci. and Tech. 8: 28-30.

Cho, I.C. and Bratzler, L.J. (1970).

Effect of sodium nitrite on flavour of cured pork.
J. of Food Sci. 35: 668-70.

Clark, D.S. (1970).

Growth of Psychrotolerant Pseudomonads and Achromobacteria on various chicken tissues.
Poultry Sci. 49: 1315-18.

Cutting, C.L. (1952).

General principles of smoke-curing of fish.
Food Investigation leaflets No.13.

Draudt, H.N. (1963).

The meat smoking process. A Review.
Food Tech. 17: 85-90.

Dyer, W.J. (1949).

Bacterial reduction of sodium nitrite and formation of trimethylamine in fish.
J. Fisheries Research Board Can-7: 461-70.

Dyer, W.J. and Castell, C.H. (1949).

Further studies on the bacteriological reduction of nitrite in fish during spoilage.
J. Fish Research Can. 7: 536-54.

Eddy, B.P. (1958).

The effects of salt concentration and temperature on nitrite production and metabolism.
2nd Int. Symp. Fd. Microbiol, Cambridge, 87.

I. V. R. I. Izatnagar (Agra University)

Eddy, B.P., Gatherum, D.P. and Kitchell, A.G. (1960).

Bacteriological metabolism of nitrate and nitrite in maturing bacon.
J. Sci. Food Agric. 11: 727.

Eddy, B.P., and Ingram, M. (1956).

Cited by Eddy, et al (1960). Bact. Metabolism of nitrate and nitrite in maturing bacon.
J. Food Sci. Agric. 11: 727.

Eddy, B.P. and Ingram, M. (1962).

Factors affecting the nitrite content of wilchire bacon.
Proc. Int Fd. Sci. Cong. Lond. Sept. 1962, 405.

Edwards, P.R. (1939).

Incidence of salmonella type in fowl in the United States.
Proc. World's Poultry Cong. 271-74.

Elliott, R.P., Straka, R.P. and Garibaldi, J.A. (1964).

Phlyphosphate inhibition of growth of pseudomonads from poultry meat.
Appl. Microbial- 12: 517-22.

Federer, W.T. (1967).

Experimental Design.
Oxford and I.B.H. Publishing Co. Indian Edition 1967.

Fields, M.D. and Dunker, C.F. (1952).

Food Tech. 6: 329.

Finzi, M. (1970).

Monosodium glutamate and the Disease of Chinese Restaurants.
Industries Alimentari 9: 85-88
Food Sci. & Tech. Abst. 2: 9: 309.

Fournaud, J., Jacquet B., Ponjordien, B. (1971).

Development of microflora of sausage meat depending on preservatives used and method of storage.
Industries Ailmen Laria et Agricolem 88: 15-26.
Food Sci. & Tech. Abst. 3: 941.

Foster, W.W. and Simpson, T.H. (1961).

Studies of the smoking process for foods.
1. The importance of vapours.
J. Sci. Food Agric. 12: 363-374.

I. V. R. I. Izatnagar (Agra University)

Foster, W.W. and Simpson, T.H. and Campbell, D. (1961).
Studies of the smoking process for Foods.
II The role of smoke particles.
J. Sci. Food Agric. : 12: 635-44.

Froning, G.W. (1965).
Effect of polyphosphates on binding properties of chicken meat.
Poultry Sci. 44: 1104-1107.

Froning, G.W. (1966).
Effect of various additives on the binding properties of chicken meat.
Poultry Sci. 45: 185-88.

Genigeorgis, C. and Sadler, W.W. (1966).
Effect of sodium chloride and pH on entrotoxin,B production.
J. Bacteriol. 92: 1383-87.

Genigeorgis, C., Riemann, H and Sadler, W.W. (1969).
Production of entrotoxin B in cured meat.
J. Food Sci. 34: 62-68.

Gibbons, N.E., Rose, D and Hopkins, J.W. (1954).
Bacteriocidal and drying effect of smoking on bacon.
Food Tech. 8: 155.

Grau, R. (1955).
Utilisation of sugar in meat processing.
Fleischwirtschaft - 7: 182-84.
J. Sci. Food Agric. Abst. 7: 116.

Grau, R. (1961).
Biochemical and Physiochemical principles of salting and curing.
Proc. of the VTh Intn. Cong. of Bio.
I.V.B. Symposium Series 28: 206-213.

Grau, R. (1969).
The use of Ascorbic acid in the production of preserved meats.
I.F.S.T. Proceedings 2: 43-47.
Food Sci. and Tech. Abst. 2: 293-1970.

I. V. R. I. Izatnagar (Agra University)

Grau, R. and Bohm, A. (1958).
Chemistry of curing.
Industr. Alim. Agric. 75: 401-406.
J. Sci. Food Agric. Abst. 10: 52 - 1959.

Greenwood, D.A., Lewis, W.L., Urbain, W.W. and Jensen, L.B. (1940).
Food Research 5: 625.

Gunderson, M.F., Schwartz, P.M. and Rose, K.D. (1946).
How much dressed poultry is as clean as it looks.
U.S. Egg and Poul Mags. 52: 389.

Gunderson, M.F., Rose, K.D. and Henn, M.J. (1947).
Poultry boning plant needs bacteriological control.
Food Indust. 19: 1516.

Gunderson, M.F., Mc Faadden, M.W. and Kyle, T.S. (1954).
The bacteriology of commercial poultry processing.
Burgess Publishing Company, Minneapolis 15, U.S.A.

Haldane, J.S. (1901).
J. Hyg Camb 1:115 cited byTaylor A. McM in final technical report- Investigation of the Biochemical properties of pork muscle as they are related to pigment formation and colour fixation during curing.

Hamm, R. (1957).
Water combining capacities of mammalian muscle.
III. Effect of neutral salts.
Abst. J. Sci. Food Agric. 9: 286- 1958.

Hamm, R. and Grau, R. (1958).
Water binding capacity of mammalian muscle V.
Effect of salt an of week acids.
Abst. J. Sci. Food Agric. 10: 274- 1959.

Hamm, R. and Iwata, H. (1962).
Effect of heating in presence of sodium chloride on water binding capacity and pH value of beef muscle.
Abst. J. Sci. Food & Agri. 13: 112- 1962.

Hansen, (1960).
Cited by Shrimpton, D.H. and Earners, E.M.
A comparison of oxygen permeable and impermeable wrapping materials for the storage of chilled eviscerated poultry.
Chemy Ind. P- 1492.

I. V. R. I. Izatnagar (Agra University)

Heurickson, R.L., Sleeth, R.B. and Bradry, D.E.(1956).
Sodiumascorbate in stabilizing cured meat colour.
Food Tech. 10: 500-503.

Hiner, R.L. and Marsden, S.J.(1961).
Curing and Smoking turkeys.
United States Department of Agric. C.A. 44-27.

Horowitz-Wlassowa (1941).
Cited by Grau,R. 1961. I.U.B. Symposium series 28-206.

Hussini, C.A. and G.E. Cooper (1957).
Fraction and Wood smoke and the composition of chemical composition of sawdust and friction smoke.
Food Tech. 11: 499.

Ingram, M. and Dainty, R.H. (1971).
Changes caused by microbes in spoilage of meats.
The J. of Appl. Bact. 34: 21-35.

Jacquest B., Mongin, J.P., Pinson, M. (1969).
Experiments in the use of ascorbic acid in meat curing.
Revue dela conserve 25: 125-29.

Jay James M (1970).
Modern Food Microbiology.
Ist Edi. Van Nostrand Reinhold Company, U.S.A. - 114.

Jensen, L.B. (1943).
Action of hard wood smoke on bacteria in cured meats.
Food Research 8: 377.

Jensen, L.B. (1954).
Microbiology of Meats.
3rd Ed. Garrardpress Champaign, Illinois, 203.

Jensen, L.B. and Hess, W.E. (1941).
Food Manuf. 16: 157. Cited by Eddy et al 1960.
Bacterial metabolism of nitrate and nitrite in maintaining bacon.
J. Food Sci. Agric. 11: 727.

I. V. R. I. Izatnagar (Agra University)

Katz, M. and Dawson, L.E. (1964).
Water absorption and retention by cut up broiler parts chilled in polyphosphate solution.
Poultry Sci. 43: 1541-45.

Kenderoskis (1971).
The degree and type of bacterial contamination in semi-pressed canned meat Schlacht-und-viehhof-zeitung 71-133-36
Food Tech. Abst. 3: 8 'S'- 1006.

King, E.J. and Wootton, I.D.P. (1956).
Microanalysis in Medical Biochemistry.
J & A. Churchill Ltd., London: 54.

Kitchell, A.G. and Ingram, M. (1966).
The selective effect of salt and smoking on the bacterial flora of bacon with special reference to vaccum packing.
Proc. 2nd Int. Cong. Fd. Sci. Tech. Warsaw, paper No.B. 3.6.

Kotula, A.W. (1966).
Variability in microbiological sampling of chicken by the sawb method.
Poultry Sci. 45: 223-36.

Kraybile (1955).
Cited by Merotra, V.K. Chatterjee, A.K. and Khabade, V.S. 1970.
Studies on curing of bacon A. Preliminary report.
I.V.J. 47: 691-94.

Kunizhev, S.M. 1970.
Effect of liquid smoke preparation on development of lactic acid bacteria.
Trudy Vologodskii, Molochryi Inst. 60. 25-31.
Food Sci. Tech. Abst.-3: 1182. 1970.

Lea, C.H. (1933).
Chemical changes in the fat of frozen and chilled meat.
V. The effect of smoking and the influence of atmospheric humidity on the keeping properties of bacon.
J. Soc. Chem. Ind. 52: 57.

Lerke, P. Adamms, R. and Farber, L. (1963).
Bacteriology of spoilage of fish muscle.
I Steril press juice as a suitable experimental medium.
Appl. Microbiol: 11: 458-62.

I. V. R. I. Izatnagar (Agra University)

Liston, J. and Shewan, J.M. (1958).
Bacteria brought into brine on fish.
Proc. Intern. Symposium Food Microbial IInd
Symposium. Cambridge England, 35-43.

Malcolm, H.R., Woodruff, J.G. and Cecile, R. (1957).
Curing and smoking turkeys.
Georgia Memeo series N.S. 37 (Athens, Ga).
cited by Hiner and Marsden, 1961, U.S.D.A.- C.A. 44-27.

May, K.N., Irby, J., D., and Carson, J.L. (1961).
Shelf life and bacterial count of excised poultry tissue.
Food Tech. 16: 66-68.

Mclean, R.A., Lilly, H.D. and Alford, J.A. (1968).
Effects of meat curing salts and temperature on
production of staphylococcal enterotoxin B.
J. Bacteriol. 95: 1207-11.

Mc Vicker, R.J., Dawson, L.E., Mallman, W.L., Walters, S and
Jones, E. (1959).
Effects of chlortetracycline on shelf life of fresh
poultry meat treated in a commercial processing plant.
Poultry Sci. 38: 337.

Merory, J. (1968).
Food Flavourings.
IInd Ed. The A.V.I. Publishing Comp. I.A.C. , 291.

Mihalyi, V. (1969).
Examination of additives improving taste and colour
of cured meat products.
Husipar 18: 121-26.
Food Sci. and Tech. Abst. 2: 131. 1970.

Mohler, K. and Raible, K. (1959).
Ascorbic acid as an additive in meat products II.
Dtsch. Lebensmitt. Rdsch- 55, 3-9.
Abst. of Food Sci. & Agric. 10: 51. 1959.

Morselli, P.L., Garattini (1970).
Monosodium glutamate and the Chinese restaurant syndrom
Nature 227: 611-12.

NAGEL, C.W., Connolly, R.F., Vaughn, R.H. and Stewart, G.F.(1958).
Want to extend shelf life? Where are some ways to do it.
Proc. & Mkt. 65(1) - 14-15.

I. V. R. I. Izatnagar (Agra University)

Nagel, C.W., Simpson, K.L., Vaughn, R.H. Ng. H. and Stewart, G.F. (1960).

Micro-organisms associated with spoilage of refrigerated poultry.
Food Technol. 14: 21-23.

Noukom (1956).

Sodium Glutamate.
Abst. of Sci. Fd. Agric. 8: 57, 155.

Niiviamara, F.P. and Pohja, M.S. (1957).

Ripening of raw sausage II. Bacterial strains isolated from raw sausage and their significance in the ripening process.
Z. Lebensmith Untersuch- 106: 187-96.
Abst. of Sci. Food Agric. 9: 162. 1958.

Nordin, H.R. (1969).

The depletion of added sodium nitrite in ham.
Canadian Inst. of Food Technology Journal- 2: 79-85.

Official method of Analysis.

Assoc. of Official gric chem.
Washington, D.C. Tenth Ed. 1965.

Osmanjones (1949).

Balon and ham manufacture.
Food XVIII- 260-261.

Panda, B. (1966).

Poultry Guide. 3.8.

Patterson, J.T. (1963).

Salt tolerance and nitrate reduction by micrococci from fresh pork curing pickles and bacon.
J. Appl. Bact.- 26. 80.

Pivnick, H. and Bird, H. (1965).

Toxinogenesis by clostridium botulinum type A and E in perishable cooked meats vaccum packed in plastic purches.
Food Techno. 19: 1156.

I. V. R. I. Izatnagar (Agra University)

Pivnick, H., Rubin, L.J., Barnett, H.W., Nordin, H.R., Feguson, F.A. and Farrin, C.H. (1967).

Effect of sodium nitrite and temperature on Toxinogenesis by clostridium botulinum in perishable cooked meats vaccum packed in air Impermeable plastic pouches.
Food Technol. 21: 204-206.

Pivnick, H., and Thatcher, F.S. (1968).

Factors affecting the safety of thermally processed canned cured meats.
Proc. 98th Annual Meeting of Ani. Pub. Healths Assoc.- 125.

Quastal, J.H. and Wooldridge, W.R. (1927).

The effects of chemical and physical changes in environment on resting bacteria.
Biochem. J. 21: 148-168.

Randall, C.J. (1969).

Alteration in procine muscle protein solubility and protein functional groups as affected by the smoking process.
Dessertation Abstract Intern. Section B. The Science and Engineering 30- 2754.

Randall, C.J. and Bratzler, L.J. (1970).

Changes in various protein properties of pork muscle during the smoking process.
J. Food Sci. 35: 248-49.

Richardson (1907).

Inhibitory action of nitrite on mixedkegy microorganisms
Cited by Mehrotra et al (1970).
I.V.J. 47: 691-694.

Rockwell, G.E. and Ebertz, E.G. (1924).

J. Intec. Diseases. 35: 573.
Cited by Jacob. B.M. The Chemistry and Technology of Food and Food Products. Interscience Publishing Inc. New York, Vol.II, 371, Vol.II.

Rodger, C.J., Mills, P.A. and Stewart, G.F. (1956).

Incorporation and distrubution of monosodium glutamate in chicken meat.
Food Technol. 10: 299-302.

I. V. R. I. Izatnagar (Agra University)

Rose, H.E. (1965).
Clostridium putrefaction- a neglected anaerobe.
J. Appl. Bact. 28: 49.

Solarino, L.J. and Nord. F.F. (1944).
The mechanism of enzyme action XXV.
Balance of accumulated pyruvic acid in carbohydrate fermentation by fusaria.
Archives. Biochem. 5: 435-43.

Shelef, L.A. and Jay, J.M. (1969).
Relationship between amino sugars and meat microbial quality.
Appl. Microbiol: 17: 931-932.

Sherman, P. (1962).
Water binding capacity of fresh pork. IV. Influence of ion absorption from neutral salts and polyphosphate on water retention by lean pork.
Food Tech. 16: 91-95.

Shewan, J.M. (1949).
Cited by H.N. Droudt. 1963.
The meat smoking process.
Food Technol. 17: 87.

Shewan, J.M. (1950).
Preservation of fish by the use of nitrite ice
Nature 166: 613-614.

Shewan, J.M. (1953).
Cited by Grau R-1961.
Biochemical and Physiochemical principles of salting and curing.
Proc. of the Vth Intn. Cong. of Bio. I.V.B. Sumposium Series 28: 206-213.

Smith, F.H. et al (1951).
Cited by Grau-R- 1961.
Biochemical and Physiochemical principles of salting and curing.
Proc. of the Vth Intn. Cong. of Bio. IVB, Symposium series 28: 206-213.

Snedecor, G.W. and Cochran, G.W.
Statistical methods. Sixth Edn. Oxford & I.B.H. Publishing Co. 1967.

I. V. R. I. Izatnagar (Agra University)

Strazenski, T., Borys, A. and Reiwe, I (1969).
Salt content of bacon sides in relation to curing technique.
Gospodarka Miesne 21: 10-12.
Food Sci. & Technol. Abst. 2: 141-1970.

Suter, C.M. (1941).
Relationships between structures and bacterial properties of phenol.
Chem. Revs. 28: 269-99.

Takagi, S., Nakao, Y., Miyawaski, M., Ishi. K. (1970).
Studies on the curing of meat I Effects of nitrite on the formation of and stability of cured meat colour.
Nihon Shokulin Kogyo Gukkai-shi.
Food Science & Technol. Abst. 3: 962 S. 1971.

Takagi, S., Nokao, Y., Miyawaki, M. Ishii, K. (1971).
Studies on the curing of meat II. Effect of nitrate during curing.
Nihou Shokutin Kagyo Gakkai-Shi.
Food Sci. and Technol. Abst. 3: 9628. 1971.

Tarr, H.C.A. (1941a).
Bacteriostatic action of nitrites.
Nature - 147: 417-418.

Tarr, H.C.A. (1942A).
The action of nitrite on bacteria: further experiments.
J. Fisheries Research Board Can.6: 74-89.

Tarr, H.C.A. (1944A).
The action of nitrates and nitrite on bacteria.
J. Fisheries Res. Board Can. 6: 233-42.

Taylor, A. McM and Walter, C.L. (1967).
Biochemical properties of pork muscle in relation to curing Part II.
J. Food Sci. 32: 261-68.

Tilgner, D.J. (1957).
A rational procedure for the WL-smoking curing of fish.
Food Manuf. 32: 365-68.

I. V. R. I. Izatnagar (Agra University)

Walker, H.W. and Ayres, J.C. (1956).
Incidence and kinds of organisms-associated with commercial dressed poultry.
Appl. Microbiology 4: 345-49.

Walters, C.L. and Taylor, A. McM (1963).
Biochemical properties of pork muscle in relation to curing.
Food Technol. 17-118.

Watts, B.M. (1956).
Freeze curing of bacon.
Food Technol. 10: 101-103.

Watts, B.M. and Faulkner, M. (1954).
Antioxident effect of liquid smoke.
Food Technol. 8: 158.

Wickerham, L.J. (1957).
Presence of nitrite assimilating species of 'Debaryomyces' in lunch meats.
J. Bact. 74: 832.

Wierbicki, E. Cahill, V.R. and Deatheraje, F.E. (1957).
Effect of added sodium chloride, Pot. Chloride, Calcium chloride, Magnesium chloride and citric acid on meat shrinkage at 70°C and of added sodium-chloride on drip losses after freezing and thawing.
Food Technol. 11: 74-76.

Wilson, E., Fattenbarger, R.S., Foter, M.J. and Lewis, K.H.(1961).
Prevalence of salmonella in meat and poultry products.
J. Infect. Diseases 109: 166-71.

Wistreich, H.E., Morse, R.F., and Kenyon, L.J. (1959).
Food Tech. 13: 641. Cited by Grau. R. 1961.

Woodburn, M. (1964).
Incidence of salmonella in dressed broiler-fryer chicken.
Appl. Microbial-12: 492-95.

Woodburn, M., Harrington, R. and William J. Stadelman,(1966).
Frying chicken purchased in retail market in one area "Microbiological Aspects".
Poultry Sci.45: 253.

Ziemba (1962).
Cited by Draudt. H.E. 1963.
The meat smoking process: A Review.
Food Technol. 17: 85-90.

I. V. R. I. Izatnagar (Agra University)

I.V.R.I. N.L.V.S. Izatnagar

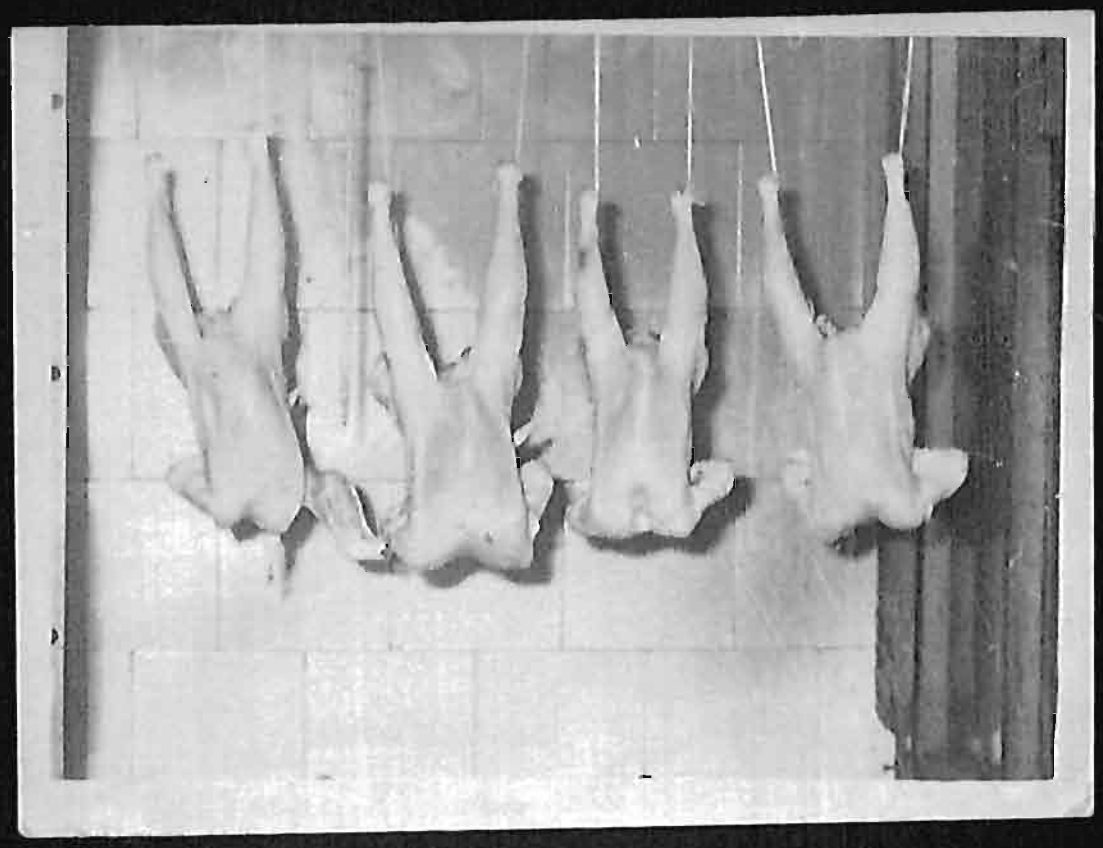


FIG. 1
BIRDS IN SMOKE CHAMBER AFTER CURING AND SMOKING

FIGURE 2
SMOKED BIRDS IN POLYETHYLENE BAGS

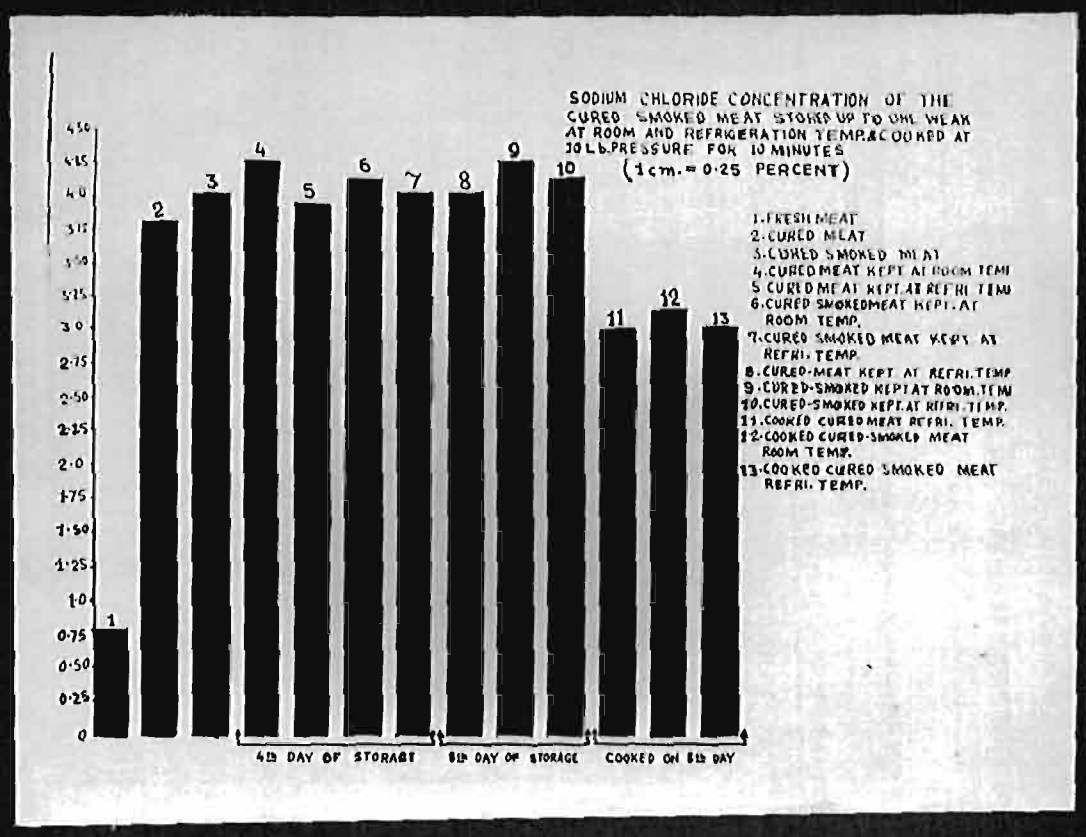


FIGURE 3
GRAPH DEPICTING CHLORIDE CONCENTRATION

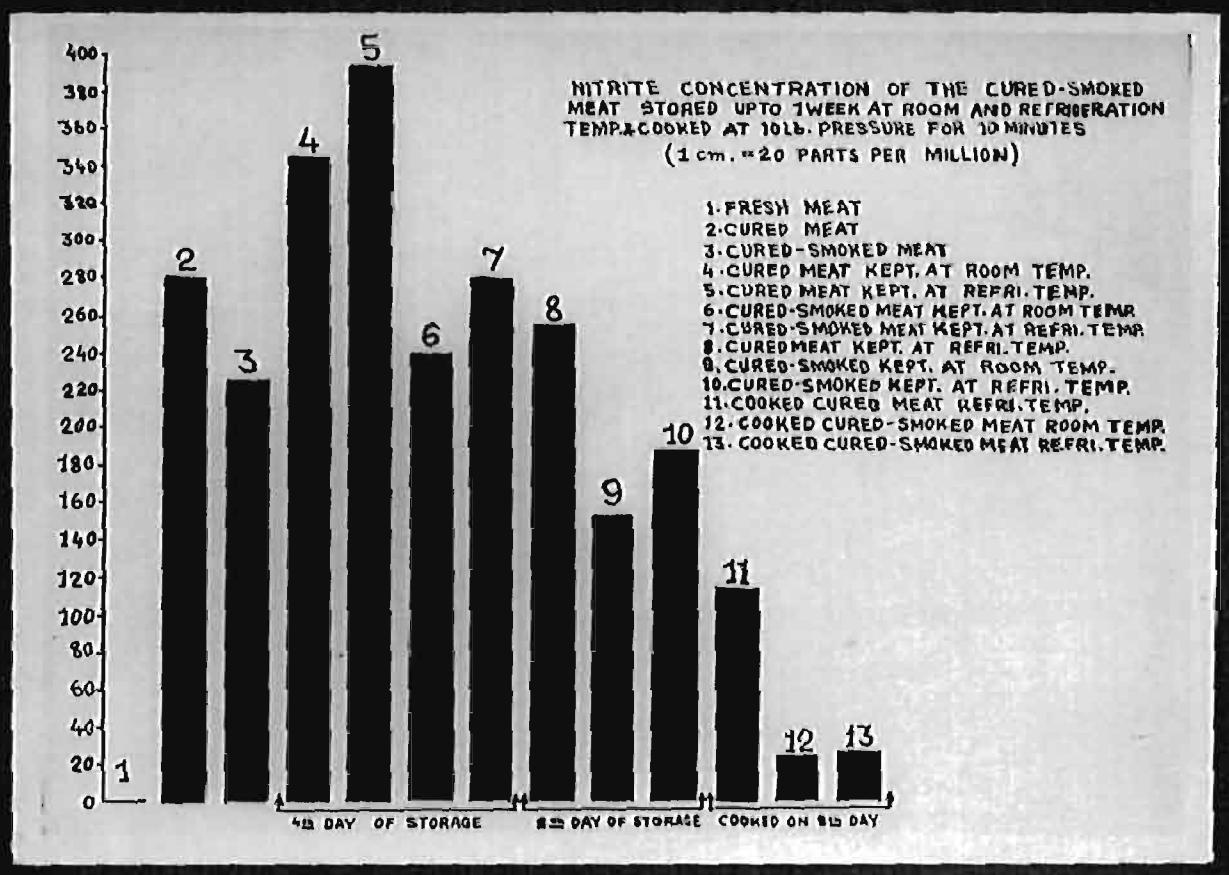


FIGURE 4
GRAPH DEPICTING NITRITE CONCENTRATION

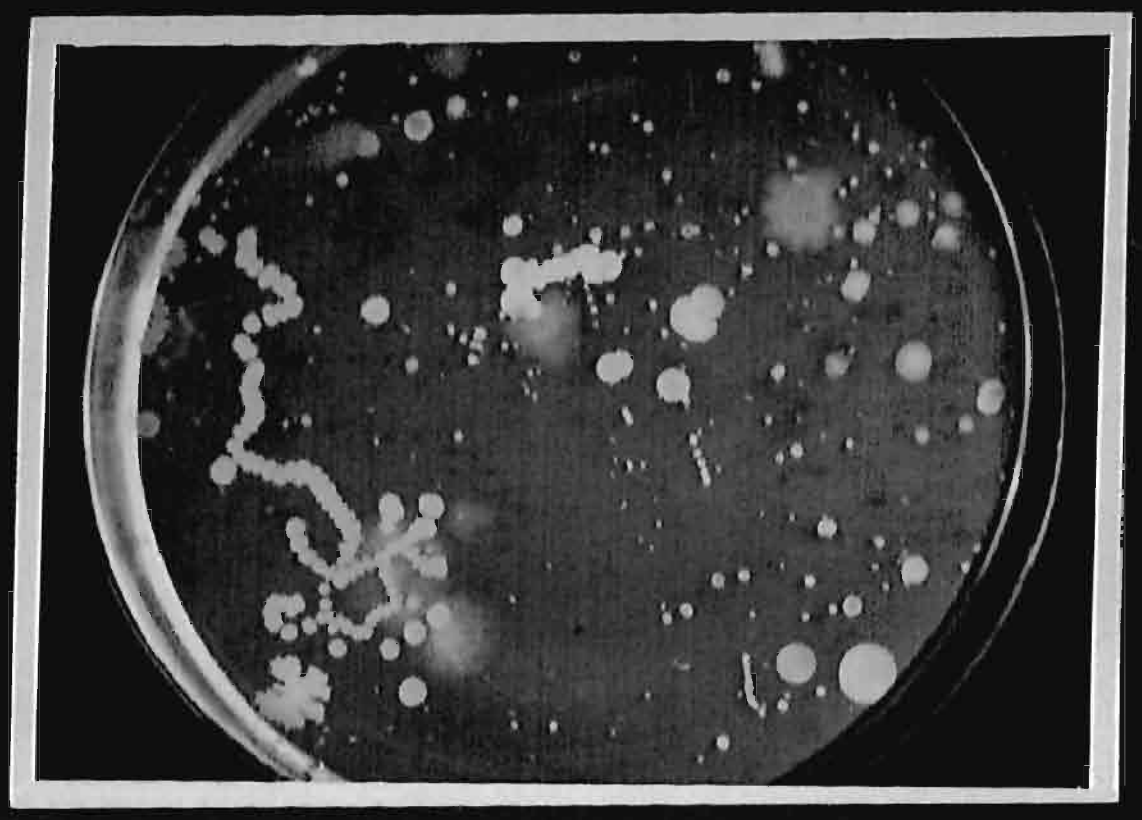


FIGURE 5
PETRIDISH SHOWING HIGH BACTERIAL LOAD IN CURED MEAT

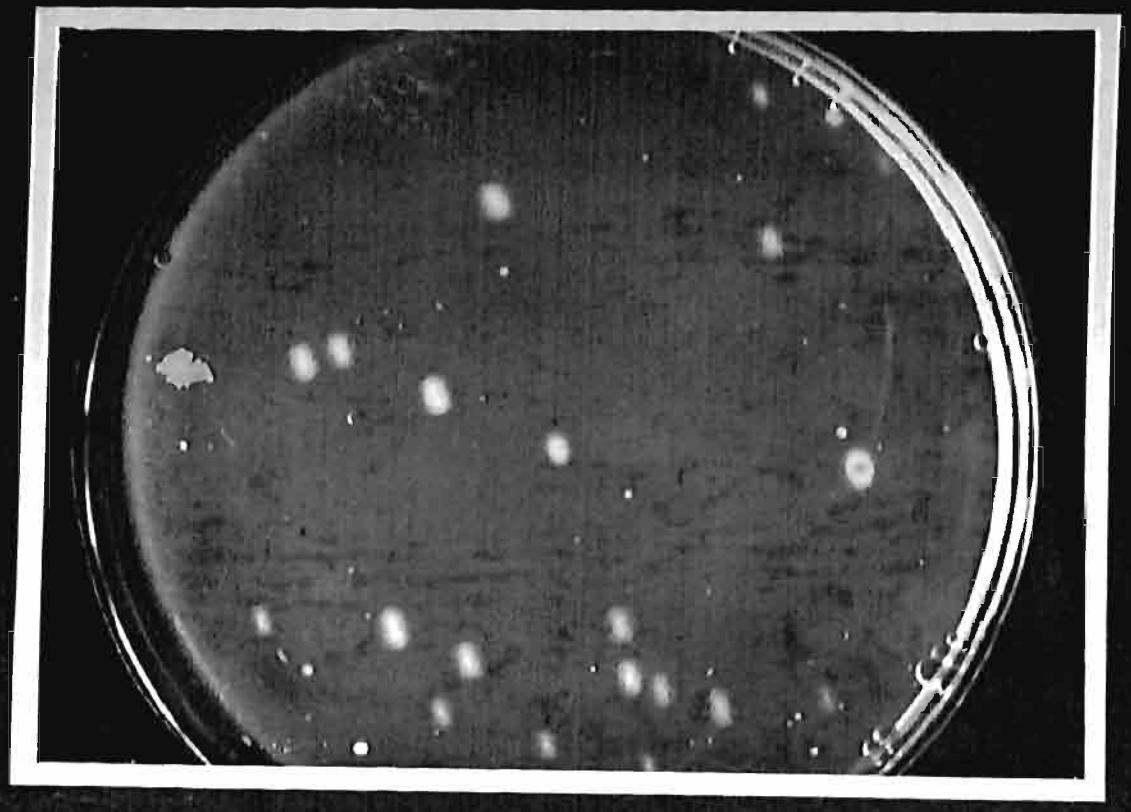


FIGURE 6
PETRIDISH SHOWING LOW BACTERIAL LOAD IN CURED-SMOKED MEAT

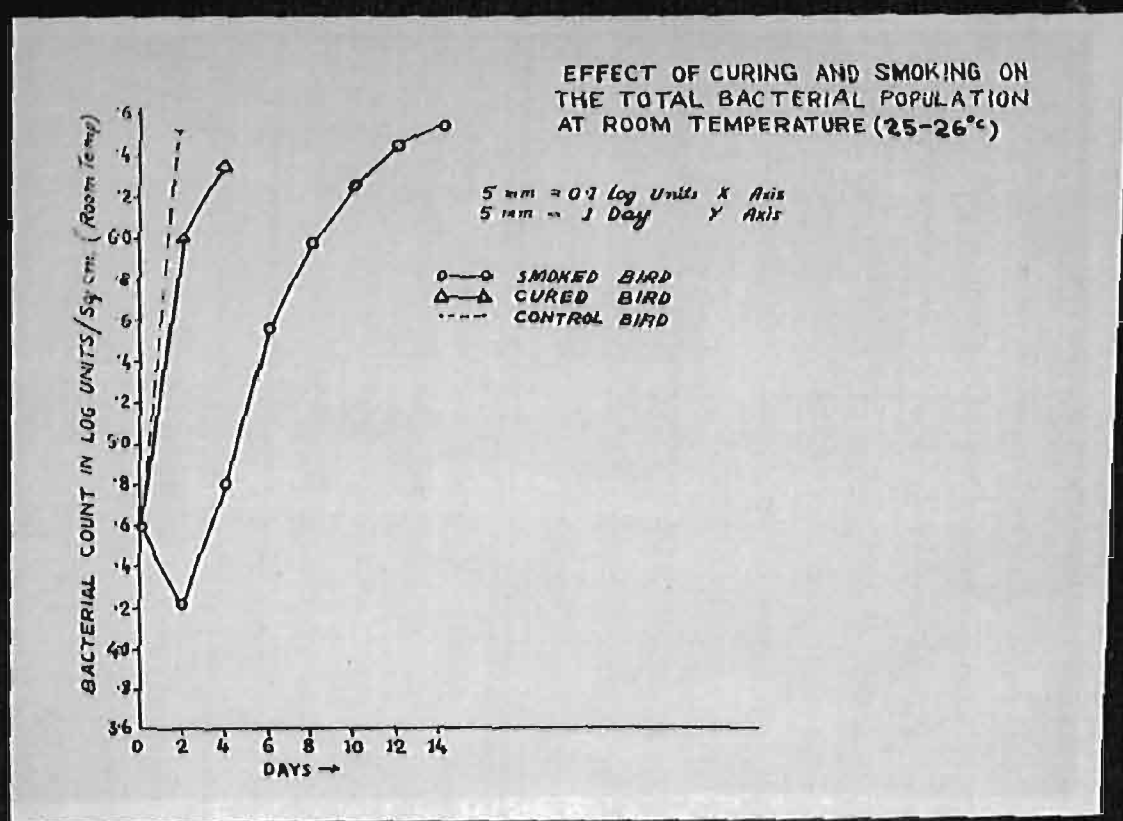
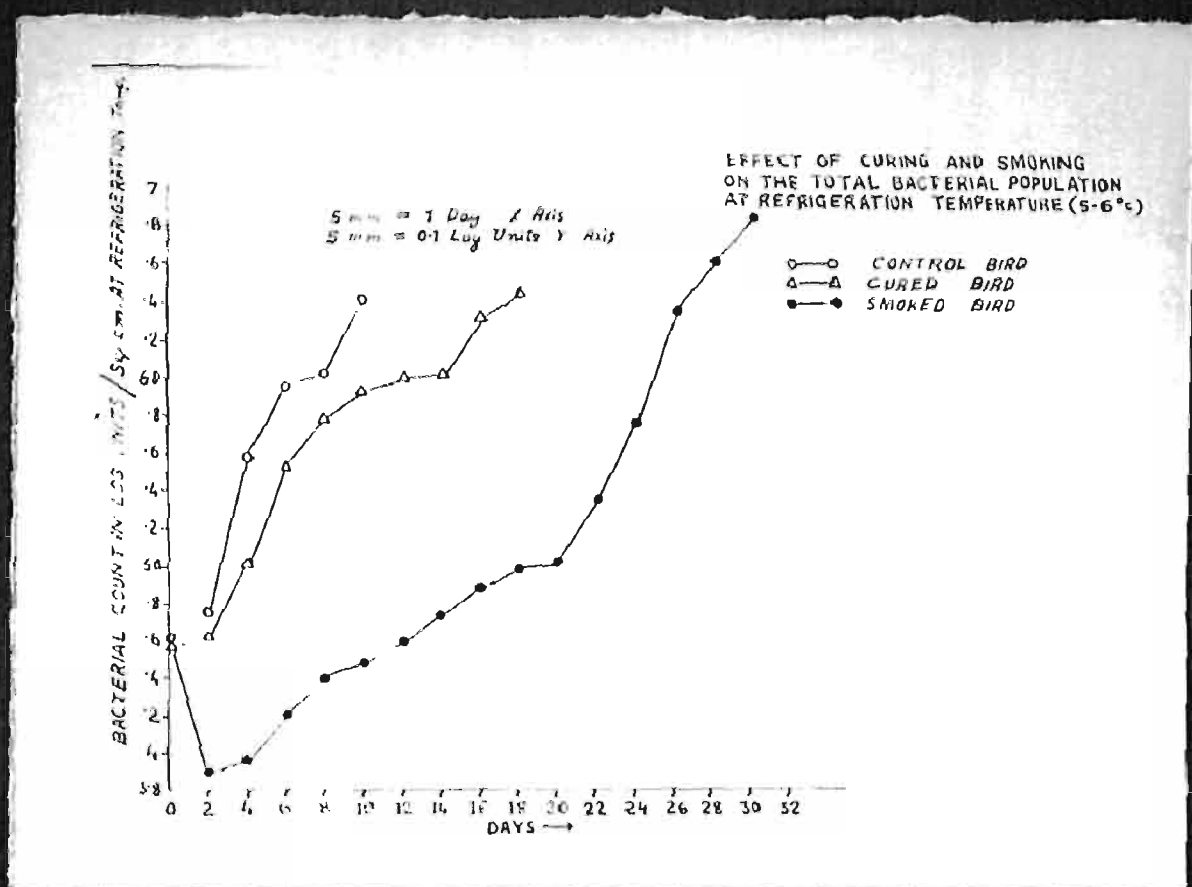


FIGURE 7
GRAPH SHOWING BACTERIAL LOAD IN MEAT AT ROOM TEMPERATURE UNDER DIFFERENT TREATMENTS



41951

FIGURE 8
GRAPH SHOWING BACTERIAL LOAD IN MEAT AT REFRIGERATION TEMPERATURE UNDER DIFFERENT TREATMENTS