Global Veterinaria 17 (4): 282-294, 2016
ISSN 1992-6197

DOI: 10.5829/idosi.gv.2016.17.04.104113

Preservation of Broiler Chicken from Food Borne Microorganisms: A Review

[1]P. Saranraj, [2]Abdulbari Abbas Sahi Alfaris and [3]S. Kavi Karunya

[1]Assistant Professor of Microbiology, Department of Biochemistry,
Sacred Heart College (Autonomous), Tirupattur – 635 601, Tamil Nadu, India
[2]Department of Surgery, College of Veterinary Medicine, University of Basrah, Basrah, Iraq
[3]Suguna Institute of Poultry Management, Udumalpet, Tamil Nadu, India

Abstract: Broiler chicken meat is one of the most popular foods worldwide. The popularity of this product is due to sensory and dietary as well as economic consideration. Broiler chicken meat is a highly digestible, tasty and low-calorie food, often recommended by nutritionists over other meats. On the other hand, in most developed and some developing countries today, high quality a broiler chicken is often less expensive than other types of meat. This was due mainly to the revolutionary industrialization of the broiler chicken industry in the last 30 years, which has changed broiler chicken from a rather exclusive product, only available to a limited group of consumers, into a popular and inexpensive product with in everyone's budget. In addition, the availability of broiler chicken meat in a large variety of processed ready meals makes it easy to prepare and thus meets the demands of modern consumers. The present review was focused on preservation of broiler chicken from food borne microorganisms. The present review covers: Quality of broiler chicken meat, Microbial count on surface of broiler chicken, bacteriological characteristics of broiler chicken heat treatment and physical decontamination methods.

Key words: Broiler Chicken · Microbial Count · Spoilage And Preservation

INTRODUCTION

Broiler chicken is more popular in the consumer market because of advantages such as easy digestibility and acceptance by the majority of people. Bacterial contamination of these foods depends on the bacterial level of the broiler chicken carcases used as the raw product, the hygienic practice during manipulation and on the time and temperature of storage the control and inspection during production, storage and distribution are generally rare. The contamination of raw chicken with bacterial pathogens has important implications for public health [1]. In addition to good manufacturing process, the microbial load of fresh broiler chicken can be reduced substantially by the application of decontaminants.

Over recent decades the poultry industry has made tremendous adjustments to meet the increasing demand for inexpensive and safe supply of meat and eggs. Over the past three decades, the poultry sector has been growing at more than 5 per cent per annum and its share in world meat production increased from 15 per cent three decades ago to 30 per cent currently. This growth has been accompanied by structural changes within the sector, characterized by the emergence and growth of "land - independent" (industrial) farming establishments and the intensification and concentration of poultry operations. Pressure to lower production costs and increase supply has led to more efficient operations, made possible through the shift to larger, specialized and more integrated facilities and through improvements in the use of animal genetics, optimized nutrition and new production technologies. The driving forces behind structural change in poultry production are no different than those that affect other livestock commodities: market pull, innovation and economies of scale.

Innovation and economies of size that characterize the livestock sector have also served to separate animal production from crop production. Large, specialized facilities today focus on producing animals and purchase most of their feed. This often means that there is limited access to land on which to spread manure. The use of large facilities associated with higher concentrations of

Corresponding Author: P. Saranraj, Assistant Professor of Microbiology, Department of Biochemistry, Sacred Heart College (Autonomous), Tirupattur – 635 601, Tamil Nadu, India.

poultry, has given rise to environmental concerns that are not only limited to the local production settings, but extend to environmental problems at regional and global scales. The obvious and often limited, impacts observed at production-site level, thus, tend to obscure much larger impacts on the regional and global environment.

The United States Department of Agricultural (USDA) pathogen reduction/Hazard Analysis Critical Control Point (HACCP) proposal includes recommendations for voluntary decontamination of Broiler chicken, within the European Union (EU). Current EU Broiler chicken hygiene regulations do not allow for any methods or product. One of the major concerns for the Broiler chicken industry is the threat of harmful bacteria association with broiler chicken products.. *Salmonella typhi*, *Campylobacter jejuni* and to a lesser extent *Listeria monocytogenes* and *Escherichia coli* are considered to be the major food borne pathogens in the Broiler chicken industry and lead to human illness. Processing of chicken litter is necessary for destruction of potential pathogens, improvement of handling and storage characteristics and maintenance or enhancement of palatability [2]. The presence of these pathogenic microorganism impacts negatively on feed utilization and physiological functions within the animal system.

Broiler chicken feeds are an essential source of energy needed to generate heat and to support the chemical reactions in which all physiological processes depended. Many of these reactions element, hence must be provided in the diet [3]. In most cases, chicks feed ingredients are delivered in bulk and usually in very large quantities conveyed from one store house to another. Broiler chicken feed component of plant and animal origin are commonly contaminated with microorganisms, mostly bacteria and fungi and insects as *Escherichia coli, Erwinia enterocolitica, Salmonella typhi, Listeria monocytogenes, Enterococcus faecalis, Aspergillus flavus, Aspergillus parasiticus, Penicillium chrysogenum* and *Fusarium oxysporum* [4 - 8].

However, the number and types of microorganisms and insects vary depending on the function of material, location of its origin. Climatic conditions encountered, harvesting, processing, storage transport technologies employed and packaging materials [4]. He further reported the import of the general environmental and handling. Circumstances including the nature and extent of quality control measures on the level of microbial contamination. Other microorganisms have been implicated as contaminants of Broiler chicken feeds include *Escherichia coli, Erwinia enterocolitica, Salmonella typhi, Listeria monocytogenes, Enterococcus faecalis, Aspergillus flavus, Aspergillus parasiticus, Penicillium chrysogenum* and *Fusarium oxysporum* [4 - 8].

According to Fries [9], the microflora of the Broiler chicken was transferred from the primary production site to production lines and further by subsequent contamination. Broiler chicken is the main source of bacteria of the genes *Campylobacter* and carriers of *Campylobacter jejuni* have been found in many broiler chicken flocks. In addition to pathogenic bacteria, special attention in the hygienic production and storage of chicken meat is paid also to total count of aerobic mesophilic bacteria, *Enterobacteria* sp. and *Escherichia coli*. These bacteria are considered indicators of microbiological quality [1, 10, 11].

Chicken meats are often found contaminated with potentially pathogenic microorganisms such as *Salmonella typhi, Campylobacter jejuni, Staphylococcus aureus, Escherichia coli* and *Listeria monocytogenes*. In some occasions also *Yersinia enterocolitica*, *Aeromonas hydrophila* and *Clostridium perfringens* have the potential to be important pathogens in Broiler chicken products. It was an evident that preventive measures, including monitoring programmers to reduce the numbers of *Salmonella typhi*, *Campylobacter jejuni* and possibly other pathogens, during the growing period should focus on changes in husbandry practices, as well as on the use of technologies and products that have been shown to the effective against colonization by these organisms. Microbial contaminants are thus transmitted from contaminated to non-contaminated carcasses or equipment. Consequently, additional treatment of product before or after they leave the processing plant and intensive consumer information and education about the potential risk of the consumption of Broiler chicken products should be part of the Broiler chicken industry strategy for the future.

Quality of Broiler Chicken Meat: The Broiler chicken meat quality depends upon the prevalence of carcass, appearance defects, broken bones and hemorrhaging in breast muscles. The microbiological quality of retail chicken parts and processed chicken products in Spain was investigated by Alvarez *et al*. [11] chicken parts were generally regarded as being of unacceptable quality. Since, phycotrophs like *Escherichia coli* counts were higher than maximum limits established in the guidelines for broiler chicken meat.

The FDA model food code recommends that food be thawed in the refrigerator or in flowing water, but provides no research to show that these methods of thawing are required to ensure safety. Thawing food, such as broiler chicken carcasses, in the refrigerator can be inefficient and time consuming, in addition to occupying refrigerator space required for other food items. This procedure can lead to the risk of cross - contamination of ready-to-eat food stored in the refrigerator if this type of food comes on contact with the drip from the raw food. Thawing time is very unpredictable because of refrigeration temperature that may be colder than planned. On the other hand, the USDA, applying the research of Klose *et al*. [12] has never had restrictions on thawing at room temperature in food processing plants and allows food to be thawed in this manner. Jimenez *et al*. [13] reported a study that supports the conclusion that broiler chicken can be thawed safely at ambient temperature, on the counter. Larger chicken carcasses weighing over 6.5 pounds were frozed and then thawed by 3 different thawing methods: thawing on the counter at ambient temperature (72 °F), thawing in flowing water (72 °F) and thawing in refrigeration ranging from 38 °F to 45 °F.

In another part of this study, chickens were inoculated with Salmonella hadar in order to assess the effect of the different thawing methods on the growth of this microorganism. It was shown that there was a slight decrease in the population of *Salmonella* hadar - inoculated chickens frozen and thawed at room temperature to an internal temperature of 40 °F within the breast. This same decrease was noted in chickens frozen and thawed in flowing water and in refrigeration. This latter observation demonstrates the reduction in cell numbers because of freezing injury and the inability of this strain of *Salmonella* to grow below 45 °F.

The USDA was correct to allow raw meat, fish and broiler chicken to thaw at room temperature. There is no risk in thawing these products at room temperature. German *et al*. [14] studied cross contamination of food borne pathogens in the domestic kitchen in republic of Ireland. Findings identified the ability of food borne disease microorganisms that disseminated from infected chickens to hand and food contact surfaces in domestic kitchen reiterating the need for consumer awareness and knowledge of effective hygiene producers in domestic kitchen.

Microbial Count on Surface of Broiler Chicken: The surface counts/cm^2 was generally more valid than counts on surface and deep tissues. It may found that mean count before cutting was log 3.18 which increased to log 4.06 after cutting. The cutting block was shown to have a total count of log 4.68/cm^2. Aoust and Pivini [15] had reported that 10^7 - 10^9/g cells are generally necessary for Salmonellosis. Jay [16] reviewed aerobic and psychrotrophic plate count procedures for fresh meat and broiler chicken products. A total of 15 different plating media were used. There is a serious need for some consensus on methodologies for aerobic and phychrotrophic counts on fresh meat and Broiler chicken products.

Ripamonti *et al*. [17] analyzed samples of meat and swabs of equipments, utensils and the surface of carcasses bacteriologically. Hargis *et al*. [18] had reported that the pistons used to remove crops were cultured after washing and immediately prior to entering the next carcass and of 100 swabs, 50 were determined to be *Salmonella* sp. Gita kumari *et al*. [19] conducted a study to determine the prevalence of *Salmonella* sp. from apparently healthy broiler chicken marketed at patna. Williams [20] stated that the feed in an important source of *Salmonella* sp. in Broiler chicken and also Schleifer *et al*. [21] demonstrated that less than one cell of *Salmonella* per gram of food could occasionally lead to colonization in 1 - 7 day old chicks.

Antunes *et al*. [22] studied the incidence of *Salmonella* sp. and *Shigella* sp. from broiler chicken products and their susceptibility to antimicrobial agent. Samples were collected from local butcher shops and the susceptibility to antimicrobial agents allowed for human or animal therapy was evaluated. The results showed that broiler chicken samples were frequently contaminated with 60 % *Salmonella* sp. and 75 % of *Shigella* sp. isolated was resistant to one or more antimicrobial agents. Resistance to nalidixic acid and enrofloxacin was demonstrated for 50 % of the isolates.

Escherichia coli infections are being increasingly detected among broiler chicken, indicating the growing importance of this pathogen to the industry. The infection being as the respiratory infection of the trachea followed by colonization of the air sacs and lungs from where it invades the blood stream, leading to infection of deeper organs like liver, heart, etc. [23].

Nizamani *et al*. [24] performed studies of *Escherichia coli* from layers and broilers. A total of 150 Broiler chicken carcasses, 75 broilers and 75 layers were collected in Pakistan and examined for presence of gross necrotic lesions on various organs. During this study a higher infection rates were recorded. The highest positive percentage for *Escherichia coli* was recorded in intestine (80 %) followed by liver (68 %), heart (64 %), lungs (56 %) and ovary (32 %).

Archana Mishra *et al*. [25] studied the antibiotic sensitivity patterns of *Escherichia coli* isolated from domestic fouls. *Escherichia coli* exhibited maximum sensitivity to Gentamycin (66 %), Furazolidone (52 %), Nitrofurantoin (46 %), Chloroamphenicol (32 %), Kanamycin (30 %), Penicillin and Chlorotetra cycline (24 %), Amphicillin and Erythromycin (18 %).

Arotupin *et al*. [26] evaluated microbiological and physicochemical qualities using standard microbiological and analytical methods. The bacterial count was highest in broiler starter with 2.50×10^4 cfu ml^{-1} while the least count of 6.60×10^2 cfu ml^{-1} was recorded in layer top mash fungal count was highest in layer top mash (7.40×10^2 cfu ml^{-1}) and least in grower mash (1.50×10^2 cfu ml^{-1}). A total of seventeen microorganisms were isolated which include *Aerobacter aerogenes*, *Bacillus cereus, Erwinia amylovora, Micrococcus luteus, Staphylococcus aureus, Aspergillus niger, Aspergillus flavus, Aspergillus fumigates, Acualopa macrospore, Cladosporum fulvum, Dotchinza populae, Fusarium* sp*., Geotrichum candidum, Pleomorphisum* sp*., Rhizopus stolonifer, Candida albicans* and *Saccharomyces cerevisiae*. Proximate composition revealed the presence of moisture as, fat, crude fiber and protein content. The mineral analysis showed that the broiler chicken feeds contained essential elements namely K^+, Na^+, Ca^{2+}, Mg^{2+} and P. The presence of some pathogenic microorganism in the broiler chicken feeds revealed the level of contamination.

Masdooq *et al.* [27] identified *Pasteurella multocida* by mouse pathogenicity test. A total of 3000 chickens were examined at post-mortem and 500 samples with pneumonia were collected. All lungs and heart blood from 15 different commercially reared chicken flocks showed respiratory disorders. Blood agar supplemented with 10 % sheep blood was used for isolation of the agent. Thirty two (6.5 %) *Pasteurella multocida* were isolated and identified. In addition, mouse pathogenicity test was carried out on *Pasteurella multocida* suspected isolates.

Renata Cegielska *et al*. [28] microbiologically analyzed and determined total counts aerobic bacteria *Escherichia coli* and *Staphylococcus aureus*. Sensory examination of the product was also conducted. The application of modified atmosphere packaging of pretreated broiler chicken meat products stored at 1 ± 1 °C makes it possible to extend their shelf life over 2 times. They modified atmosphere packaging and store of pretreated broiler chicken meat products with the simultaneous maintenance of a continuous cooling chain is a highly effective method for extending their shelf life.

Chaiba Abdellah *et al*. [29] isolated and detected *Salmonella* sp. in 57 (9.90 %) of the samples analyzed. Among the chicken sample examined, high proportion of gizzard (13.88 %), liver (11.11 %), leg (8.33 %) and breast (6.25 %) were contaminated with *Salmonella* sp. In summary 30 (20.83 %) of the popular market samples, 24 (16.66 %) of the traditional slaughter houses samples and 3 (2.08 %) of poulterer's shops were positive for one or more *Salmonella* sp. Four different serotype were identified of which *Salmonella typhimurium* (40.35 %) was the most frequent followed by *Salmonella newport* (26.31 %). *Salmonella montevide* (17.54 %) and *Salmonella heidelberg* (15.78 %). Results of this study indicated that there was level of *Salmonella* sp. contamination of chicken which could be considered as one of the major potential source of human Salmonellosis in Morracco.

Bacteriological Characteristics of Broiler Chicken Heat Treatment: The raw meat, fish and broiler chicken are contaminated with various spoilage and pathogenic bacteria. These bacteria do not multiply when frozed and may actually decrease slightly in population because of freezing injury. However, as soon as frozen raw meat, fish and broiler chicken products begin to thaw, any bacteria that may have been present before freezing can begin to multiply again when the temperature increases to their growth range. Since, spoilage bacteria begin to multiply at 23 °F, pathogen multiplication at 29.3 °F, the problem in thawing raw meat, fish and broiler chicken should be a little spoilage bacteria multiplication.

Ngodisha and Owen [30] monitored the temperature of the stack with a thermometer. At the end of the heat treatment, particles were removed from the litter with a mechanical sieve. Litter samples were subjected to proximate analysis, mineral composition profile culture in a McConkey medium and then incubated for 24 - 48 hours at 37 – 42 °C for various pathogens. Results showed that litter dry matter (DM) and crude protein (CP) contents were 87 % and 20 % respectively. Mineral composition varied from 0.10 % for sodium to 4.50 % for phosphorus. The isolated broiler chicken litter ranged between 37 °C for *Salmonella* sp. and *Mycobacterium* sp., 41 °C for *Clostridium* sp. and *Escherichia coli* to 42 °C for *Staphylococcus* sp. No pathogens were isolated after heat treatment (40.1 – 55 °C) for 21 days.

Carmen Cretu *et al*. [31] identified that the main sources of Salmonellosis were broiler chicken and its products. *Salmonella* sp. is one of the most important

worldwide causes of food borne disease. In order to reduce the contamination, the broiler chickens were treated experimentally the washing water with lactic acid solution. The microorganisms were susceptible to environmental pH changes. This pH change reduced the microbial load, especially of *Salmonella* sp. From the surface of the carcass, the pH of the carcass washing water was 6.75, after the addition of lactic acid it was reached to 2.34 and the temperature of washing water was 15 °C the contamination of fresh carcasses with *Salmonella* sp. had an incidence of 14.06 %. After treatment of washing water, it was decreased until 4.6 %. In case of 4 °C chilled carcasses, the incidence of *Salmonella* species in the presence of untreated carcass was of 4.6 %, being reduced to 1.5 % after treatment.

Elena Dal Rio *et al*. [32] estimated trisodium phosphate decontamination of broiler chicken to pathogens and increase microbiological risk to consumers. Chicken legs were co-inoculated with similar concentration of pathogenic (*Salmonella enteritidis* or *Listeria monocytogenes*) and spoilage (*Pseudomonas fluorescence* or *Brochothrise thermosphacta*) bacterial samples were dipped in TSP (12 %, 15 min) or non-treated control microbiological analyses carried out at 0.1, 3 and 5 days to storage (3 °C), levels of spoilage bacteria were higher than those of *Salmonella enteritidis* on both treated legs. Similar bacterial loads observed for *Listeria monocytogenes* at all sampling times. Their results found that *Pseudomonas fluorescence* was more susceptible to TSP treatment than *Listeria monocytogenes* when inoculated at 10^6 cfu g^{-1}.

Lidija kozacinski *et al*. [33] tested the presence of bacteria *Salmonella* spp*., Listeria monocytogenes, Staphylococcus aureus, Campylobacter* sp. and Sulphate reducing *Clostridia*. Bacteriological tests were performed by means of standard methods of isolation and identification of individual species of bacteria according to ISO requirements. Microbiological quality and contamination of chicken of importance was the finding of *Salmonella* sp. (10.60 %), *Staphylococcus aureus* (30.30 %), *Listeria monocytogenes* (3.03 %), *Enterobacteria* (34.84 %) and sulphite reducing *Clostridia* (1.50 %), *Campylobacter* sp. were not found in any of the analyzed samples. Total bacteria count found in frozen ground chicken was 5.23 ± 0.50 $\log_{10}$ cfu/g, it was lower in cut chicken meat. Total bacteria count in chicken breast fillets amounted to 4.72 ± 0.38 $\log_{10}$ cfu/g in chicken breasts with skin respectively. Results of study suggested that a significant risk of meat spoilage and an increase in the number and species of bacteria depend on the specific part of analyzed chicken meat, mode of packaging and storage after distribution to the market.

Bryan and Doyle [34] reviewed the literature on *Salmonella* sp. and *Camplylobacter* sp. contamination of broiler chicken products. The data presented on *Salmonella* contamination of broiler chicken (i.e, broilers and turkeys at the retail level) in that review indicated that over the years between 2 and 100 % of the products were contaminated with *Salmonella* sp. The variation in results was attributed to difference in numbers of sample taken, the sampling itself and the *Salmonella* sp. detection methods used as well as to the chance factor of sampling a *Salmonella* - positive flock or lot. The median was 30 % *Salmonella* positive. Looking at the data for *Campylobacter* contamination, the situation was similar contamination percentages ranged between 0 and 100 % with the median at 62 %. This figure for *Campylobacter* agreed with these reported by Jacobs Reitsma *et al.* Saranraj and Ramya [35, 36].

Anon [37] reported that the prevalence of Salmonellae in whole UK raw chicken had fallen from 54 % in 1990 to 41 % 1994 for frozen birds and from 41 % to 33 % for chilled birds. The predominant serotypes were *Salmonella enteritidis* PT4, followed by *Salmonella enteritidis* PT7. Another important observation was the detection of antibiotic resistant *Salmonella* strains, including serotypes *of Salmonella indiana, Salmonella virchow* and *Salmonella typhimurium*.

Van de Giessen [38] reported *Salmonella* and *Campylobacter* contamination in chickens and chicken products sampled in three consecutive years (1933 - 1935) and examined with the same method. *Salmonella* contamination of Dutch broiler chicken was constant over the period studied and the contamination with *Campylobacter* sp. which had decreased in 1994, increased again in 1995. No inference for the future can be formulated on the basis of these data. With respect to the presence of *Salmonella enteridis* in retail broiler chicken products, it can be concluded that the *Salmonella enteridis* eradication program in the breeding and reproduction sector in the Netherlands, which started in 1989, rather than improving the situation, isolation of *Salmonella enteritidis* at the retail level increased.

Pohl *et al*. [39] reported similar data for Belgium. In 1995, 43 % of the *Salmonella* isolates were *Salmonella hader*, 6 % *Salmonella typhimurium*, 23 % *Salmonella enteritidis*, 6 % *Salmonella infantis* and 3 % were *Salmonella virchow*. In recent years, multiresistant Ampicillin, Streptomycin, Chloroamphenicol,

Sulfonamides and Tetracycline and some 4-quinolone strains of *Salmonella typhimurium* have become a predominant serotype in relation to human disease in several countries, including the United Kingdom, Germany and the United States. In the United Kingdom *Salmonella typhimurium* comprises 81 % of all *Salmonella typhimurium* isolates from human and has increased from 259 human cases in 1990 to 40006 human cases in 1996 [40]. *Salmonella typhimurium* DT104 differs from the serotype, enteritidis in that the latter in general does not carry antibiotic resistance. Therefore, DT104 may become a more serious problem to the consumer than *Salmonella enteritidis* PT4 because of problems in selecting drugs for therapeutic use. Although, the serotype was considered to be mainly bovine related, the prevalence of *Salmonella typhimurium* DT104 has increased 10 fold in UK swine production from 1990 to 1996 [41]. Whether this was the case for broiler chicken is not known, but broiler chicken and broiler chicken products have been related to human cases in the UK [42]. In Denmark, *Salmonella typhimurium* DT104 has not yet been detected in chicken, but four surine herds have been destroyed to control this bacterium personal communication [43]. It is too early to judge whether the danishs action in this field will be effective but experience from other countries where *Salmonella typhimurium* DT104 has increased dramatically during the last year leaves little hope of controlling this specific phage type. So far, human case on that country was suggested to be related mainly to import broiler chicken.

Carmen Cretu *et al*. [31] reported the *Salmonella* sp. is one of the important worldwide causes of food borne disease. In order to reduce the contamination, they treated experimentally the washing water with lactic acid solution 1 %. Thus, they stopped the evolution of the microorganisms susceptible to environmental pH changes. This pH change reduced the microbial load, especially of *Salmonella* sp., from the surface of the carcass. The pH of the carcass washing water was 6.75, after the addition of lactic acid, it reached 2.34 and the temperature of washing water was 15 °C. The contamination of fresh carcasses with *Salmonella* sp. had an incidence of 140.6 %. After the treatment of washing water, it decreased until 4.6 %. In case of 4 °C chilled carcasses, the incidence untreated carcases was of 4.6 % being reduced 1.5 % after treatment.

Elmer and Marth [44] reported that the chief microbiological concerns associated with broiler chicken products. Center around two types of microorganisms - psychrotrophic and mesophilic pathogens that could grow during extended refrigerated storage or temperature abuse. Psychrotrophs are bacteria, yeast and molds that grow, although slowly, at refrigeration temperature (below 7 °C) but grow optimally at temperature above refrigeration, e.g., 25 – 30 °C.

Lidija Kozacinski *et al*. [33] reported the presence of bacteria *Salmonella* sp., *Listeria monocytogenes*, *Staphylococcus aureus*, *Campylobacter* sp. and sulphite - reducing *Clostridia*. The total count of aerobic mesophilic bacteria was also determined. Bacteriological tests were performed by means of standard methods isolation and identification of individual species of bacteria according to ISO requirements (Becton Dickinson) were used for biochemical determination. With regard to microbiological quality and contamination of chicken meat of importance was the finding of *Salmonella* sp. (10.06 %), *Salmonella aureus* (30.30 %), *Listeria monocytogenes* (3.03 %), *Enterobacter* sp. (34.84 %) and sulphite reducing clostridia (1.50 %) *Campylobacter* spp. Total bacteria count found in frozen ground chicken meat was 5.23 ± 0.50 $\log_{10}$ cfu/g, whilst it was lower in cut chicken meat total bacteria count in chicken breast fillets amounted to 4.72 ± 0.38 $\log_{10}$ cfu/g, 3.67 ± 0.88 $\log_{10}$ cfu/g in chicken breast with skin, respectively. The results of this study suggested that a significant risk of meat spoilage and increase in the number and species of bacteria depend on the specific part of analyzed chicken meat, mode of packaging and storage after distribution to the market.

Chaiba *et al*. [29] studied the microbiological quality of broiler chicken meat on the market. A total of 96 samples of chicken meat were collected from retail outlets. The level of microorganisms on chicken carcasses was assesses using the excised breast-skin technique. Level of mesophiles, coliforms, *Escherichia coli* and *Staphylococcus aureus* on carcasses from popular market and artisanal slaughter houses were significantly higher ($p<0.05$) than in poulterer's shops and super market. On the basis of the CNERNA "Centre Nationalized' Etudes et de Recommendations sur La Nutrition et 1' Alimentation". Standards, 24 % of the samples from popular market and 16 % from artisanal slaughter house were also regarded as being of unacceptable quality. The main reason for the lack of acceptability was excessive counts of mesophiles and coliforms.

Physical Decontamination Methods

Irradiation: The major extracellular environmental factors that influence the survival of irradiated cells are temperature [45], gaseous environment, water activity,

pH and chemical composition of the food. These conditions presumably can modify the physical and chemical consequences of intracellular deposition of energy. Bacterial spores appear to be less susceptible to modifying factors than vegetative cells because of their structure and particularly because spores contain very little water. Since, part of the effect of ionizing radiation on microorganisms was due to indirect action medicated through free radicals, the nature of the medium or menstrum (e.g. food) in which the microorganisms are irradiated plays an important role in determining are irradiated plays an important role in determining the dose required for a given antimicrobial effect. The more complex the medium, the greater is the competition by its components for the free radicals formed by irradiation outside the cell, thus protecting the microorganisms by absorbing free radicals. Therefore, care should be taken in comparing radiation resistance in laboratory media and in food. Generally, microorganisms are more resistant to irradiation in food than in laboratory media.

It is now well established that microorganisms that survive radiation treatment, as is the case with heat damaged cells, tend to be more sensitive to subsequent adverse environmental conditions such as heat, pH, inhibitors etc, than are untreated cells [46]. This fact could be used to advantage in combination treatments of food involving irradiation and other preserving factors (e.g. food additives, low temperatures, mild heat, vaccum packaging etc).

Thayer *et al*. [47] examined the effects of gamma-irradiation preceded or followed by heating at 60 °C for 3 minutes on the survival of *Salmonella typhimurium* in chicken meat. Gamma radiation made *Salmonella* sp. much more sensitive to the effects of heat, so that a radiation dose of 0.90 KGy followed by the above heat treatment decreased the number of survivors by 8.9 $\log_{10}$ units. Patterson [48] investigated the sensitivity of *Campylobacter jejuni*, *Campylobacter coli, Campylobacter fetus* and *Campylobacter lari* to irradiation in broiler chicken meat. The radiation sensitivity was between different *Campylobacter* species and between strains of the same species. Confirmed that *Campylobacter* species and between strains of the same species. Confirmed that *Campylobacter* sp. are more radiation sensitive than *Salmonella* sp. In addition, Petterson [49] demonstrated that radiation doses suggested to eliminate *Salmonella* from broiler chicken would also be sufficient to remove *Listeria monocytogenes.*

Ultrasonication: Ultrasounds are vibrations similar to sound waves but at a frequent too high to be noticed by the human ear. These vibrations cause locally high pressure and temperature resulting in the distribution of cellular structures. Since product quality is altered by the treatment, this process is mainly suitable for decontamination of scald water to prevent spreading of microorganism to uncontaminated broiler chicken carcasses. It can be used to aid cleaning of knives shackles and steel mesh gloves.

Electron Beam Irradiation on Broiler Chicken: Electron beam irradiation at doses of 1.0 and 1.8 KGy on the elimination of bacteria from boneless, skinless chicken without significantly altering product quality. Microbial testing was conducted in triplicate using a whole carcass reins method with each non irradiated control group and an irradiation treatment group consisting of 10 samples. Results indicated that mean counts for coliforms, generic *Escherichia coli* and psychotrophs were 3.13, 3.26 and 1.92 $\log_{10}$ cfu/200 ml rinsate, respectively, in the control samples. However, these populations were not detected after the samples were irradiated with 1.0 or 1.8 KGy. Mean count of 4.60 $\log_{10}$ cfu/200 ml rinsate was detected for aerobic bacteria in the control samples. Irradiation doses of 1.0 and 1.8 KGy reduced the levels to 2.23 and 1.62 $\log_{10}$ cfu/200 mL rinsate, respectively. Irradiation also rendered the fillets free of *Salmonella* sp. and *Campylobacter* sp. Consumer taste panels (product stored for 0, 14 and 28 dat OC) indicated that, at day 0, there were no differences among controls and treatment groups for any of the quality attributes tested. At day 14, texture and flavor attributes were lower for the irradiated groups. At day 28, samples irradiated with 1.0 and 1.8 KGy were less desirable with decreased texture, flavor and overall acceptability. Degree of lipid oxidation also increased as storage time and level of irradiation increased.

Chemical Decontamination Methods: The effectiveness of lactic acid, of a mixture of poly-phosphates, organic acids and oligosaccharides and of trisodium phosphate (TSP) on broiler chicken carcass decontamination has been compared. Acid and alkaline substances are both effective. As treatment of carcasses with lactic acid always resulted in slightly discoloured products, Zeitoun and Debevere [51] tested the effectiveness of buffered lactic acid. Treatment of carcasses with a buffered lactic acid system decreased numbers of Enterobacteriaceae and especially in combination with

modified atmosphere packaging of the products gave prolonged shelf-life under refrigeration. These effects were attributed to an increase in the concentration of undissociated acid molecules and not to pH. These authors obtained best results against *Listeria monocytogenes* on broiler chicken by the combined use of 10 % lactic acid/sodium lactate buffer (pH 3.0) and modified-atmosphere packaging.

Mulder [50] suggested that the treatment may result in *Salmonella* - free products, as *Salmonella* sp. numbers in broiler chicken are usually lower than 100/g. however, side effects such as a change of colour of the meat or a slight, reversible bleaching and bloating of carcass skin make commercial application of these compound questionable [51]. Conner *et al*. [52] investigated die effect of several food additives and storage temperature on *Escherichia coli* 0157:H7 in chicken meat. They reported that at 37 °C, NaCl and sodium lactate reduced growth of *Escherichia coli* whereas polyphosphate had no effect. At 10 °C, NaCl did not permit *Escherichia coli* growth and sodium lactate reduced it. At 1 °C, populations of *Escherichia coli* steadily declined during storage in untreated samples and after polyphosphate and NaCl treatments, but after 5 weeks at 4 °C, *Escherichia coli* began to grow again in the presence of sodium lactate. The results suggested that sodium lactate and NaCl may enhance survival of *Escherichia coli* 0157:H7 at refrigeration temperatures.

Lillard [53] found that dipping chicken carcasses in a 10 % trisodium phosphate (TSP) solution for 15 minutes reduced *Salmonella* sp. levels by 2 $\log_{10}$ cycles, but *Salmonella* sp. was still recovered from skin and carcasses inoculated with 10^6 or 10^2 cfu/g when a water rinse followed TSP treatment and buffered peptone was used for bacteria recovery. Somres *et al*. [54] reported that *Escherichia coli* 0157:H7 (10^5 cfu/cm^2 of biofilm cells) was eliminated by a 30 seconds treatment with 1 % TSP. *Campylobacter jejuni* was slightly less sensitive and *Listeria monocytogenes* was the most resistant, requiring exposure to 8% TSP for 10 minutes to reduce biofilm bacteria by at least 1 $\log_{10}$ cycle. The effect of a 10 % TSP dip on the incidence and level of *Campylobacter* sp. on post-chill chicken carcasses was studied by Slavik *et al*. [55]. *Campylobacter* sp. levels were reduced by 1.5 and 1.2 $\log_{10}$ after 1 and 6 days, respectively. Rodriguez de Ledesma *et al*. [56] reported that a combined 10 % TSP and hot water treatment of chicken skin was effective in reducing counts of *Salmonella typhimurium, Salmonella aureus* and *Listeria monocytogenes* by 95 to 99.7 %, 84 to 97 % and 79 to 95 %, respectively.

Elena Dal Rio *et al*. [32] trisodium phosphate decontamination of broiler chicken could give a competitive advantage to pathogens and increase microbiological risk to consumers. Chicken legs were co-inoculated with similar concentrations of pathogenic (*Salmonella enteritidis* or *Listeria monocytogenes*) and spoilage (*Pseudomonas fluorescens* or *Brochothrix thermosphacta*) bacteria. Samples were dipped in TSP (12 %, 15 min) or were non treated (control). Microbiological analysis was carried out at 0, 1, 3 and 5 days of storage (3 °C). Levels of spoilage bacteria were higher than those of *Salmonella enteritidis* on both treated and non-treated legs. Similar bacterial loads were observed for *Listeria monocytogenes* and *Bacillus thermophosphacta*. However, *Pseudomonas fluorescens* counts of TSP - treated samples were significantly lower than those of *Listeria monocytogenes* at all sampling times. Our results found that *Pseudomonas fluorescens* (spoilage organism) was more susceptible to TSP treatment than *Listeria monocytogenes* when inoculated at 10^6 cfug^{-1}.

Trisodium Phosphate Lactic Acid Acetic Acid in Reduction in *Escherichia coli* and Microbial Load: Bin Jasass [57] procedures for dipping of chicken carcasses in trisodium phosphate (TSP), lactic acid (LA) and acetic acid (AA) were evaluated to determine their effectiveness for reducing *Escherichia coli* NCTC 10538 and aerobic total counts on the chicken meat surfaces. Chicken portions were dipped in a suspension of *Escherichia coli* (7 log cfu/ml) for 90 min to allow *Escherichia coli* to get attached to the chicken surface. The chicken portions were then dipped in 8, 10 and 12 % concentration of TSP 1, 2, ad 3 % concentration of LA and 0.5, 1 and 1.5 % concentration of AA for 20 sec each followed by dipping in tap water for 20 sec, a sterile 4 × 4 cm was placed on the chicken surface and then swabbed by swab cotton. The number of *Escherichia coli* and aerobic total counts were enumerated. The reduction of *Escherichia coli* on chicken meat surfaces dipped in 8, 10 and 12 % of TSP decreases *Escherichia coli* by 0.5, 1.2 and 1.6 log cfu/cm^2, respectively. The reduction of *Escherichia coli* on chicken meat surfaces dipped in 1, 2 and 3 % LA was 0.5, 1.8 and 2.1 log cfu/cm^2 respectively. The reduction of *Escherichia coli* on chicken meat surface dipped in 0.5, 1.0 and 1.5 % of AA had decreases the *Escherichia coli* counts of 0.7, 1.1 and 1.4 log cfu/cm^2, respectively. The results showed that LA was more effective against *Escherichia coli* and aerobic total counts than TSP and AA.

Alla Eldin Mohammed and Khalid Ibrahim [58] studied the influence of trisodium phosphate (TSP) and Lactic acid (LA) dipping on the microbial load and shelf life of broiler chicken carcasses during refrigerated storage for 8 days at 2 ± 1 °C. the results indicated that both TSP (12 %) and LA (2 %) dipping significantly rediced the initial microbial load of aerobic plate counts (APC), psychotrophic counts (PTC), total proteolytic counts (PLC) and Enterobacteriaceae counts (EBC) just after dipping and throughout the storage period in comparison with the control. At the beginning of storage (day 0), no significant differences in the microbial reductions were detected between TSP and LA treatments. By the day 8 of the storage, however, LA - dipping indicated a higher ($p<0.01$) mean reductions in APC, PTC and PLC than the corresponding reductions obtained by TSP - dipping. The untreated carcasses would have a refrigerated shelf life between 4 and 5 days while after chemical dipping, the shelf life extended to about 7 days in TSP - treated carcasses and days in LA - treated carcasses. Therefore, both TSO and LA can be applied on broiler chicken carcasses to reduce their microbial load and extend their shelf life during refrigerated storage.

Ozone and Chlorine Application of Microbiological Quality of Chicken: Canan Hecer *et al*. [59] effects of two antimicrobial applications (ozone and chlorine) on broiler carcasses after evisceration were investigated. The ozone and chlorine (sodium hypochlorite, NaHCIO) were applied to broiler carcasses as 1.5 ppm and 30 ppm for 7 minutes, respectively. During the broiler processing, the samples were taken from 14 different points in production line, 17 surface points and 5 workers hands for the microbiological analysis as ten replicates. At the beginning, *Escherichia coli* growth increased after portioning and grading of broiler carcasses. It was assumed that contamination. Ozone can also be used in lower concentration and more safely than the chlorine.

Indicator Population of Bacteria from Chicken: Russel [60] stated that research was conducted to determine whether a new sanitizer, Timsen (N-Alkyl dimethyl benzyl ammonium chloride - ADBAC), was effective for killing populations of bacteria that are of concern to the Broiler chicken industry. Populations of pathogenic bacteria (*Salmonella entritidis*, *Staphylococcus aureus* and *Listeria monocytogenes*), spoilage bacteria (*Pseudomonas fluorescens*, *Pseudomonas putida*, *Pseudomonas fragi* and *Shewanella putrefaciens*), aerobic bacteria and coliform bacteria were exposed to various levels of ADBAC, then monitored to determine their survival rate. ADBAC was able to completely eliminate the pathogenic bacteria tested at concentrations of 150 ppm or less which was much lower than the allowable use concentration of 400 ppm. ADBAC eliminated or reduced the growth of spoilage bacteria at a level of 200 ppm or less. ADBAC eliminated *Escherichia coli* at a concentration of 100 ppm. ADBAC significantly inhibited the growth of aerobic and coliform populations of bacteria. Therefore, Timsen (ADBAC) appears to be an effective means of eliminating pathogenic and spoilage bacteria and the fecal indicator *Escherichia coli*.

Biopreservative Activity of Lactic Acid Bacteria: Adesonkan *et al*. [61] studied the influence of lactic acid bacteria (LAB) isolated from broiler chicken meat on the attributes was investigated. *Lactobacillus plantarum* with the highest frequency of occurrence (90 %) produced the highest amount of lactic acid (16.2 g/l) and inhibited all the indicator organisms with the exception of *Candida albicans* and *Proteus vulgaris*. Consequently, *Lactobacills plantarum* was chosen as the starter culture to inoculate pieces of Broiler chicken meat before (CB) and after (CA) grilling for production. Relatively low microbial counts (log cfu/g) of coliform (8.23), *Staphylococcus* sp. (4.83), LAB (8.1) and yeast/mould (5.63) were observed for CA samples after six days of storage. Grilling at 80 °C for 30 min gave the best attributes with crude protein content of 33.45 %. The best packaging material was polyphenylchloride as compared to aluminum.

Cosby *et al*. [62] increase the shelf life of Broiler chicken by treatment with a disodium ethylenediametetra - aceiate (EDTA) and nisin (NIS) combination and storage under modified atmosphere packaging (MAP) or vacuum packaging (VP). Chicken drummettes were soaked with various combinations of EDTA and NIS for 30 min at 15 °C and stored at 4 °C parts treated with EDTA-NIS stored under VP bad significantly lower ($P=0.1$) total aerobic plate counts than untreated controls stored under aerobic conditions. EDTA-NIS increased shelf life by a minimum or 4 days when package in aerobic conditions and a maximum of 9 days when vacuum packed. A second experiment evaluated the VP and EDTA-NIS combinations

in more detail. Parts treated with EDTA-NIS stored under VP had significantly different (P=0.1) aerobic counts from parts treated with EDTA-NIS stored under aerobic conditions or untreated control parts. EDTA-NIS treatment increased shelf life 4 to 7 days in the second experiment. The results indicate that a combination of EDTA-NIS treatment and vacuum packaging has the potential to significantly increase the shelf life of raw processed broiler chicken.

Lysozyme: Kijowski *et al*. [63] investigated the effect of spraying chicken with skin with lysozyme solutions of varying activity on their microbiological stability and organoleptic features. Lysozyme was applied at concentrations ranging from 3000 to 48000 U/ml. The effect of storage time at the temperature of +4°C on the total aerobic bacterial count, coli titre the occurrence of *Enterococci*, anaerobic spore forming bacilli and pathogenic *Staphylococcus* was analyzed, along with the examination of sensory quality attributes. The investigations showed that the addition of lysozyme resulted in a considerable inhibition of growth of the initial aerobic bacterial counts and a limitation of disadvantageous organoleptic changes during cold storage of samples. Lysozyme solution with the activity of 48000 U/ml caused a 20 fold reduction in the initial aerobic bacteria count. Sensory examination showed that samples subjected to the action of lysozyme and stored for 120 hrs under cold storage conditions did not differ qualitatively fresh elements. The obtained results showed that lysozyme might be an effective agent extending shelf-life of portioned broiler chicken meat.

Allicin: Allicin, present in the garlic clove. Garlic contains about 1 % alliin, which converts to allicin in the presence of the enzyme allinase [64]. Matthew Egbabor Ejal *et al*. [65] carried out the antimicrobial sensitivity tests on *Escherichia coli, Shigella* sp*., Salmonella* sp. and *Proteus mirabilis* using standard procedures significant differences ($p<0.01$) were seen in the effect of the antimicrobial agent (garlic) and in the sensitivities of the microbial species ($p<0.01$) to the antimicrobial agents were observed. Ross *et al*. [66] have proved that allicin has antimicrobial effects. It inhibits the growth of both Gram negative and Gram positive organisms. The antimicrobial activity of garlic has been attributed to the presence of thiosulfinates (eg. allicin) whose removal completely renders garlic ineffective against microorganisms.

CONCLUSION

Poultry is more popular in the consumer market because of advantages such as easy digestibility and acceptance by the majority of people. However, the presence of the pathogenic and spoilage microorganisms in poultry and it's by products remains a significant concern for suppliers, consumers and public health officials worldwide. Bacterial contamination of these foods depends on the bacterial level of the poultry carcasses used as the raw product, the hygienic practice during manipulation and on the time and temperature of storage the control and inspection during production, storage and distribution are generally rare. Therefore, it is very important to prevent the hazards and to provide a safe and whole some product for human consumption. The contamination of raw chicken with bacterial pathogens has important implications for public health. In addition to good manufacturing process, the microbial load of fresh poultry can be reduced substantially by the application of decontaminants.

REFERENCES

1. Capita, R., C. Alonso - Calleja, M. T. Garcia - Arias, B. Moreno and M. Del Camino Garcia – Fernandez,2002. Methods to detect the occurrence of various indicator bacteria on the surface of retail Broiler chicken in Spain. Journal of Food Science, 67: 675-771.
2. Fontenot, J.P., 2000. Utilization of Broiler chicken litter as feed for beef cattle. Animal Residuals Management, 19: 234-252.
3. Uwaezuoke, J.C., J.N. Ogbbulie and J.N. Njoku, 2000. Antibiotic sensitivity pattern of bacterial isolates from Broiler chicken feed. International Journal of Environmental Health Development, 1: 23-28.
4. Jageethadevi, A., P. Saranraj and N. Ramya, 2012. Inhibitory effect of chemical preservatives and organic acids on the growth and organic acids on the growth of bacterial pathogens in poultry chicken. Asian Journal of Biochemical and Pharmaceutical Research, 1(2): 1-9.
5. Saranraj, P. and M. Geetha, 2012. Microbial spoilage of Bakery products and its control by preservatives. International Journal of Pharmaceutical and Biological Archives, 3(1): 204-214.

6. Klinger, I. and M. Lapdiot,1993. Irradiation of Broiler chicken meat and its products IEA A-TEC Doc-688, Vienna. Nigerian Journal of Microbiology, 12: 13-17.
7. Dhand, N.K., D.V. Joshi and S.K. Jand, 1998. Contamination of dairy feeds and their toxigenicity. Indian Journal of Animal Science, 68: 1095-1096.
8. Jeffrey, J.S., J.H. Kirk, E.R. Atwill and J.S. Cullor, 1998. Prevalence of selected microbial pathogens in processed Broiler chicken waste used as dairy cattle feed. Poultry Science, 77: 808-811.
9. Fries, R., 2002. Reducing *Salmonella* transfer during industrial broiler chicken meat production. World Broiler Chicken Science Journal, 58: 527-540.
10. Stolle, F.A., 1998. Establishing microbiological surveillance programmes at slaughter-lines new concept of meat hygiene. Meat Science, 22: 203-211.
11. Alvarez-Astorga, M., R. Capita, C. Alonso Calleja, B. Moreno and B.E. Garcia–Fernandez, 2002. Microbiological quality of retail chicken by products in Spain. Meat Science, 62(1): 45-50.
12. Darwina, M., D. Kanchana and P. Saranraj, 2012. Biocontrol efficacy of various preservatives against food borne pathogens in poultry chicken. Novus International Journal of Biotechnology and Biosciences, 1(1): 1-13.
13. Jimenez, S.M., M.E. Pirovani, M.S. Salsi and M.C. Tiburzi, 1999. The effect of freezing and different thawing methods on the growth of bacteria in chicken. Submitted for publication to the Journal of Food Protection, 22: 1310-1314.
14. German, R., A. Bloomfield and C.C. Adley, 2002. Food borne pathogen in domestic kitchen. International Journal of Food Microbiology, 76(1/2): 143-150.
15. Kanchana, D., R. Kavitha and P. Saranraj, 2015. Microbial Spoilage of Modified Atmosphere Packaging on Fruits and Vegetables. Advances in Biological Research, 9(4): 253-256.
16. Jay, J.M., 2002. A review of aerobic and psychrotrophic plate count procedures for fresh meat and broiler chicken products. Journal of Food Protection, 65(7): 1200-1206.
17. Ripamonti, B., F. Zechini, S. Colombo and Cantonic,2002. Localization of *Salmonella* in abbatoirs. Broiler Chicken Abstract, 18(3): 7-13.
18. Hargis, B.M., R.L. Caldwell, D.E. Brewe, G. Corrier and J.R. Deloach, 1995. Evaluation of the chicken crop as all source of *Salmonella* contamination for broiler chicken carcasses. Broiler Chicken Science, 74: 1548-1552.
19. Gita Kumari Prasad, A.S., K. Sinha, G.S. Modi and B.K. Sinha, 2001. Prevalence of *Salmonella* species in Patna. Indian Journal of Comparative Microbiology, Immunology and Infectious Disease, 22(2): 158-159.
20. Kanchana, D., P. Saranraj and R. Kavitha, 2015. Isolation and characterization of some Spoiled Yellow Goat Fish (*Sulphureus cuvier* L.). World Journal of Fish and Marine Sciences, 7(4): 243-246.
21. Prem Kumar, D., M. Jayanthi, P. Saranraj and S. Kavi Karunya, 2015. Effect of Potassium Sorbate on the inhibition of growth of fungi isolated from spoiled Bakery products. Life Science Archives, 1(4): 217-222.
22. Antunes, P., C. Reu, J.C. Sousa, L. Piexe and N. Pestana, 2003. Incidence of *Salmonella* from broiler chicken products and their susceptibility to antimicrobial agents. International Journal of Food Microbiology, 82(2): 97-103.
23. Vandemaela, F., A. Assadzadeh, J. Derucke, M. Verecken and B. M. Goddeeris, 2002. Avian pathogenic *Escherichia coli* in Broiler chicken. Disease and Health Broiler chicken Abstract, 127(19): 582-588.
24. Nizamani, Z., L. Siddiqu, T. Rind, S. Khaskheli and A.W. Nizamani, 2003. Studies of *Escherichia coli* from layers and broilers. Journal of Animal and Veterinary Advances, 2(4): 221-224.
25. Archana Mishra Rakesh Sharda., Daljet Chabra and S.K. Tanvani, 2002. Antibiogram of *Escherichia coli* isolates from domestic Broiler chicken. Indian Veterinary Journal, 79(8): 863-864.
26. Arotupin, D.J., R.M.O. Kayode and K.O. Awojobi, 2007. Microbiological and physiochemical qualities of selected commercial Broiler chicken feeds in Ajure, Nigeria. Journal of Biological Sciences, 6: 981-984.
27. Masdooq, A.A., A.E. Salihu, A. Muazu, A.K. Habu, J. Ngbede, G. Haruna and M.Y. Sugum, 2008. Pathogenic bacteria associated with respiratory disease Broiler chicken with reference to *Pasterella multocida*. International Journal of Broiler chicken Science, 7: 674-675.
28. Renata Cegielska-Radziey Jeurska, Barbara Tycner, Jacekkijowski, Jan Zabielski and Tomasz Szablesoski,2008. Quality and shelf life of chilled. Pretreated map Broiler chicken meat products. Bulletin Veterinary Journal, 52: 603-609.
29. Chaiba Abdellah, Rhazi Filai Fouzia, Chahlaoui Abdelkader, Soulaymani Rachida and Zerhouni Mouloud,2008. Occurrence of *Salmonella* in chicken carcasses and Giblets in Meknes-Morocco. Pakistan Journal of Nutrition. 7: 231-233.

30. Nagodisha, E.M. and O.J. Owen, 2002. Evaluation of the bacteriological characteristics of Broiler chicken litter as feed stuff for cattle. Scientific Research and Essay, 4: 188-190.
31. Carmen Cretu, V. Floristean, M. Carpcarare, G. Brakatan and Elena Isan, 2009. The influence of pH and temperature on *Salmonella* spp. from fresh, chilled and frozen broiler chicken carcasses. Cercetari Agronomice in Moldova, 42(2): 138.
32. Elena Dal Rio, Rosa Captia, Miguel Prieto and Carlos Alonso Calleja,2006. Comparison of pathogenic and spoilage bacterial levels on refrigerated broiler chicken parts following treatment with trisodium phosphate. Food Microbiology, 23: 195-198.
33. Lidija Kozacinski, Mirza Hadziosmanovic and Nevijo Zololec, 2006. Microbiological quality of broiler chicken meat on the creation market. Veterinariski Arhives, 76: 305-313.
34. Prem Kumar, D., M. Jayanthi, P. Saranraj and S. Kavi Karunya, 2015. Effect of Calcium propionate on the inhibition of fungal growth in Bakery products. Indo-Asian Journal of Multidisciplinary Research, 1(3): 273-279.
35. Jacobs Reitsma, W.F., C.A. Kan and N.M. Bolder, 1994. The introduction of quinolone resistance in *Campylobacter* bacteria in broilers by quinolone treatment. Letters in Applied Microbiology, 19: 228-231.
36. Saranraj, P. and M. Ramya, 2016. Role of Organic acids and Hydrogen peroxide in fruit juice preservation: A Review. Journal of Pharmaceutical and Biological Sciences, 4(2): 58-73.
37. Anonnymous, 2006. Trend and sources of zoonoses, zoonotic agents and antimicrobial resistance in the European Union in 2004. European Food Safety Authority, Italy.
38. Van de Giessen, A., 1996. Epidemiology and control of *Salmonella enteritidis* and *Campylobacter* spp. in poultry flocks. Ph. D Thesis, University of Utrecht, The Netherlands.
39. Pohl, P., H. Imberechts, M. Marin, A. Stockmans and G. Van Robaeys, 1996. Serovars of Belgian *Salmonella* isolates serotypes during the years 1992, 1993, 1994 and 1995. Evolution among poultry, pigs and bovine 1983-1995. National Institute for Veterinary Research, Brussels, Belgium.
40. Wall, P.G., D. Ross, P. Van Someren, L. Ward, J. Threlfall and B. Rowe, 1997. Features of the epidemiology of multidrug resistant *Salmonella typhimurium* DT104 in England and Wales. Proceedings of *Salmonella* and Salmonellosis, May 20-22, Ploufragan, France, pp: 565-567.
41. Wray, C. and R.H. Davies, 1997. Reflections on the epidemiology of *Salmonella*: a challenge for disease control. Proceedings of *Salmonella* and Salmonellosis, May 20-22, Ploufragan, France, pp: 309-314.
42. Ward, L. and J. Threlfall, 1997. Human Salmonellosis in England and Wales-current situation. Proceedings of *Salmonella* and Salmonellosis, May 20-22, Ploufragan, France, pp: 547-549.
43. Baggesen, D.L., I. Laconcha, A. Rementeria and J. Garaizar, 2000. Genotypic characterization by PFGE of *Salmonella enterica* serotype Enteritidis phage types 1, 4, 6 and 8 isolated from animal and human sources in three European countries. Veterinary Microbiology, 75: 155-165.
44. Elmer, H. and S. Marth, 1998. Extended shelf life refrigerated foods. Microbiological quality and safety. Scientific Status Summary, 52: 2.
45. Grecz, N., D.B. Rowley and A. Matsuyama, 1983. The action of radiation on bacteria and viruses. In: Preservation of Food by Ionizing Radiation, Vol. II. Josephson, E.S. and M.S. Peterson (eds.). CRC Press, Boca Raton, pp: 167-218.
46. Welch, A.B. and R.B. Maxcy, 2000. Characterization of radiation resistant hemolytic *Micrococcus* isolated from chicken. Journal of Food Science, 44: 673-675.
47. Thayer, D.W., G. Boyd and C.N. Huhtanen, 1995. Effects of ionizing radiation and anaerobic refrigerated storage on indigenous microflora, *Salmonella* and *Clostridium botulinum* types A and B in vacuum-canned, mechanically deboned chicken meat. Journal of Food Protection, 58(7): 752-757.
48. Patterson, M.F., 1995. Sensitivity of *Campylobacter* spp. to irradiation in poultry meat. Letters in Applied Microbiology, 20(6): 338-340.
49. Patterson, M.F., 1989. Sensitivity of *Listeria monocytogenes* to irradiation on poultry meat and in phosphate-buffered saline. Letters in Applied Microbiology, 8(5): 181-184.
50. Mulder, R.W.A.W., 1999. Hygiene during transport, slaughter and processing. In: Broiler chicken meat science. Broiler chicken science symposium series volume twenty five. Eds. Richardson and Mead. CABI Publishing 1999, 277-285.
51. Zeitoun, A.A. and J.M. Debevere, 1991. Inhibition, survival and growth of *Listeria monocytogenes* on poultry as influenced by buffered lactic acid treatment and modified atmosphere packaging. International Journal of Food Microbiology, 14: 161-169.

52. Conner, D.E., J.S. Kotrola, W.B. Mikel and K.C. Tamblyn, 1997. Effects of acetic-lactic treatments applied to beef trim on populations of *Escherichia coli* O157:H7 and *Listeria monocytogenes* in ground beef. Journal of Food Protection, 60: 1560-1563.
53. Lillard, H.S., 1995. Incidence and recovery of *Salmonella* and other bacteria from commercially processed poultry carcasses at selected pre- and post-evisceration steps. Journal of Food Protection, 52(2): 88-91.
54. Somers, E.B., J.L. Schoeni and A.C. Wong, 1994. Effect of trisodium phosphate on biofilm and planktonic cells of *Campylobacter jejuni*, *Escherichia coli* O157: H7, *Listeria monocytogenes* and *Salmonella typhimurium*. International Journal of Food Microbiology, 22(4): 269-276.
55. Slavik, M.F., J. Kim, M.D. Pharr, D.P. Raben, S. Tsai and C.M. Lobsinger,1994. Effect of trisodium phosphate on *Campylobacter* attached to post-chill chicken carcasses. Journal of Food Protection, 57: 324-326.
56. Rodriguez de Ledesma, A.M., H.P. Riemann and T.B. Farver, 1996. Short-time treatment with alkali and/or hot water to remove common pathogenic and spoilage bacteria from chicken wing skin. Journal of Food Protection, 59: 746-750.
57. Bin Jasass, F.M., 2008. Effectiveness of trisodium phosphate, lactic acid and acetic acid in reduction of *Escherichia coli* and microbial load on chicken surfaces, African Journal of Microbiology Research, 2: 50-55.
58. Alla Eldin Mohammed Ali Morshedy and Khalid Ibrahim Sallam, 2009. Improving the microbial quality and shelf life of chicken carcasses by Trisodium phosphate and lactic acid dipping. International Journal of Broiler chicken Science, 8: 645-650.
59. Canan Hacer, Faruk Balci and Cevahir Duyguvdum, 2007. The effects of ozone and chlorine applications on microbiological quality of chickens during processing. Journal of Biological Environment Science, 1: 131-138.
60. Russel, S.M., 2000. Effect of a novel sanitizer on pathogenic, spoilage and indicator population of bacteria from chicken carcasses. Journal of Applied Broiler chicken Science, 9: 393-402.
61. Adesonkan, I.A., B.B. Odetoyinbo and A.O. Olubamiwa, 2008. Biopreservative activity of lactic acid bacteria on suya produced from broiler chicken meat. African Journal of Biotechnology, 7: 3799-3803.
62. Cosby, D.E., M.A. Harrison and R.T. Toledo, 1990. Vacuum or modified atmosphere packaging and EDTA-Nisin treatment to increase Broiler chicken product shelf life. Journal of Applied Broiler Chicken Science, 8: 185-190.
63. Kijowski, J., C. Marciszewska and A. Popiol, 2005. Quality and Microbiological stability of chilled chicken legs treated with lysozyme. European eymposium of the quality of broiler chicken meat doorwerth, the Netherlands: 23-26.
64. ESCOP, 1997. Monographs on the Medicinal uses of Plant Drugs. Fascicules 3-5. Devon, UK: ESCOP.
65. Matthew Egbobor Eja, Bassey Asikong, Clement Abriba, Giddings Arikpo, Edet Anwan and Kingsley Enyi-Idoh,2007. A comparative assessment of the antimicrobial effects of garlic (*Allium sativum*) and antibiotics on diarrheagenic organisms. Southeast Asian Journal of Tropical Medical and Public Health, 38(2): 343-348.
66. Ross, Z.M., E.A. O'Gara, D.J. Hill, H.V. Sleightholme and I.J. Maslin, 2001. Antimicrobial properties of garlic oil against human enteric bacteria: Evaluation of methodologies and comparisons with garlic oil sulfides and garlic powder. Applied Environmental Microbiology, 67: 475-480.