# Chicken

Fried Chicken ● Grilled Chicken

NTRS 519 final report

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## Introduction

Chicken is one of Americans' favorite foods. According to USDA, chicken is the number one species consumed by Americans. In the year of 2003, Americans consumed 81.5 pounds of chicken on a per capita basis, more than beef (64.9 lbs) and pork (51.9 lbs) (Consumer Trends, n.d.). Chicken is a descendant of the Southeast Asian red jungle fowl first domesticated in India around 2000 B.C. (United State Department of Agriculture, Food Safety and Inspection Service [USDA, FSIS], Focus on Chicken, 2000). It is delicious, flavorful, and rich in protein, iron, zinc, selenium, phosphorus and some B vitamins, such as niacin, thiamin, riboflavin, and B12.

Chicken can be cooked in many different ways, either by itself or combined with other foods such as grains, vegetables or fruits. It can be used in appetizers, soups, salads, sandwiches and main dishes. Deep-fat frying, grilling, broiling, roasting, baking, stir-frying and braising are the more common cooking methods. Among these, deep fat frying and grilling are probably the most popular, dry-heat cooking methods. While fried chicken is juicy with a crispy crust, grilled chicken is tasty with appealing smoke flavor. In grocery stores, fried chicken and grilled chicken are two of the hottest sales of chicken products.

As people are getting more knowledgeable about nutrition, there are more and more concerns about the healthiness of food intake, including chicken, of course. Chicken itself is a healthy, nutritious food. However, after deep fat frying or grilling, the nutrition of chicken will be changed. The nutrition changes may be good or bad. As a smart chicken product consumer, people should be aware of the nutrition changes of chicken after processing so that when they shop, they can make the right choice.

To collect market information about fried chicken and grilled chicken for this study, supermarkets such as Albertson and Vons were visited. It was observed that Tyson Foods, Foster Farms, and Kraft Foods are three of the big grilled chicken producers while Advance Brands, ConAgra Brands and Tyson Foods are three of the big fried chicken manufacturers. To collect information about the process, nutritional value, future trend and market information about fried/grilled chicken, the following people were interviewed via phone: Jeannie O. (Advance Brands), Tim G. (Foster Farms), Vickie M. (Foster Farms), Erica (Kraft Foods), Lynette A. (ConAgra Brand) and Dr. Hunter (Technical Support, USDA).

In this study, the literature about chicken will be reviewed and the chicken industrial information, the processing techniques and nutrition changes during processing of fried chicken and grilled chicken will be discussed. The information in this paper should help consumers enrich their knowledge about fried chicken and grilled chicken.

**Literature**

Based on the size, weight and age, chickens are classified as: poussin, rock Cornish Hen, broiler/fryer, roaster, capon and stewing hen. (Rombauer, Becker, & Becker, 2000). Most of the chicken products in the supermarkets are or made from broiler chicken, which is meat-type chicken. According to USDA standards, chicken is also categorized as free range, organic or natural, depending on the way they are raised (Rombauer et al., 2000). In US, chicken are very safe to eat. The regulations of the FDA prohibit the use of hormones in the productions of chicken and all chickens are inspected for visible signs of disease after slaughtered. Chicken may be graded based on meatiness,

appearance and freedom from defects, which is optional (National Chicken Council [NCC], 2002)

Over 50 years, chicken production has become industrialized and evolved from fragmented, locally oriented businesses into highly efficient, vertical integrated industry, which gives producers greater control over the production of quality products that successfully meet customer wants and needs in an attractive, timely, and efficient manner (NCC, 2002). The production of chicken is a long process: primary breeder → breeder farm → hatchery → growout farm→ processing plant (slaughter) → further processing plant → transportation and marketing (NCC, 2002). Each stage in the process plays an important role in the production of high quality chicken product.

According to National Chicken Council, more than 30,000 million pounds of broiler chicken were produced in 2003. There are different kinds of chicken products being sold in the supermarkets, many of which are precooked. To meet consumer needs, chicken manufacturers produce products of various flavors by different cooking methods. Fried chicken and grilled chicken are two examples, which are probably more popular than others. According to a survey sponsored by NCC, 51% and 50% Americans like grilled chicken and fried chicken, respectively (NCC, 2002). There are different brands of fully cooked fried chicken or grilled chicken in the supermarkets, such as Tyson®, Foster Farms®, Banquet®, and Fast Fixin'®.

Starting from the time that the chicken is killed, a lot of food technologies have been incorporated into the manufacturing process, such as heat decontamination, food irradiation, flash freezing, vacuum packaging, use of food additives, etc. In each step of processing, there are techniques to improve the quality of the chicken product by

reducing microbial content, preventing oxidation, improving texture of the food, etc. These process techniques can alter the shelf life, taste, and even nutrition of the food. Precooked chicken from the supermarkets is timesaving. However, before making precooked fried chicken or grilled chicken a part of their dinner menu, consumers should take the healthiness of the products into consideration.

According to the food labels provided by the manufacturers, the nutrition and ingredient of fried chicken (chicken breast nuggets, Fast Fixin'®, Advance Brands) and grilled chicken (grilled chicken breast strips, Tyson®, Tyson Foods) are pretty different, as shown in table 1. More than 24 ingredients are used during processing for each product, majority of which are food additives. Each ingredient plays a role in the product quality, acting as an antioxidant, a coloring agent, a flavoring agent, etc.

All the food additives used by the manufacturers are visibly listed on the food label. However, there are some chemical compounds that form during the processing or cooking are not listed on the label and they are invisible to the consumers. These compounds include cholesterol oxidation products (COPs), heterocyclic amines (HCA) and polycyclic aromatic hydrocarbons (PAH), which are bad for health. Some of these compounds are even carcinogenic. There are increasing findings on the connection between cancer risk and meat intake. The carcinogenic compounds may be the root cause. According to a study by Augustsson et al. fried meat is an important source of exposure to HCA in the Western diet and parameters influencing the intake are the amount and type of meat ingested, frequency of consumption, cooking method, cooking temperature and the duration of cooking (Augustsson, Skog, Jagerstad, & Sterineck, 1997). Many studies showed that exposures to HCA could increase risk of some cancers. In a study by Zheng et al. (1998), exposures to

HCA formed during high-temperature cooking were found playing an important role in the risk of breast cancer. Both fried and grilled chickens are cooked at high temperature. The frequency and amount of consumption of them significantly correlate to exposure to HCA and thus the risk of some cancers. In addition, grilled chicken may also contain PAH, some of which are potent carcinogens. PAH, particularly benzo[a]pyrene(Bap), have been suggested as one etiological factor in large bowel cancer and stomach cancer (Larsson, Sahlberg, Erikssaon, & Busk, 1983). Cooking, such as frying and grilling, and storage of raw and cooked chicken also lead to formation of thiobarbituric acid reactive substances(TBARS) and cholesterol oxidation products (COPs), the oxidation products of lipid and cholesterol, which may have cytotoxicity and mutagenic effects (Conchillo, Ansorena, & Astiasaran, 2005). Oxidation of lipids in meat and meat products is influenced by storage temperature, oxygen availability, water activity, exposure to light, pro-oxidants and antioxidants. Oxidation is responsible for changes in the nutritional quality --- loss of vitamins and essential amino acids as well as in color, flavor, odor and texture (Aguirrezabal, Mateo, Dominquez, & Zumalacarregui, 2000).

**Industrial information**

The chicken industry is growing every year. In 2004, more than $20 billion of broilers were produced in US (NCC, 2002). During the process of chicken production, different units of the industry play an important role as follow (NCC, 2002). The primary breeders develop and reproduce strains of chicken that meet the requirements of chicken producer/processing companies. Beginning with selected lines (pedigree lines), chicken are multiplied over several generations to achieve desirable characteristics such as

abundant white meat and efficient feed conversion. Breeder chicks are then sold to integrated chicken firms. The breeder farms raise the breeder chicks to adult birds. Breeding hens and roosters are kept under tight biosecurity on breeder farms to produce fertile hatching eggs for the integrated company. The offspring of breeder parents will then be raise to become broilers for the market. The hatcheries are specialized facilities designed to hatch fertile eggs received from breeder farms. Fertile eggs are placed in incubators and carefully monitored to ensure that correct temperature and humidity levels are maintained throughout the entire incubation period. The growout ranches then raise the hatched chick to market weight under contract with the chicken processing companies. The companies provides the chicks, feed, and necessary pharmaceuticals, while the farmer provides the growout house, water, bedding, electricity, and his own management skill. In a few cases, the broiler companies own and manage their own growout houses, but the contract arrangement is more typical. When the chickens reach market weight of about 5 pounds in 6 or 7 weeks, they are collected to be taken to the processing plant. During the growing process, feed mills, the chicken feed providers, are responsible for converting raw materials such as corn, soybean meal, vitamins and minerals into finished feed according to very specific formulas developed by poultry nutritionists. The feed given to the birds is formulated into 4 or 5 different phases to meet the changing nutritional requirements of the birds as they grow. The chicken feed may contain compounds that prevent diseases and promote growth of the animal by improving its intestinal flora, but it does not include any hormones or steroids. Pharmaceuticals approved for animal use by the FDA are used to treat outbreak of illness if they occur; if medication is used, there is a withdrawal period before slaughter. Regular tests are

conducted to ensure the chicken test negative for antibiotics before processing. In the slaughter houses, the chickens are stunned unconscious by a low voltage electrical charge and are then humanly killed. The feather, feet and head are removed and internal organs pulled for inspection by USDA. Inspectors look for signs of poultry disease and for manufacturing defects, such as broken wings. After inspection, the carcasses are immersed in ice-cold water to reduce their temperature to 40ºF to inhibit bacterial growth. Then whole chickens are packed for distribution or cut into parts. The slaughter processing plants operate under Hazard Analysis and Critical Control Points (HACCP) principles to reduce potential hazards from microbiological, chemical and physical sources. They also operate under USDA Pathogen Reduction rules to improve the microbiological quality of the products. The further processing plants receive whole chicken or cut-up parts and perform a variety of further processing steps, such as marinating, breading and cooking. In these plants, the operations environment must be highly sanitary, with comprehensive food quality control and safety management system in place (NCC, 2002). Finally, chicken products are transported in refrigerated trucks from processing and further processing facilities to market outlets such as supermarket, food service operations, distributors and other market channels to reach domestic and oversea customers.

Most of the chicken production plants are located in the southeast US due to availability of resources and land. The top five broiler-production states are Georgia, Arkansas, Alabama, Mississippi and North Carolina, which produced 8,492,850,000 broilers in 2003 (USDA, Economic Research Service, 2004). Among all the chicken

producers, Tyson Foods, Pilgrim's Pride Corporation and Gold Kist rank the top three, according to Walt Poultry USA.

More and more consumers demand convenient, fully cooked chicken products. Figure 3 shows how broilers are marketed from the 1962 to 2002. Accordingly, in 2002 whole chicken sales was only about 10% of the total, while cup-up/parts and further processed chicken product sales consisted of 40% and 50% of the total sale, respectively. In the future, sales of precooked chicken/further processed chicken, which include fried/grilled chicken, are expected to increase.

**Processing techniques**

Chicken is rich in protein and easily spoiled. According to USDA, the bacteria associated with chicken include: *Samonella Enteritidis*, *Staphylococcus aureus, Campylobacter jejuni and Listeria monodytogenes* (USDA, FSIS, 2000). Most food borne outbreaks are a result of contamination from food handlers. Sanitary food handling and proper cooking and chilling can prevent food borne illness. Before chickens are shipped to the market or to the further processing plants for cooking, they may have already passed through various stages of processing. Figure 1 shows the process flow diagram of raw chicken. Some stages are very critical to the microbial quality of chicken, such as immersion scalding and irradiation.

*Immersion Scalding*

Immersion scalding is to dip the chicken body in hot water before defeathering. During the various stages of processing, the microbial growth in chicken may increase due to cross contamination from the processing environment, from other chicken and

from the processing equipment. To reduce pathogenic microorganisms, a heat based decontamination system is used to raise the surface temperature rapidly to a value at which pathogens are killed. The heat must be quickly removed to prevent it penetrating into the muscle and denaturing the protein. In commercial tank scalders, the continuous overflow of contaminated scald water and destruction of bacteria by heat (122-129ºF scalding temperature) may limit the build up of microbial load in scald water. Washing reduces the population of bacteria by removing of liquid film containing microorganisms before they become more closely attached with the skin surface. (Sakhare, Sachindra, Yashoda, & Narasimha, 1999).

*Irradiation*

Food irradiation is a process used to prevent food borne illness by exposing products to radiant energy in an amount approved by FDA and destroying harmful bacteria, parasites, insects, and fungi. It is not a substitute for good manufacturing practices. Irradiation does not destroy all pathogens in amounts approved by FDA for refrigerated or frozen raw poultry sold to consumers, but it does reduce their number. Like pasteurizing, freezing, canning, and drying, irradiation can extend the shelf life of perishable food products. In a study by Lamuka et al., the shelf life for irradiated carcasses is 15 days compared to about 6 days for the unirradiated samples when stored at 4ºC. (Lamuka, Sunki, Chawan, Rao, & Shackelford, 1992). According to USDA, only refrigerated or frozen raw meat and poultry products, meat by products, and certain other meat food products may be irradiated. Cooked meats and poultry products may not be irradiated.

Both fried and grilled chickens are cooked at high temperature, but they have dissimilar flavor and texture due to different cooking methods. Their commercial production process is shown in figure 2. This process flow diagram is provided by the USDA. Among the many steps, the followings are more critical:

*Marinating (fried/grilled chicken)*

Marinating of chicken with food additives prior to cooking is a preparation frequently used for chicken. Meat is marinated for a variety of reasons, including improvement of flavor, tenderness and moistness of the cooked products, etc. Besides, marinating can reduce carcinogenic compounds formed during cooking. Studies showed that marinating can significantly reduce total heterocyclic amines in grilled chicken. (Salmon, Knize, & Felton, 1997). However, according to USDA, the marinating solution must not exceed 14% (USDA, FSIS, 1999).

*Application of food additives (fried/grilled chicken)*

Food additives are used in chicken production for different purposes, as antioxidants, coloring agents, preservatives, emulsifiers, etc. A lot of food additives are used during manufacturing of fried chicken or grilled chicken, as shown in Table 1. The functionalities of some of them have been proved in studies. During storage, quality attributes of chicken product deteriorates due to lipid oxidation and microbial growth. Application of suitable agents possessing both antioxidant and antimicrobial activities may be useful for maintaining meat quality and extending shelf life. Natural and synthetic antioxidants such as sodium phosphates, butylated hydroxyaniosole (BHA) and butylated hydroxytoluene (BHT) are used in food industry to prevent oxidation. Many herbs and spices can also inhibit rancidity, such as garlic and paprika. Paprika has low redox

potentials and thus high antioxidant content, while garlic is an effective hydroxyl radical scavenger (contains organosulfur compounds, ascorbic acid, nitrates and nitrites). Garlic also has antibacterial, antiviral, antifungal functions (Aguirrezabal, et al., 2000)

*Deep fat frying (fried chicken)*

Deep-fat frying is to cook the food by immersing it in hot oil so that all the flavors and the juices are retained in a crisp crust. The high temperatures of the frying fat typically lead to the appreciated textual dichotomy of the food: dry and crispy crust, tender inside. Typical frying flavor is provided by Maillard reactions in the crust. Fried foods contain significant amount of fats, reaching in some cases 1/3 of the total food product by weight, which can also pose a risk (Brook, 1991).

During production of fried chicken, vegetable oil is used to fry the chicken, usually is a mixture and continuously filtered. The vegetable oil used includes soybean, cottonseed, corn, canola, sunflower, etc. Soybean, sunflower, and canola oils are always hydrogenated before being used for frying to increase its stability. To add a crunchy coating and to protect its tender flesh, chicken is usually battered before cooking (Rombauer, et al., 2000). In deep-fat frying of foods, the type of oils used, the temperature of the heated oil, the frying time, the fryer, and the additives play an important role to the quality of the fried chicken. The temperature of the oil is between 302 and 374ºF, which bring the internal temperature of the meat to at least 160ºF, the minimum temperature to kill most pathogens. The surface appearance and texture are the most significant factors for acceptability. The frying industry monitors product quality by how it looks, tastes, and smells. The appearance of the fried product is monitored by color charts and taste panels (Brook, 1991).

*Grilling (grilled chicken)*

According to Vickie M. from Foster Farms, the grilling process is done on gas oven. The meat is determined to be fully cooked when it is tested with a meat thermometer. The product is then cooled quickly after grilling and it takes an hour to cool. The grilling temperature is usually 160ºF and is a critical factor to the quality of product as the mutagenicity of the processed chicken sample increased with increasing grilling temperature. In a study, the chicken products was low or non-mutagenic at the grilling temperature of 340ºF and 230ºF, while chicken sample grilled at 430ºF exhibited high mutagenicity. (Tikkanen, Latva-kala, & Heinio, 1996).

*Cooling (fried and grilled chicken)*

Cooling after frying or grilling is critical to the microbiological quality of the final product. There is compliance guidelines provided by USDA for cooling heat-treated meat and poultry products to prevent the growth of spore-forming bacteria. It is important that cooling be continuous through the given time/temperature control points. Excessive dwell time in the range of 130 to 80ºF is especially hazardous, as this is the range of most rapid growth for the clostridia. Therefore, cooling between these temperature control points should as rapid as possible. During cooling, the product's maximum internal temperature should not remain between 130 and 80ºF for more than 1.5 hours nor between 80 and 40ºF for more than 5 hours (USDA, FSIS, 1999). The products should not be shipped until it reaches 40ºF. Slow cooling may applied to ready-to-eat meat and poultry cured with nitrite. Product cured with a minimum of 100ppm ingoing sodium nitrite may be cooled so that the maximum internal temp is reduced from 130 to 80ºF in 5 hours and from 80 to 45ºF in 10 hours (15 hours in total). (USDA, FSIS, 1999).

**Nutrition changes**

Chicken is nutritious. However, cooking and storage can change the nutrition content of chicken, including trace elements, fat, vitamins, proteins, etc. and cause formation of some carcinogenic compounds.

*B Vitamins and minerals*

B vitamins of broiler meat may be reduced after cooking. A study showed that frying caused B vitamins loss in cooked meat: thiamin retention ranged from 28-64%, riboflavin retention 46-94% (Abdulrahman & Abdelbary, 1992).With cooking method without water, such as frying and grilling, trace elements can be highly retained.

*Lipids and cholesterol*

Oxidation of lipid and cholesterol occurs in chicken during processing and storage. As lipid oxidized, they form hydroperoxides, which are susceptible to further oxidation or decomposition to secondary reaction products. These compounds may adversely affect flavor, aroma, taste, nutritional value and overall quality of the meat. Cooking (such as grilling) and aerobic storage increase thiobarbituric acid reactive substances (TBARS) and cholesterol oxidation products (COP) levels. Salt is a common additive in the meat industry and a powerful pro-oxidant. Salt can accelerate lipid and cholesterol oxidation following cooking and refrigerated storage. Many toxicological effects of COPs have been reported, such as cytotoxicity, atherogenesis, mutagenesis, carcinogenesis, changes in cellular membrane properties and inhibition of 3-hyroxy-3-methylglutaryl coenzyme A reductase activity (Conchillo, Ansorena, & Astiasaran, 2005). To reduce the extent of lipid and cholesterol oxidation in chicken meat, dietary supplementation of more than 400mg α-tocopherol/ kg chicken feed may be used during

the growth of chicken (Galvin, Morrissey, & Buckley, 1998). In addition, frozen storage is frequently used during distribution to retail stores as a preservation method for meat and meat products to prevent bacteria growth and slow down lipid oxidation, which can increase shelf life of the products. Freezing chicken at 0ºF or below doesn't kill bacteria, but it keeps food safe by slowing the movement of molecules, causing bacteria to enter a dormant stage, which may be destroyed later by thorough cooking to 160ºF (USDA, FSIS, 1999).

Grilling or frying can increase significantly the unsaturated/saturate and polyunsaturated/saturated ratios of fatty acid in comparison to raw samples if vegetable oil, such as sunflower oil is used to prepare the chicken, which is due to fatty acid exchange between chicken and oil. As shown in Table 1, fat content of fried/grilled chicken is higher than raw meat due to fat absorption.

*Heterocyclic amines (HCA) (fried and grilled chicken)*

Heterocyclic amines (HCA) are dietary compounds formed naturally during the cooking of some foods, especially muscle meats. The most common reported HCA are: 2-amino-3,8-dimethylimidazo[4,5-f]quinoxaline(MeIQx), 2-amino-3,4,8-trimethylimidazo[4,5-f]quinoxaline(DiMeIQx), 2-amino-3-methylimidazo[4,5-f]quinoline(IQ) and 2-amino-1-methyl-6-phenylimidazo[4,5-b]pyridine(PhIP). These compounds are mutagenic and thought to be a product of pyrolysis reaction during the cooking process involving creatine, creatinine, , sugars and amino acids, all common components of muscle tissue. (Salmon, Knize, & Felton, 1997).

The concentration of HCA is dependent on the cooking method. Frying and grilling can cause formation of HCA, which is related to cooking time, internal

temperature and degree of surface browning (Chiu, Yang, & Chen, 1998). Accumulated evidence from recent animal study and human studies showed heterocyclic amines in the pathogenesis of breast cancer.

*Polycyclic Aromatic Hydrocarbons (PAH) (grilled chicken)*

Grilling food can lead to the production and uptake of PAH, which is associated with certain cancers, such as large bowl cancer and stomach cancer. The levels of PAH grilled meat was dependent on the fat content and the closeness of the meat to the heat source: the melted fat from the heated meat drips onto the hot coals and is pyrolyzed, giving rise to the formation of PAH, which are deposited on the meat surface as the smoke rise. Thy hydrocarbons seem to arise mainly from incomplete combustion of the fuel. Frying doest not lead to the production of PAH because the meat is not exposed the heat source directly during cooking (Larsson, Sahlberg, Erikssaon, & Busk, 1983). Some of the common PAH are Phenanthrene, anthracene and 2-methylphenanthrene.

**Questions remained from the study**

During the interviews with people from different companies, it was realized that food manufacturers are not responsible for testing carcinogenic compounds or oxidation byproducts contained in the chicken meat during or after production, nor do they do research on them. However, numerous studies showed that those compounds are unhealthy to human beings. As a result, the following questions are remained and may be the topic for later study:

1. How likely is it to force food processors test (potential) carcinogenic compounds as part of their food quality control and make it a federal regulation?

2. Is it possible to put a warning sign of carcinogenic compounds on the food label?

3. Is there any way to prevent formation of HCA/PAH, or to neutralized them?

4. How much fried/grilled chicken are consumed in US every year?

5. How many people die from HCA/PAH related diseases every year?

**Suggestions for consumers:**

Since chicken is easily spoiled, consumers should handle and store chicken products as instructed on the food label. Usually, chicken should be stored in the back of the refrigerator, where the temperature is coldest, if it will be cooked and eaten within a day or two of purchase. It should be frozen if cannot be eaten promptly, and thawed in the refrigerator or in cold water. To reduce the chances of contamination, raw chicken should not be stored, even when wrapped, next to an unwrapped food that will be eaten raw, such as salad greens or bread. Wash hands, cutting board, counter surface and knives in hot water after handling raw chicken.

Since fried chicken or grilled chicken may contain carcinogenic compounds such as PAH and HCA, do not eat them too much or too often to reduce exposure. If possible, use alternative cooking methods, such as steaming. Between fried chicken and grilled chicken, the latter one is possibly healthier due to less fat content. When buying grilled chicken products, choose those that are less burned on the surface since charring may be an indicator for carcinogens.

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Table 1. Nutrition facts and ingredients of fried chicken, grilled chicken and raw chicken.

| brand | **Fast Fixin'® fried chicken** (Chicken Breast Nuggets-breaded nugget-shaped chicken patties with rib meat) | **Tyson® grilled chicken** (Grilled chicken breast strips-Boneless, skinless with rib meat) | Raw chicken breast, meat only[1] |
|---|---|---|---|
| Serving size | 6 nuggets (85g) | 84g | 85g |
| Calories | 230 | 110 | 94 |
| Total fat | 13g | 3g | 1g |
| Sat. fat | 3g | 1g | 0.3g |
| Cholesterol | 20mg | 50mg | 50mg |
| Sodium | 610mg | 480mg | 55mg |
| Total CHO | 15g | 2g | 0g |
| Dietary fiber | 2g | 0g | 0g |
| Sugar | 0g | 2g | 0g |
| Protein | 11g | 19g | 19g |
| Vitamin A | 4% | 0% | na |
| Vitamin C | 0% | 0% | 1% |
| Ca | 4% | 0% | 1% |
| Fe | 10% | 0% | 4% |
| ingredients | Chicken, breader (wheat flour, salt, dextrose, spice, soybean oil, whey, extractives of paprika), water, batter ( water, yellow corn flour, corn starch, spices, salt, sugar, autolyzed yeast extract, guar gum, leavening [sodium acid pyrophosphate, sodium bicarbonate, monocalcium phosphate], garlic powder), isolated soy protein, salt, hydrolyzed plant protein blend ( hydrolyzed soy and corn protein with pepper (mono and diglycerides), extractives of black pepper and lactic acid). Fried in partially hydrogenated soybean oil with BHT. Contains: wheat, milk, soy. | Grilled Chicken breast meat with rib meat, water, seasoning (sugar, dextrose, soy protein concentrate, maltodextrin, salt, soy sauce(wheat, soy bean, salt), flavor (from partially hydrogenated cottonseed and soybean oil), yeast extract, garlic powder, natural flavors(with smoke flavor), onion powder, modified food starch, corn syrup solids, polysorbate 80, caramel color, potassium lactate, salt, sodium phosphates, lactic acid, sodium nitrite. | Raw chicken breast, meat only |

[1]Source: Nutritionist V program

Figure 1. Process flow diagram of raw chicken

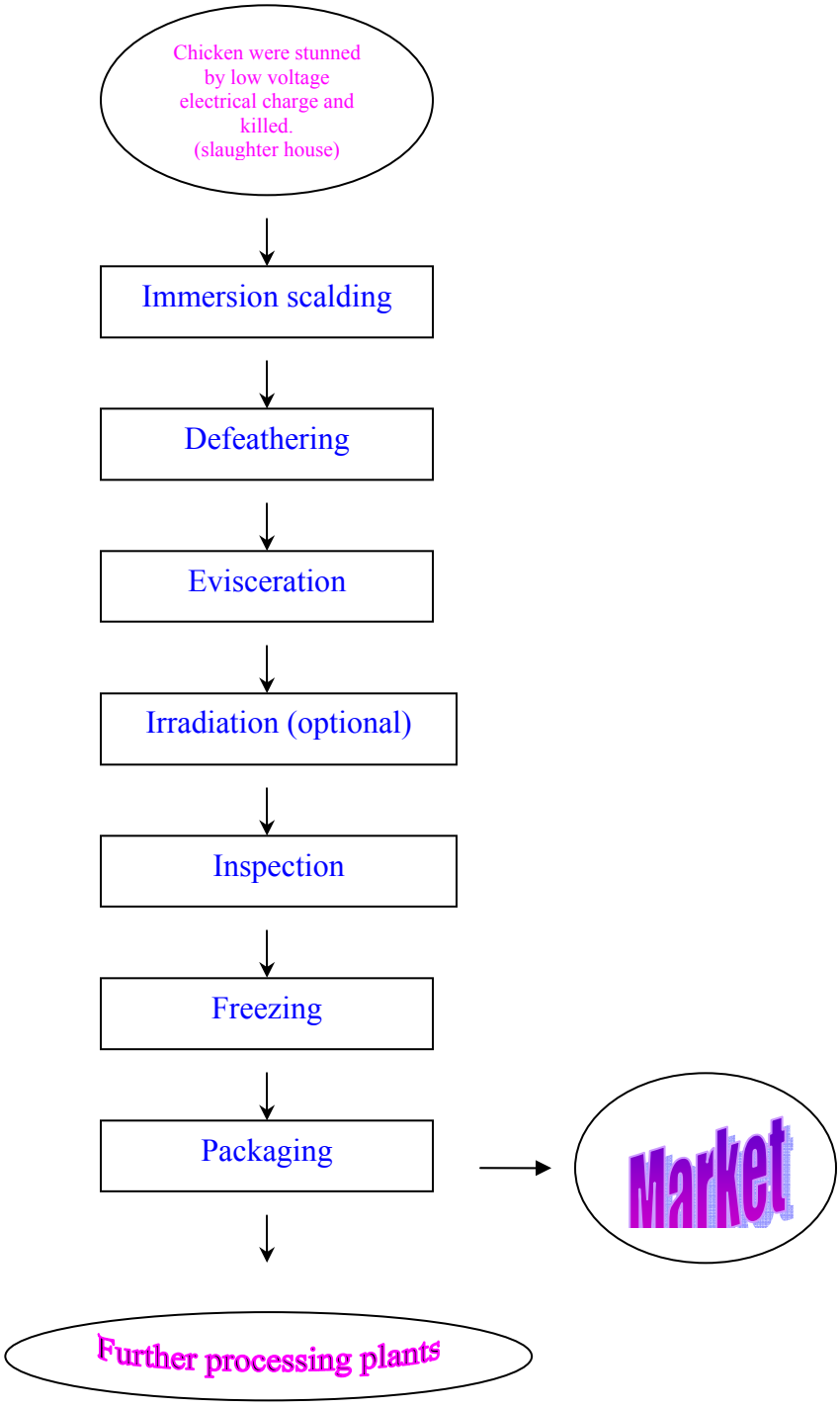

Figure 2. Process flow diagram of fried/grilled chicken

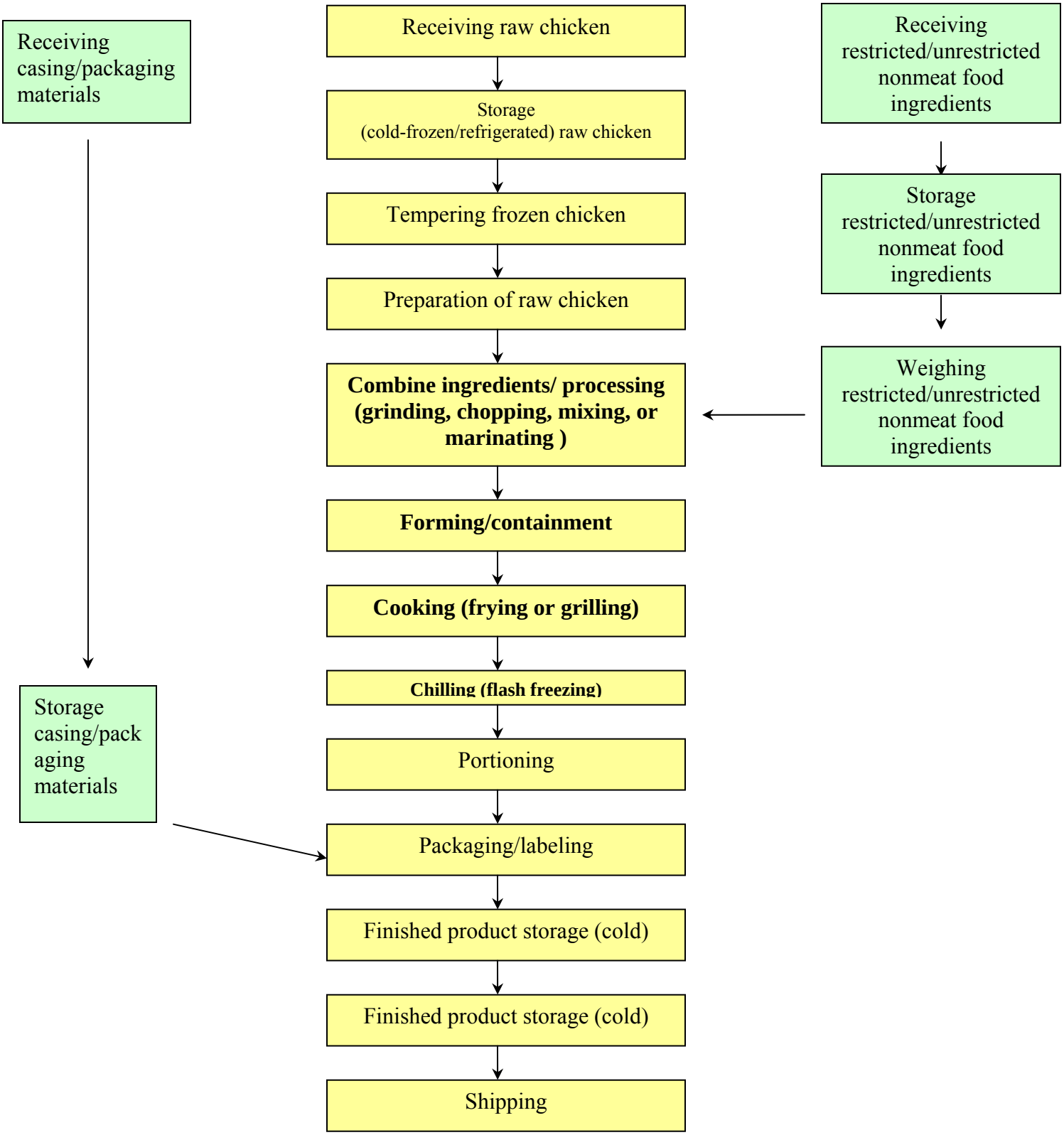

Figure 3. The broilers market during 1962-2002.