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Title: Quality of Fryers Purchased in Retail Markets Using Microbial and Sensory Assessment.

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Dressed, bagged whole chickens from three Oregon and several out-of-state processors were purchased from retail markets in each season in 1988. Birds were stored at 3°C for 6 days. Total aerobic microorganisms, total psychrotrophic microorganisms, pseudomonads and fluorescent pseudomonads were determined by appropriate procedures. Total aerobic microorganisms and psychrotrophic microorganisms were counted on standard plate count agar with incubation at 20°C for 3 days and at 5°C for 7 days, respectively. Two media, King's B medium and CFC medium, were used in counting pseudomonads. Fluorescent colonies were observed on King's medium under ultraviolet light. A simple slime smear test was used to determine the sliminess.

Sensory evaluation was done by thirteen panelists using 9-point scales. The flavor of cooked white and dark meat and skin, the flavor

intensity of cooked white and dark meat and skin, the aroma of raw and simmered meat, the aroma intensity of raw and simmered meat and raw sliminess were evaluated.

Simple regression analysis was used to determine the relationships between the microbial parameters and sensory evaluations. The paired *t* test was used in determining the difference between counts on King's medium and CFC medium. A significance level of 95% was set for all tests. Correlation coefficients were also calculated.

All the microbial counts were at or below $10^7/cm^2$, which indicated from literature comparisons that most of the fryers purchased from retail markets and stored for six days were of acceptable quality. The season had no significant effect on the microbial counts and sensory qualities. The means of flavor of cooked meat and skin and aroma of raw and simmered meat were all above fair. Only the raw aroma intensity was significantly ($p<0.05$) and strongly correlated ($r=-0.88$) to the aroma quality. Relationships between microbial counts and flavor of cooked meat and aroma of raw and simmered meat were all significant but the correlations were weak. The narrow range of microbial counts may explain the weakness of the correlations found. The slime smear tests had a positive relationship ($p< 0.05$) to the raw sliminess score by panelists, total aerobic microorganisms, total psychrotrophic microorganisms, pseudomonads, and fluorescent pseudomonads.

Quality of Fryers Purchased in Retail Markets Using Microbial and Sensory Assessment

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INTRODUCTION

The United State's poultry industry since 1960 has become the most efficient producer of animal protein in the history of agriculture. Per capita consumption of poultry has risen from 52 lb. in 1976 to about 78 lb. today and surpassed beef in 1987 (Swientek, 1988). Poultry research has played an important role in this development. Poultry includes chicken, turkeys, ducks, geese and pigeons, but chickens account for about 80% of all poultry products. Therefore, the quality of chicken purchased in retail markets is a concern of consumers. The quality attributes of chickens include nutritional value, purity, safety, convenience, functional properties, and acceptability. Most consumers are concerned primarily about the acceptability (Brant, 1980). Consumers seek the freshest fryer available, i.e. one which appears fresh, has no off-odor when raw or cooked, and a normal cooked flavor. Most consumers know little, if anything, about how poultry products are produced, processed, and delivered to retail and institutional outlets. Many consumers would be surprised and perhaps horrified to learn that fresh meat has a diverse natural microflora including bacteria, yeast, molds and virus (May , 1987). " The quality of poultry meat is

considered optimum immediately after processing, and maintenance of acceptable quality depends on initial microbial levels and measures taken to minimize growth of organisms" (Cunningham, 1987, p.29). One of the major concerns is the growth of spoilage organisms which causes consumers to reject the product due to odor or flavor (Cunningham, 1987).

From a practical standpoint, poultry processors must concentrate on reduction of total numbers of microorganisms to assure adequate shelf life during distribution and retail display and in the consumer's home. It is hoped that we can obtain poultry meat products of better microbial quality and longer shelf life. Since production has become more centralized and processing methods have changed over the past 20 years, it is important to examine the microbial counts of raw birds and the sensory evaluation of poultry and determine the relationships between them. The specific objectives of this study were to determine if:

(1). There is a significant effect of season on

a. flavor of cooked fryers meat or skin.

b. aroma of raw fryers.

c. microbial population of raw fryers.

(2). Flavor of cooked white meat, dark meat, and skin of poultry, aroma score of raw bird and simmered meat, and sliminess are each related to

a. total microbial count.

b. psychrotrophic microbial count.

c. pseudomonads count.

(3). There is a relationship between flavor quality of cooked meat and

a. off-odor of raw meat detected by the sensory panel.

b. off-odor of simmered samples detected by the sensory panel.

c. sliminess of raw meat detected by sensory panel.

(4). There is a relationship between flavor quality and flavor intensity and aroma quality and aroma intensity.

(5). There is a relationship between sliminess score by sensory panel and the slide smear test.

(6). There is a correlation between pseudomonads counts on two media, King's B and CFC.

LITERATURE REVIEW

Food quality and spoilage

Food quality has been defined as" the combination of attributes or characteristics of a product that have significance in determining the degree of acceptability of the product to a user" (Gould, 1977). These attributes or characteristics which are product dependent include the nuitritional value, microbiological safety, convenience, stability, cost, and sensory chacteristics of the product---its appearance, odor, flavor, texture. However, a strong argument can be made that for the average consumer those related to the sensory characteristics of the food are the factors most closely associated with the concept of food quality (Cardello and Maller, 1987).

" Food spoilage is any organoleptic change that the consumer considers to be an unacceptable departure from the normal state. Spoilage can be microbial or mechanical in origin." (Ayres, Mundt, and Sandine, 1980, p.44). Flavor changes may be caused by incomplete metabolism of the amino acids and fatty acids or fermentations of the simple sugars. Flavor can be lost through destruction of a flavor component, as when *Pseudomonas fragi* converts diacetyl to acetylmethylcarbinol in cottage cheese, or when *Pseudomonas* and *Achromobacter* in fish muscle act on methyl mercaptans and methyl mono-, di- and tri-sulfides and produce some volatile substances (Miller et al., 1973). Volatile microbial by-products are associated with the

spoilage odor of poultry held at refrigerated temperatures. The more significant volatile spoilage compounds produced by these microorganisms were sulfur-containing, eg. methanethiol, dimethyl sulfide, propylene sulfide, and dimethyl disulfide(Bowman et al., 1983).

When meat is stored refrigerated in air, the aerobic spoilage flora are largely composed of Gram-negative aerobic bacteria. Many workers have identified these organisms because of their importance in causing economic loss, and almost all report *Pseudomonas* as the predominant genus. The generally low pH of fresh meat does not promote rapid growth of *Pseudomonas* spp., but the microbial degradation of refrigerated meat in an aerobic enviroment produces a gradual elevation in pH which favors *Pseudomonas* growth. After two weeks of storage, the pH of fresh meat increased from 5.6-5.8 to over 8.0 at 5°C, while incipient spoilage was generally detectable at pH values of 6.2, when microbial numbers were *ca.* 5 x 10^8/g (Shelef, 1981). At higher numbers, off-odors were followed by slime formation on the meat surfaces (Shelef, 1981). Generally when counts of aerobic microorganisms reach 5 x 10^7 per sq. cm area of surface, poultry will be considered spoiled (Fung, 1987).

Microbiological and palatability aspects of frying chickens purchased in retail markets in Lafayette, Indiana were examined by Woodburn et al. (1966 a and b). They found that the flavor score of white meat (but not of dark meat or skin) was negatively related to the total microbial numbers with 20°C incubation. Bacterial counts tended to be

lowest in the winter and higher in summer and fall. They also suggested that the more important factors influencing the quality were source of birds, volume of sales of the retail store, length of time the bird was held in the retail store, and season .

Poultry processing

Although in many countries much poultry is sold live in the market, in most industrially developed countries the birds are dressed in a commercial processing plant before being marketed. In the United States, all poultry is marketed fully dressed now. Commercial processing eliminated much of the drudgery of preparing birds for the table, but it has also introduced a number of microbiological considerations. Microorganisms that eventually cause spoilage of poultry are either present at the time of slaughter or are introduced by workers' handling and their cutting tools or by the water and air during dressing, evisceration, cutting and packaging. In a study of microoganisms associated with processed turkey, Walker and Ayres (1959) found that there was approximately a ten-fold increase in the number of organisms on the birds from the time of kill to the final product. The total numbers recovered from the skin were greater than those obtained from the visceral cavity. Higher numbers of organisms were recovered from thighs than from breasts or drumsticks of chicken fryers (Kotula,1966). Patterson (1972) found that the neck skin, the back and the part near vent sites were more heavily contaminated than the

drumsticks or underwing. Although various microorganisms can be found on live or freshly slaughtered birds, a much smaller variety is responsible for the spoilage of refrigerated poultry meat. In an early study, Ayres et al. (1950) found that immediately after killing and processing, 75 to 80% of the colonies recovered from chicken parts consisted of chromogenic bacteria, molds, yeasts, and sporeforming microorganisms. During storage, the proportion of chromogens and miscellaneous organisms decreased, and within a few days after processing the psychrotrophic flora predominated, causing off-odors and slime. Both indications of deterioration were closely associated with the growth and coalescence of colonies of several species of *Pseudomonas*. These organisms reproduce rapidly and cause a characteristic sweetly rancid "dirty dishrag" odor. Accompanying the off-odor, minute, translucent, moist colonies appear in large numbers on the cut surface and skin. At first the colonies superficially resemble droplets of moisture, but later they enlarge and become white or creamy color, finally coalescing into a more or less uniform, sticky or slimy layer and developing a pungent ammoniacal odor. At the time that birds developed off-odor and slime, the dominant flora were found to be motile, Gram-negative rods and some Gram-negative cocci or coccobacilli. *Pseudomonas* and *Achromobacter* spp. accounted for 90% or more of the total population at the time of sliming. The total load of organisms reached approximately 10^8 per sq. cm. at the time off-odor developed; 5-6 x 10^8 cells or more per sq. cm. were recovered when slime

was visible (Ayres,1966). The storage temperature of poultry also greatly influences microbial development and shelf life. According to the observation of Ayres and co-workers (1950), birds stored at 0°C have a storage life of 14 to 16 days; at 5°C, birds spoil in 6 to 7 days; and at 10°C off-odor and slime may be observed in 3 days .

Psychrophile/Psychrotroph

A psychrophile is an organism that can grow best at or around 5°C, while a psychrotroph is capable of growth at 5°C or less but has a higher optimum temperature (Jay, 1986). Psychrotrophic bacteria are gram-negative rods. *Pseudomonas, Flavobacterium, Alcaligenes,* and *Arthrobacter* are common genera. In low temperature food preservation, the genus *Pseudomonas* represents by far the most important psychrotrophic bacteria. Although psychrotrophic microorganisms are very important in the low-temperature preservation of foods like meats, poultry, fish and milk, the basic characteristics that underlie psychrotrophism are not yet well understood. Most of what is presently known about the mechanisms can be grouped into 3 categories (Jay,1986, p.580):

(1) Temperature-induced changes in the production of metabolic end products. These include: (a) A greater proportion of unsaturated fatty acid residues in the lipids of psychrotrophs when grown at lower temperatures. (b) A greater synthesis of polysaccharides than by mesophiles. (c) Production of more pigment under psychrotrophic

conditions than under mesophilic by pigment-producing microorganisms. (d) Under psychrotrophic conditions, a differential attack on certain metabolizable substrates.

(2) Temperature effects on physiologic mechanisms: (a) There is a lower metabolic rate as the temperature decreases. (b) A solute transport across the cell membrane is better maintained by psychrotrophs. (c) Psychrotrophs more often produce flagella than do mesophiles. (d) Aeration promotes the growth of psychrotrophs.

(3) There is a small upper margin between optimum and maximum growth temperature for psychrotrophic microorganisms.

Pseudomonads

Pseudomonads are short, gram negative, non-spore forming, aerobic rods which usually produce a single polar flagellum. Many psychrophilic species and strains as well as mesophiles exist in this genus. They are widely distributed in soils, water, on plants, and in the intestinal canal of man and other animals. They are the most important bacteria in the spoilage of foods such as meats, poultry, eggs, and seafoods stored chilled in air. Some strains can produce fluorescent pigments; many of those that cause food spoilage do not produce the water-soluble pigment but may fluoresce under ultraviolet light. *Pseudomonas* can use molecular hydrogen as a source of energy and most of them can oxidize glucose to gluconic acid, 2-keto-gluconic acid or other intermediates (Jay, 1986, p.23; Palleroni,1983). After identification

according to classical criteria (shape, Gram strain, motility, flagellar arrangment, oxidase, mode of attack on glucose), the *Pseudomonas* strains were divided according to the classification of Barnes and Imply (1968) into two groups: pigmented and non-pigmented. Concerning fluorescein production on King's medium B, initially, for strains isolated from chicken processing plants, pigmented pseudomonads were usually more abundant than non-pigmented. During storage, non-pigmented strains overgrew the others (Barnes and Impey, 1968; Lahellec and Colin, 1981).

A numerical taxonomic study of strains isolated from meats by Shaw and Latty (1982) identified 4 clusters. Cluster 1 strains appeared to be closely related to those in cluster 2, which included a reference strain of *Pseudomonas fragi*, and the majority of strains in both clusters were non-fluorescent. These clusters were distinguished by their pattern of carbon source utilization, in particular by the ability of most cluster 2 members to use trehalose, mesaconate, itaconate and m-tartrate which were used by very few cluster 1 strains. Many strains on meat belonged to cluster 2. Representatives of the non-fluorescent strains in clusters 1 and 2 are probably ubiquitous on refrigerated meat. The cluster 3 and 4 strains were predominantly fluorescent . The cluster 3 is quite frequently encountered on spoiled meat but cluster 4 is uncommon (Shaw and Latty, 1982).

The fluorescent pseudomonads are of particular interest because they have been considered as biological control agents against various

root diseases and in the degradation of oil spills. The fluorescent pseudomonads have also been frequently reported as contaminants in certain meat and dairy products, in the biodegradation of pesticides and chemical wastes, and in the industrial fermentation of organic acids and have been suggested as an indicator of water quality (Gould et al., 1985). The non-fluorescent pseudomonads have been implicated as the major spoilage organisms because of their growing faster at the beginning and often outnumbering the fluorescent pseudomonads at spoilage (Barnes and Impey, 1968). However, it was found that the sulfide off-odors associated with spoiled poultry were produced mainly by the fluorescent pseudomonads (Thomas and McMeekin, 1981) which produced some of the more significant volatile, sulfur-containing compounds (Prittard et al.,1982; Bowman et al.,1983). In another study the initial total aerobic counts did not correlate well with shelf life, whereas the initial numbers of fluorescent pseudomonads showed a strong negative correlation(r= -0.86)(Knabel et al., 1987).

Methodology For Studying

In adopting microbiological standards for foods, the primary concerns are those of product safety and shelf-life. It might well be that total plate counts, rather than other indicators, applied primarily to plant sanitation and practices rather than merely to the finished products would be the most suitable approach to this problem (Jay, 1986). The bacterial population on the surface of chicken is generally

considered to be a good index of its shelf life (Kotula, 1966). Because of the ease of sampling by swabing the surface, swabing is frequently used for removal of bacteria from a prescribed surface area. Aerobic microorganisms were not uniformly distributed on the skin surface of chickens but were shown to be dependent on the chicken part that was sampled. Total aerobic microorganisms were more predominant on thighs than on the breast or drumsticks of fryer chickens. There was no significant difference in counts between corresponding areas of the left and right side of the bird. The swab method can be used for comparing processing effects but not as an index of absolute counts (Kotula, 1966).

In determining the number of *Pseudomonas*, selective media are used. King's B medium was developed by King et al., as a simple pigment-enhancing medium for routine use (King et al., 1954). This is a currently accepted diagnostic medium for fluorescence even in the investigation of molecular characteristics of pseudomonads (Staskawicz et al., 1987; Fredrickson et al., 1988). Dilutions are surface plated on King's medium and all colonies included for the total count of pseudomonads, and fluorescent psudomonads are determined under ultraviolet light (King et al., 1954). A selective medium (CFC) has been developed for the rapid isolation of pseudomonads associated with the spoilage of poultry meat held under chill conditions (Mead and Adams, 1977). It was found that CFC medium was more selective than three other media (CETCH, ALCV, MGV) which have been used for isolating pseudomonads from foods. It supported the growth of a high

proportion of pseudomonads from freshly-eviscerated carcasses and processing equipment when the organisms were present in low numbers relative to other genera. CFC has proved valuable for detecting pseudomonads in other foods and is used to supplement the basic agar for pseudomonads (Mead, 1985; Brocklehurst et al., 1987).

The slime smear method is a rapid, qualititive physical method for determining spoilage of fresh poultry as described by Ziegler et al. (1954). According to their observation, there is good correlation between the slime smear method and the sensory (off-odor) method. However, spoilage was detected about one to three days earlier by the smear method.

Sensory evaluation

The Institute of Food Technologists' (IFT) Sensory Evaluation Division U.S.A. defines sensory evaluation as "a scientific discipline used to evoke, measure, analyze and interpret sensations as they are perceived by the senses of sight, taste, touch and hearing" (Anonymous, 1975). It is possible to determine some qualities of a product by instruments using many test procedures; still, there is certain desired information which cannot be measured other than by the human senses (Gatchalian and de Leon,1975; Gatchalian, 1981). This is especially true for odor and flavor sensations. Aroma, the odor of a food product, is detected when its volatiles enter the nasal passage and are perceived by the olfactory system (Meilgaard et al., 1987). Flavor, as an attribute of

foods, beverages, and seasonings, is the impression perceived via the chemical senses from a product in the mouth (Caul, 1957). Flavor and odor are very important attributes of food products which greatly determine their acceptance or rejection by consumers.

The two general categories of sensory evaluation tests are affective and analytical (Stahl and Einstein, 1973, p.608). The affective tests are to evaluate preference and/or acceptance of products; and the analytical tests evaluate differences or similarities, quality, and/or quantity of sensory characteristics of products. For analytical sensory tests, procedures have been developed in an effort to control or minimize the effect that psychological and physical conditions can have on the panelists' reactions. The procedures recommended in planning and conducting sensory evaluations are described by Kapsalis and John (1987, p.4). "(1) Statement of objective. Fundamental to the successful conduct of any sensory evaluation test is a clear understanding and statement of the objective of the study... (2) Experimental design and analysis. The experimental design selected for conducting the study and the method of analyzing the data obtained will influence the accuracy of the results... (3) Physical equipment. Since humans are being used as measuring instruments, every effort must be made to control the effect of the environment on judgment... The aim is to provide the panelists with the optimum setting for unbiased judgment. It includes: (a) testing area, (b) testing setup, and (c) lighting... (4) Samples... (a). sample preparation... (b). dilution and carriers... (c)

serving temperature... (d) containers... (e). quantity of sample... (f). coding and order of presentation... (g). rinsing... (5) Sensory methods..."

Strictly speaking, there are only two general types of sensory panels: the laboratory panel and the consumer panel (Gatchalian, 1981). The number of respondents required for reliable results in consumer panel usually exceeds 100, which is greatly larger than a laboratory panel. Large variability among responses is expected and this can be minimized only by efficient sampling methods and by increasing the number in the sample from the identified consumer population. For consumer panels, the judges are not given any training nor can tests be replicated. Identification of product characteristics or discrimination according to specified product attributes are not to be asked of consumer panels. Hence a consumer panel is mainly utilized to measure product acceptability or preference. The laboratory panel is of greater use for research and quality control. In the field of foods, it has been found most useful in product development, establishment of quality level and flavor and odor studies. Basically, this type of panel differs from the consumer panel in the number of panelists required and the nature of information to be elicited from the respondents. The laboratory panel is useful for discriminative tests and identification of specific product attributes, qualities or characteristics. From the standpoint of time saving and effort, the procedure of providing efficient panels involves two stages: first, testing of ability to make simple discrimination of differences from

two samples; second, testing of ability to produce qualitative judgments. Except for interest, desire to do well and the use of two stages in panel selection, motivation is always an important determinant of a person's value as a panel member.

"As with any laboratory instrument, the precision of results depends on the precision of the tool and the condition under which that tool is used" (Dawson et al., 1963, p.50). Among the different methods of sensory evaluation, Pangborn (1976, p.6) considers scaling as the one most frequently utilized because of "its diversity, apparent simplicity and ease of statistical analysis." Scales provide researchers with the opportunity to measure perceived intensity and to average the rating across a panel of individuals to obtain a consensus level of perceived intensity for each stimulus (Guilford, 1954). A scale can be made for a selected product attribute which could have varying degrees of intensity. Each panelist would be expected to indicate the intensity in the scale which corresponds to his/her own reaction to that particular attribute of the product. When all responses from judges are obtained, scores may be assigned to the intensity at each point in the scale, then the analysis can easily be done (Gatchalian, 1981). Interval scaling provides information about the sensory distance among stimuli. The category scale is the most widely used interval sensory scale. The most common category scale used in the food industry is the 9-point hedonic scale (Cardello and Maller, 1987). The approach requires the use of a scale which corresponds to certain descriptions of, or reactions to, a given

product attribute. This involves the development of a vocabulary describing varying intensities of a sensory stimulus or the possible reactions to a product in graduated degrees of negativity or positivity (Gatchalian, 1981). The parameters chosen should not be based on preference but rather on an objective assessment of product characteristics (Kramer, 1976) . For purposes of analysis, each defined intensity of an attribute can be assigned a numerical score.

Compared to other methods, the scaling approach appears to be easiest for the panelists. Presenting the set of answers on the scale makes evaluation an easy task even if several stimuli are being evaluated at one time. The presence of descriptive terms provides a guide to the panel. Results when analyzed can provide direct descriptive information about the product being evaluated besides the knowledge of existing differences. Considering that several attributes of the product are being judged relative to their varying intensities, results will provide the experimenter an idea of the product qualities. There are some disadvantages of the scaling method: "(a) difficulty in selecting realistic adjectives; (b) non-linearity of scores assigned, making interpretation questionable; (c) problems in obtaining a common understanding of the terms used; and (d) possible drift in meaning of selective attributes" (Gatchalian, 1981, p.189).

MATERIALS AND METHODS

Preparation of Fryers

Three Oregon and several out-of-state processors were used in each season in 1988. The birds were purchased from retail markets in Corvallis, Albany, Salem and Eugene, Oregon. Duplicate birds from each processor were purchased six times. For each purchasing day, two whole dressed chickens from each of three different processors were purchased from retail markets. Each of the four seasons, a total of seventy two birds were purchased. Birds were transported on ice in coolers and refrigerated at $3 \pm 1^{o}C$. Laboratory assessments of quality were made on the sixth day after purchase. On the day of assessment, random code numbers were assigned for each fryer.

Microbial Determinations

Total aerobic microorganisms, aerobic psychrotrophic bacteria, and pseudomonads were included in microbial tests. The sample for microbial counts was prepared by use of sterile cotton-tipped wooden swabs. Four different 3.5 square cm. areas (including thigh, breast and two cavity surfaces) delineated by sterile metal guides were swabbed for each bird.

The swabs were shaken in 99 mL sterile 0.1% peptone dilution water. Appropriate dilutions were plated on standard plate count agar (Difco Laboratories, Detroit, MI) with duplicate plates. After incubation

for three days at 20 ± 1°C, total aerobic plate counts were determined. Aerobic psychrotrophic bacteria were counted on the same agar with plates incubated for seven days at 5 ± 1°C. Pseudomonads were counted on CFC medium (Mead and Adams, 1977) with incubation for two days at 25 ± 1°C and King's medium (King et al., 1954) with incubation for three days at 20 ± 1°C. The fluorescent pseudomonads were observed under ultraviolet light. A portable 115 volt ultraviolet lamp (Long wave, UVL-22, Ultra-violet products Inc, San Gabriel, CA) was hung 1.5 feet above the table so that the plate could be examined beneath the light under conditions where outside light was excluded. The fluorescin observed on the King's B medium, developed for enchancement of fluorescin, was of a greenish yellow hue.

The presence of sliminess was determined by the method of Ziegler et al. (1954) with smear samples drawn from the portion of the pectoral feather tract beneath the wings by means of a wire loop and spread uniformly on a glass slide. These smears were fixed, stained with Gram's stain (Difco Laboratories, Detroit, MI) and examined microscopically to determine the concentration of microorganisms. The slime smears were classifed as negative when relatively few organisms were present and as positive when a large number of organisms were noted.

Sensory Evaluation

After sampling for the microbial tests was completed, the fryer

was cut into two quarters and one half. One quarter (front) was placed in a bowl to be touched by panelists and sliminess determined. Another quarter (rear) was simmered in water for one hour in a covered casserole for evaluation of the cooked aroma. The remaining half was roasted at 163 ± 1°C to an internal temperature of 80 ± 1°C. Samples of dark and white meat and skin were cut into uniform size and placed on a white plate labeled with code numbers for flavor evaluation by panel members. A 9-point scale was used in this study (a copy of each score sheet is in the appendix.). The flavor was rated on the scale from excellent to extremely poor; the aroma was rated from absent or excellent to extremely poor; the intensity of flavor and aroma were rated from very strong to none; and the sliminess was rated from extreme to none. The trained sensory panels were selected from volunteers who were staff, faculty and graduate students in the college. There were twelve females and one male. For two weeks prior to the beginning of the experiment, they were trained in evaluation of the flavor, aroma, odor and sliminess of poultry. On any sampling day, a minimum of nine members scored the samples. An average value for each sample and each attribute was calculated for analysis.

Statistical Analysis

The simple regression was used in the analyses of relationships between the scores of sensory evaluation and microbial counts. A log transformation was used for microbial counts. The equation between

two parameters from the intercept and slope showed the relationship. The significance of the relationship was determined by the P value and checked with the residual plot to ensure the accuracy. Correlation coefficients were also calculated.

The analyses of relationships between the slime smear result and raw sliminess detected by panelists and microbial counts was done by the pooled *t* test. Difference between the two methods for determining the pesudomonads, King's medium and CFC medium, was determined by the paired *t* test. The correlation was also determined. A significance level of 95% was set for all tests.

RESULTS AND DISCUSSION

Microbial determinations

Plate counts of total aerobic microorganisms, total psychrotrophic microorganisms, pseudomonads on King's medium, pseudomonads on CFC medium and fluorescent pseudomonads from swab samples of 288 fryers are compiled in Table 1 for poultry grouped by season.

At 20°C incubation, the mean of total aerobic counts of all birds was 10,000,000 per sq. cm.. The tendency appears to be for higher counts in Summer and Fall; however, the differences were not significant. The mean counts of fryers for each season were under 10^8 per sq. cm. and most of them were at or below 10^7 per sq. cm. which indicated that most of the birds would not be expected to have undesirable quality. Ayers (1950, 1966) suggested that the total aerobic load reached 10^8 per sq. cm. at the time off-odor is developing and 4-5x 10^8 per sq. cm. when slime is visible. In storage at 4.4°C, spoilage before six to eight days was infrequent (Ayres et al., 1950). But in study of microbial modifications in raw and processed meats and poultry at low temperatures, Jay and Shelef (1978) pointed out that when the organisms reached 10^7 off-odor and slime production began, which became stronger when counts increased to 4-5x 10^7. Thomson et al.(1984) also indicated that mean total aerobic plate counts of whole broiler carcasses reached 10^7 in about 8 days with the development of off-odor when stored at 5°C. In addition, a convenient guideline for microbial loads was developed by Fung et al.

Table 1. The microbial counts[1] of raw, commercially-processed fryers purchased and held refrigerated 6 days in four seasons.[2]

		Winter	Spring	Summer	Fall	Mean
Total aerobic count[3]	mean	$6.4x10^6$	$6.8x10^6$	$2.1x10^7$	$1.2x10^7$	$1.0x10^7$
	range	1.5~71000 $x10^4$	3.3~58000 $x10^4$	3.9~40000 $x10^4$	7.5~710000 $x10^3$	7.5~710000 $x10^3$
Total psychrotrophic count[4]	mean	$7.1x10^6$	$5.7x10^6$	$1.9x10^7$	$1.0x10^7$	$9.4x10^6$
	range	1.3~34000 $x10^4$	2.0~50000 $x10^4$	2.0~30000 $x10^4$	1.8~710000 $x10^3$	1.8~710000 $x10^3$
Pseudomonads						
King's B medium[5]	mean	$8.2x10^6$	$9.4x10^6$	$2.2x10^7$	$1.3x10^7$	$1.2x10^7$
	range	5.4~73000 $x10^4$	2.2~73000 $x10^4$	5.2~52000 $x10^4$	9.6~730000 $x10^3$	9.6~730000 $x10^3$
CFC medium[6]	mean	—	$5.5x10^6$	$1.5x10^7$	$8.2x10^6$	$8.8x10^6$
	range	—	1.4~71000 $x10^4$	2.2~44000 $x10^4$	7.1~5100000 $x10^2$	7.1~7100000 $x10^2$
Fluorescent pseudomonads[7]	mean	—	$3.1x10^6$	$7.1x10^6$	$2.3x10^6$	$3.7x10^6$
	range	—	7.3~7300000 $x10^2$	4.3~52000 $x10^4$	7.3~73000000 x10	7.3~73000000 x10

[1] Logarithm conversion of data was used for statistical calculations; the unit of counts is per sq. cm..
[2] Seasonal effects were not statistically significantly different ($p > .05$).
[3] Standard plate count agar at $20^oC \pm 1^oC$ incubation for 3 days.
[4] Standard plate count agar at $5^oC \pm 1^oC$ incubation for 7 days.
[5] King et al.(1954). The count was determined at $20^oC \pm 1^oC$ incubation for 3 days.
[6] Mead and Adams(1977). The count was determined at $25^oC \pm 1^oC$ incubation for 2 days.
[7] King's medium at $20^oC \pm 1^oC$ incubation for 3 days. The fluorescent pseudomonads were counted under UV light.

(1980) as follows: log 0-2 CFU/cm^2 on meat surface is low; log 3-4 CFU/cm^2 is intermediate; log 5-6 CFU/cm^2 is high and 7 CFU/cm^2 is very high. Counts above log 7.5 CFU/cm^2 will result in foods developing off-odor and slime.

At 5°C incubation on standard plate count agar for 7 days, the mean of total psychrotrophic count of all birds was 9,400,000 per sq. cm.. As for the total aerobic count, there was a tendency toward higher counts in Summer and Fall, but no significant differences. The psychrotrophic count was 94% of the total aerobic count which indicated that the predominant microorganisms multiplying under refrigeration storage conditions on the processed fryers were psychrotrophic. This phenomenon has been noted in the earlier studies by many researchers (Ayres et al., 1950; Barnes and Impey, 1968; Mead and Adams, 1977; Bremner, 1977; Jay, 1986).

The mean counts were 12,000,000 per sq. cm. on King's medium and 8,800,000 on CFC medium. In most carcasses, counts were comparable with or lower on CFC than counts on King's medium. The pseudomonads on King's medium showed significantly ($p < .05$) higher count than on CFC medium in every season, but they was a high correlation ($r > .96$) between counts on the two media. Pseudomonads were the majority of the organisms on the poultry carcasses. Walker and Ayres (1956) reported that the predominant organisms present at the time poultry developed off-odor and sliminess were *Pseudomonas* which grew well at 4.4°C and outgrew the other organisms less favored

by this temperature. In the current study, CFC medium was more selective than King's medium. The King's B medium is widely used by many laboratories in counting pseudomonads in diagnostic work. In a comparison of pigment production on several media, just those few strains which did not produce fluorescin were negative on King's B. Of the 107 strains tested, 93% were positive which was higher than on the other media compared (King et al., 1954). However, some organisms of the enteric group and some Alcaligenes-like organisms were also frequently observed on King's medium. CFC was not only effective in suppressing the growth of Gram-positive organisms but also inhibiting other Gram-negative bacteria while supporting good growth of all the pseudomonads in pure culture study (Mead and Adams, 1977). In a study of identification of bacteria isolated from poultry carcasses, they found a higher percent of the isolates on CFC than on other media to be pseudomonads. Hence, these authors concluded the CFC may be applicable to food products in which the presence of pseudomonads is significant.

In the present study, the mean count of fluorescent pseudomonads on the King's medium was 3,700,000 per sq. cm.. Fluorescent colonies were 31% of the total pseudomonads. This agreed with the finding of Barnes and Impey (1968) and Thomas and McMeekin (1984) who reported the predominant organism on whole carcasses to be non-pigmented pseudomonads. Barnes and Impey (1968) characterized pseudomonads on poultry undergoing spoilage and

found that the pigmented pseudomonads(Shewan's group I) decreased from 34 to 16% from initial storage to the development of strong off-odors, while the nonpigmented actually increased from 11 to 58%. Thomas and coworkers (1984) also found that Shewan's group II pseudomonads grow faster than the group I strains and concluded that strong odor-producing capacity is a property of these strains. On the contrary, Lahellec et al. (1975) found that 61.8% were fluorescent on King's medium. They found in a study of processing that the *Pseudomonas* strains which produced pigment on King's medium B were more abundant than non-pigmented strains by a ratio of about 2 to 1. In a recent report by Knabel et al.(1987), the predominant organisms were nonfluorescent pseudomonads preceding day 7; by the end of day 9, however, the fluorescent pseudomonads predominated, and both fluorescence on the surface of the chicken and definite off-odors were detected.

The results of the slime smear are in Table 2. The total number of birds positive was 158 and negative, 90, the ratio of positive to negative was near 2 to 1. The positive /negative ratio increased from Winter to Fall. The number of birds detected to have slime in Summer and Fall were higher than other seasons. From the results of the slime smear test, it seems the birds were of poorer quality in Summer and Fall.

Table 2. The result of slime smear test on raw, commercial-processed fryers purchased and held refrigerated 6 days in four seasons[1].

	Positive[2]		Negative[3]		
	No.	%	No.	%	Ratio
Full year	158	64	90	36	1.76
Winter	37	60	25	40	1.48
Spring	44	61	28	39	1.57
Summer	52	72	20	28	2.60
Fall	55	77	17	23	3.24

[1] Ziegler et al. (1954). Drawn smears were stained with Gram's stain and examined microscopically.
[2] Positive: a large number of organisms were present.
[3] Negative: relatively few organisms were present.

Palatability determination

After the fryers had been purchased as "fresh" birds in retail markets and stored at 3°C in a refrigerator for 6 days, there were some fryers too poor in quality to be served: 9, 9, 5, and 10 birds in Winter, Spring, Summer and Fall, respectively (Table 3).

Table 3. Number of fryers served in four seasons from those purchased.

	Winter	Spring	Summer	Fall	Total
Total purchased fryers	72	72	72	72	288
No. of fryers not served because of spoilage	9	9	5	10	33
No. of fryers served	63	63	67	62	255

The sensory evaluation scores by panelists in the four seasons and the mean for the year are presented in Table 4. The percent of birds scored as above or below "fair" or "moderate" are compiled in Table 5.

For the 255 birds included in the panel test, there were no significant effects of season on flavors. The mean scores of flavor of white and dark meat and skin were all "below good-above fair", scored as 3.9, 3.8 and 4.1, respectively (Table 5). The skin had a slightly poorer score than the meat but was not significantly different. Most of the samples received scores between excellent and fair (below 6 on scale) on all flavor attributes. Less than 3% received average scores below fair (equal or higher than 6 in scale) for flavor of skin, white and dark meat of cooked product. Although testing by other workers indicated skin samples had the shortest shelf life and spoilage odors developed first on this tissue; in the current study, it appeared to be no different from white

Table 4. The evaluation of flavor and aroma of cooked fryers and aroma and sliminess of raw fryers by sensory panelists (n=9-12) in four seasons[7].

	Winter[6]	Spring[6]	Summer[6]	Fall[6]	Full[6] year
Flavor score[1]					
White meat	3.9	3.8	4.0	3.6	3.8
Dark meat	3.9	3.9	3.9	3.7	3.8
Skin	4.2	4.1	4.3	3.9	4.1
Flavor intensity[2]					
White meat	5.1	5.1	4.9	4.6	4.9
Dark meat	4.9	4.9	4.6	4.4	4.7
Skin	4.5	4.8	4.3	3.9	4.3
Aroma score[3]					
Raw meat	3.9	3.9	4.6	4.1	4.1
Simmered meat	4.2	4.1	4.3	4.2	4.2
Aroma intensity[4]					
Raw meat	6.3	6.2	5.5	5.3	5.8
Simmered meat	4.6	4.6	4.4	4.0	4.4
Raw Sliminess[5]	5.8	5.9	5.6	5.9	5.8

[1] From excellent (1) to extremely poor (9).
[2] From very strong (1) to absent (9).
[3] From absent or excellent (1) to extremely poor (9).
[4] From very strong (1) to absent (9).
[5] From extreme (1) to none (9).
[6] Mean of scores from n birds: Winter, n=63; Spring, n=63, SFL and SI, n=62; Summer, n=67, SFL and SI, n=65: Fall, n=62: The full year, n=255, SFL and SI, n=252.
[7] Season effects were not statistically significant different ($p<.05$).

Table 5. The percent of fryers evaluated by sensory panel for the year and in each of seasons.

Sensory score	period	WFL	WI	DFL	DI	SFL	SI	RA	RI	RS	SA	SII[1]
≥6[2]	full year	2	2	2	1	5	0	30	138	122	20	3
%	full year	1	1	1	0	2	0	12	54	48	8	1
<6[2]	full year	253	253	253	254	247	252	225	117	133	235	252
%	full year	99	99	99	100	98	100	88	46	52	92	99
≥6[2]	Winter	0	1	0	1	2	0	6	45	26	3	2
%	Winter	0	2	0	2	3	0	10	71	41	5	3
<6[2]	Winter	63	62	63	62	61	63	57	18	37	60	61
%	Winter	100	98	100	98	97	100	90	29	59	95	97
≥6[2]	Spring	0	1	1	0	2	0	5	42	34	6	0
%	Spring	0	2	2	0	3	0	8	67	54	10	0
<6[2]	Spring	63	62	62	63	60	62	58	21	29	57	63
%	Spring	100	98	98	100	97	100	92	33	46	91	100
≥6[2]	Summer	2	0	1	0	2	0	12	25	31	6	0
%	Summer	3	0	2	0	3	0	18	37	46	9	0
<6[2]	Summer	65	67	66	67	63	65	55	42	36	61	67
%	Summer	97	100	98	100	97	100	82	63	54	91	100
≥6[2]	Fall	0	0	0	0	1	0	7	26	31	5	1
%	Fall	0	0	0	0	2	0	11	42	50	8	2
<6[2]	Fall	62	62	62	62	61	62	55	36	31	57	61
%	Fall	100	100	100	100	98	100	89	58	50	92	98

[1] WFL: white meat flavor; WI: white meat intensity; DFL: dark meat flavor; DI: dark meat intensity; SFL: skin flavor; SI: skin intensity; RA: raw aroma; RI: raw intensity; RS: raw slimeness; SA: simmered aroma; SII: simmered intensity.

[2] Flavor score: ≥ 6—below fair, < 6—fair or above.
Aroma score: ≥ 6—below fair, <6—fair or above.
Intensity score: ≥ 6—below moderate, < 6—moderate or above.
Slimimess: ≥ 6—less than moderate, < 6—moderate or more than moderate.

and dark meat. Essary and Howes (1960) and May et al. (1962) indicated spoilage odors may often develop first on skin, and Walker and Ayres' study (1956) showed muscle samples had the longest shelf life, with a mean of 14.9 days at 4°C; skin was the first tissue to spoil, with a mean of 11.7 days.

The mean aroma scores over the year of both raw and simmered meat were " below good-above fair", 4.1 and 4.2, respectively. Most birds received scores between absent or excellent and fair which was comparable to flavor scores. A slightly higher percent for simmered aroma, 8%, than for flavor received scores below fair (above or equal to 6 in scale); for aroma of raw meat, 12% had scores below fair. There were no statistical significant differences between four seasons. An earlier study found carcasses stored at 3°C had strong off odors by about 9 days of storage (Thomson et al., 1984).

In all four seasons, the intensity of flavor of skin was slightly stronger than white and dark meat. There was a trend of flavor intensity being higher in Summer and Fall than in Winter and Spring; however, there were no significant differences in seasons. Scores between very strong and moderate in intensity of raw meat were received by 46% of birds. In Summer and Fall, the intensity of raw meat was stronger than Winter and Spring, more than 50% received the scores above moderate. The intensity of cooked meat flavor did not show strong correlation with the flavor of cooked meat (Table 6). However, the intensity of raw meat aroma was negatively correlated (r= -0.88) with the

Table 6. The relationships between flavor and flavor intensity of white and dark meat and skin for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Intensity(Y)[2]	FLavor(X)[3]	equation	P value[4]	r[5]	Relationship
Full year	WI[6]	WFL[6]	Y=4.57+0.0942X	.06	0.12	not significant
Winter	WI	WFL	Y=3.17+0.5102X	.00	0.51	sig. but weak[7]
Spring	WI	WFL	Y=4.72+0.1048X	.30	0.13	not significant
Summer	WI	WFL	Y=5.23-0.0929X	.15	-0.18	not significant
Fall	WI	WFL	Y=5.12-0.1491X	.08	-0.22	not significant
Full year	DI[6]	DFL[6]	Y=4.46+0.0628X	.21	0.07	not significant
Winter	DI	DFL	Y=4.72+0.0511X	.67	0.05	not significant
Spring	DI	DFL	Y=4.90-0.0133X	.84	-0.03	not significant
Summer	DI	DFL	Y=4.73-0.0342X	.70	-0.05	not significant
Fall	DI	DFL	Y=5.11-0.1882X	.09	-0.22	not significant
Full year	SI[6]	SFL[6]	Y=4.42-0.0199X	.71	-0.02	not significant
Winter	SI	SFL	Y=4.19+0.0799X	.45	0.10	not significant
Spring	SI	SFL	Y=3.23+0.3890X	.00	0.51	sig. but weak[7]
Summer	SI	SFL	Y=2.25+0.4826X	.00	0.55	sig. but weak[7]
Fall	SI	SFL	Y=4.89-0.2422X	.01	-0.32	not significant

[1] Simple regression analysis.
[2] Intensity score was from very strong (1), moderate (5), to absent (9).
[3] Flavor score was from excellent (1), fair (5), to extremely poor (9).
[4] P value was checked by residual plot.
[5] r is correlation coefficient.
[6] WI: white meat intensity; WFL: white meat flavor; DI: dark meat intensity; DFL: dark meat flavor; SI: skin intensity; SFL: Skin flavor.
[7] The relationships were significant, but the correlations were weak. Significant relationship means the poorer the flavor was judged to be, the stronger intensity it had.

aroma of raw meat (Table 7); the poorer the aroma, the stronger the intensity of the aroma. The intensity of simmered meat in three seasons had a significant weak correlation with the aroma of simmered meat (r= -0.40) for year.

One essential feature of poultry spoilage is sliminess on the outer surfaces of the carcass (Jay, 1986). The mean scores for sliminess of raw meat in every season were between moderate and slight to moderate; one-half of the birds were below " slight to moderate" (table 4 and 5).

Relationships between microbial and palatablility factors

Relationships between microbial counts and flavor of cooked meat are shown in Tables 8, 9, 10, 11, 12. Microbial counts from surfaces, including total aerobic count, total psychrotrophic count, pseudomonads and fluorescent pseudomonads, had very weak positive correlations with flavor of white and dark meat and skin. From the analyses in the current study, the dark meat flavor always was less related to microbial counts than the white meat and skin. This was different from the results of an earlier study of flavor of fryers by Woodburn and coworkers (1966) in which the 20°C count had a higher correlation with white and dark meat than with skin.

The aroma of raw and simmered meat had positive correlations with microbial counts, too (Table 13, 14, 15, 16, 17). The correlations in these analyses were higher than for meat flavor and microbial counts ,

Table 7. The relationships between aroma and aroma intensity of raw and simmered meat for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Intensity(Y)[2]	Aroma(X)[3]	Y=a+bX	P value[4]	r[5]	Relationship
Full year	RI[6]	RA[6]	Y=8.96-0.7619X	.00	-0.88	significant[7]
Winter	RI	RA	Y=9.30-0.7723X	.00	-0.89	significant[7]
Spring	RI	RA	Y=9.03-0.7171X	.00	-0.89	significant[7]
Summer	RI	RA	Y=8.87-0.7448X	.00	-0.95	significant[7]
Fall	RI	RA	Y=8.49-0.7730X	.00	-0.93	significant[7]
Full year	SII[6]	SA[6]	Y=5.37-0.2304X	.00	-0.40	sig. but weak[7]
Winter	SII	SA	Y=5.86-0.2937X	.00	-0.43	sig. but weak[7]
Spring	SII	SA	Y=4.95-0.0916X	.13	-0.20	not significant
Summer	SII	SA	Y=5.54-0.2684X	.00	-0.58	sig. but weak[7]
Fall	SII	SA	Y=5.43-0.3401X	.00	-0.65	sig. but weak[7]

[1] Simple regression analysis.
[2] Intensity score was from very strong (1), moderate (5), to absent (9).
[3] Aroma score was from excellent or absent (1), fair (5), to extremely poor (9).
[4] P value was checked by residual plot.
[5] r is correlation coefficient.
[6] RI: raw meat intensity; RA: raw meat aroma; SII: simmered meat intensity; SA: simmered meat aroma.
[7] The realationships were significant, but the correlations were weak. Significant means that the poorer the aroma was judged to be, the stronger intensity it had.

Table 8. The relationships between the meat flavor and total psychrotrophic count for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Flavor(Y)[2]	Psychrotroph[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	WFL[6]	TPMC[6]	Y=2.75+0.1309X	.00	0.25	sig. but weak[7]
Winter	WFL	TPMC	Y=3.23+0.0722X	.23	0.16	not significant
Spring	WFL	TPMC	Y=3.88-0.0056X	.93	-0.32	not significant
Summer	WFL	TPMC	Y=1.47+0.3006X	.00	0.39	sig. but weak[7]
Fall	WFL	TPMC	Y=2.09+0.1753X	.00	0.38	sig. but weak[7]
Full year	DFL[6]	TPMC	Y=3.18+0.0810X	.01	0.16	sig. but weak[7]
Winter	DFL	TPMC	Y=3.27+0.0798X	.21	0.17	not significant
Spring	DFL	TPMC	Y=3.94-0.0017X	.98	-0.03	not significant
Summer	DFL	TPMC	Y=2.02+0.2207X	.02	0.29	sig. but weak[7]
Fall	DFL	TPMC	Y=2.68+0.1272X	.00	0.36	sig. but weak[7]
Full year	SFL[6]	TPMC	Y=2.64+0.1777X	.00	0.29	sig. but weak[7]
Winter	SFL	TPMC	Y=2.85+0.1726X	.06	0.25	not significant
Spring	SFL	TPMC	Y=3.09+0.1250X	.29	0.14	not significant
Summer	SFL	TPMC	Y=0.48+0.4564X	.00	0.41	sig. but weak[7]
Fall	SFL	TPMC	Y=2.29+0.2016X	.00	0.46	sig. but weak[7]

[1] Simple regression analysis.
[2] Flavor score was from excellent (1), moderate (5), to extremely poor (9).
[3] Standard plate count agar at 5°C±1°C incubation for 7 days. Logarithm of data was used for statistical calculation. The unit of counts is per sq. cm..
[4] P value was checked by residual plot.
[5] r is correlation coefficient.
[6] WFL: white meat flavor; DFL: dark meat flavor; SFL: skin flavor; TPMC: total psychrotrophic microorganisms count.
[7] The relationships were significant but the correlation were weak. Significant means the higher the psychrotrophic count, the poorer the flavor.

Table 9. The relationships between the meat flavor and total microbial count for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Flavor(Y)[2]	Total microbial[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	WFL[6]	TAMC[6]	Y=2.78+0.1257X	.00	0.24	sig. but weak[7]
Winter	WFL	TAMC	Y=3.24+0.0709X	.24	0.16	not significant
Spring	WFL	TAMC	Y=3.86-0.0067X	.92	-0.01	not significant
Summer	WFL	TAMC	Y=1.86+0.2513X	.01	0.31	sig. but weak[7]
Fall	WFL	TAMC	Y=2.02+0.1951X	.00	0.40	sig. but weak[7]
Full year	DFL[6]	TAMC	Y=3.23+0.0736X	.03	0.14	sig. but weak[7]
Winter	DFL	TAMC	Y=3.33+0.0718X	.26	0.15	not significant
Spring	DFL	TAMC	Y=4.04-0.0141X	.87	-0.02	not significant
Summer	DFL	TAMC	Y=2.21+0.1967X	.04	0.25	sig. but weak[7]
Fall	DFL	TAMC	Y=2.54+0.1429X	.00	0.38	sig. but weak[7]
Full year	SFL[6]	TAMC	Y=2.66+0.1736X	.00	0.27	sig. but weak[7]
Winter	SFL	TAMC	Y=2.91+0.1638X	.07	0.24	not significant
Spring	SFL	TAMC	Y=3.00+0.1353X	.27	0.14	not significant
Summer	SFL	TAMC	Y=0.57+0.4416X	.00	0.38	sig. but weak[7]
Fall	SFL	TAMC	Y=2.13+0.2208X	.00	0.48	sig. but weak[7]

1 Simple regression analysis.
2 Flavor score was from excellent (1), moderate (5), to extremely poor (9).
3 Standard plate count agar at 20°C±1°C incubation for 3 days. Logarithm of data was used for statistical calculation. The unit of counts is per sq. am..
4 P value was checked by residual plot.
5 r is correlation coefficient.
6 WFL: white meat flavor; DFL: dark meat flavor; SFL: skin flavor; TAMC: total aerobic microorganisms count.
7 The relationships were significant but the correlation were weak. Significant means the higher the total aerobic count, the poorer the flavor.

Table 10. The relationships between the meat flavor and pseudomonade count (on King'e B medium) for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Flavor(Y)[2]	Pseudomonads[3] count(X)	Equation	P value[4]	r[5]	Relationehip
Full year	WFL[6]	PK[6]	Y=2.83+0.1187X	.00	0.23	sig. but weak[7]
Winter	WFL	PK	Y=3.52+0.0354X	.56	0.08	not significant
Spring	WFL	PK	Y=4.14-0.0376X	.55	-0.08	not significant
Summer	WFL	PK	Y=1.52+0.2933X	.00	0.38	sig. but weak[7]
Fall	WFL	PK	Y=2.15+0.1775X	.00	0.37	sig. but weak[7]
Full year	DFL[6]	PK	Y=3.13+0.0862X	.01	0.17	eig. but weak[7]
Winter	DFL	PK	Y=3.12+0.0971X	.13	0.20	not significant
Spring	DFL	PK	Y=4.11-0.0229X	.77	-0.04	not significant
Summer	DFL	PK	Y=2.07+0.2137X	.01	0.30	sig. but weak[7]
Fall	DFL	PK	Y=2.57+0.1381X	.00	0.38	sig. but weak[7]
Full year	SFL[6]	PK	Y=2.71+0.1667X	.00	0.26	sig. but weak[7]
Winter	SFL	PK	Y=3.18+0.1297X	.16	0.19	not eignificant
Spring	SFL	PK	Y=2.79+0.1598X	.16	0.18	not significant
Summer	SFL	PK	Y=0.75+0.4226X	.00	0.40	sig. but weak[7]
Fall	SFL	PK	Y=2.24+0.2057X	.00	0.45	sig. but weak[7]

1 Simple regression analysie.
2 Flavor score was from excellent (1), moderate (5), to extremely poor (9).
3 King et el.(1954). King'e B medium at 20°C±1°C incubation for 3 daye. Logarithm of data was used for etatistical calculation. The unit of counts ie per sq. am..
4 P value was checked by residual plot.
5 r is correlation coefficient.
6 WFL: white meat flavor; DFL: dark meat flavor; SFL: ekin flavor; PK: pseudomonads count on King'e B medium.
7 The relationships were eignificant but the correlation were weak. Significant meane the higher the pseudomonads count, the poorer the flavor.

Table 11. The relationships between the meat flavor and pseudomonads count (on CFC medium) for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Flavor(Y)[2]	Pseudomonads[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	WFL[6]	PCFC[6]	Y=2.52+0.1579X	.00	0.31	sig. but weak[7]
Spring	WFL	PCFC	Y=3.82-0.0029X	.96	0.01	not significant
Summer	WFL	PCFC	Y=1.37+0.3178X	.00	0.44	sig. but weak[7]
Fall	WFL	PCFC	Y=2.29+0.1635X	.00	0.38	sig. but weak[7]
Full year	DFL[6]	PCFC	Y=3.04+0.0934X	.01	0.19	sig. but weak[7]
Spring	DFL	PCFC	Y=3.98-0.0069X	.93	-0.01	not significant
Summer	DFL	PCFC	Y=1.91+0.2378X	.01	0.34	sig. but weak[7]
Fall	DFL	PCFC	Y=2.69+0.1263X	.00	0.38	sig. but weak[7]
Full year	SFL[6]	PCFC	Y=2.48+0.1907X	.00	0.32	sig. but weak[7]
Spring	SFL	PCFC	Y=2.75+0.1707X	.14	0.19	not significant
Summer	SFL	PCFC	Y=0.53+0.4565X	.00	0.43	sig. but weak[7]
Fall	SFL	PCFC	Y=2.41+0.1882X	.00	0.46	sig. but weak[7]

1 Simple regression analysis.
2 Flavor score was from excellent (1), moderate (5), to extremely poor (9).
3 Mead and Adams (1977). CFC medium at 25°C±1°C incubation for 2 days. Logarithm of data was used for etatistical calculation. The unit of counts is per sq. am..
4 P value was checked by residual plot.
5 r is correlation coefficient.
6 WFL: white meat flavor; DFL: dark meat flavor; SFL: skin flavor; PCFC: pseudomonade count on CFC medium.
7 The relationahipe were significant but the correlations were weak. Significant means the higher the pseudomonads count , the poorer the flavor.

Table 12. The relationships between the meat flavor and fluorescent pseudomonads count for commercially-processed fryers purchased and held refrigerated 6 daye in four seasons[1].

Season	Flavor(Y)[2]	Fluor.pseu.[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	WFL[6]	FP[6]	Y=2.63+0.1519X	.00	0.32	sig. but weak[7]
Spring	WFL	FP	Y=3.35+0.0599X	.29	0.14	not significant
Summer	WFL	FP	Y=2.00+0.2520X	.00	0.40	sig. but weak[7]
Fall	WFL	FP	Y=2.50+0.1485X	.00	0.36	sig. but weak[7]
Full year	DFL[6]	FP	Y=3.12+0.0889X	.01	0.19	sig. but weak[7]
Spring	DFL	FP	Y=3.73+0.0208X	.78	0.03	not significant
Summer	DFL	FP	Y=2.44+0.1805X	.02	0.29	sig. but weak[7]
Fall	DFL	FP	Y=2.80+0.1213X	.00	0.38	sig. but weak[7]
Full year	SFL[6]	FP	Y=2.65+0.1797X	.00	0.33	sig. but weak[7]
Spring	SFL	FP	Y=2.45+0.2133X	.05	0.26	not significant
Summer	SFL	FP	Y=1.14+0.3995X	.00	0.43	sig. but weak[7]
Fall	SFL	FP	Y=2.60+0.1770X	.00	0.45	sig. but weak[7]

1 Simple regression analysis.
2 Flavor score was from excellent (1), moderate (5), to extremely poor (9).
3 King et al.(1954). King's B medium at 20°C±1°C incubation for 3 days. Logarithm of data was used for statistical calculation. Ths unit of counts ie psr sq. am..
4 P valus was checked by residual plot.
5 r is correlation coefficient.
6 WFL: white meat flavor; DFL: dark meat flavor; SFL: skin flavor; FP: fluorsscent pseudomonads count .
7 The rslationships wers significant but the corrslations were weak. Significant meane the higher the fluorescent pseudomonads count, the poorer the flavor.

Table 13. The relationships between the meat aroma and total psychrotrophic count for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Aroma(Y)[2]	Psychrotroph[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	RA[6]	TPMC[6]	Y=1.53+0.7070X	.00	0.64	sig. but weak[7]
Winter	RA	TPMC	Y=1.11+0.6383X	.00	0.61	sig. but weak[7]
Spring	RA	TPMC	Y=2.36+0.8144X	.00	0.68	sig. but weak[7]
Summer	RA	TPMC	Y=4.50+1.0846X	.00	0.72	sig. but weak[7]
Fall	RA	TPMC	Y=0.04+0.5196X	.00	0.59	sig. but weak[7]
Full year	SA[6]	TPMC	Y=1.49+0.3385X	.00	0.38	sig. but weak[7]
Winter	SA	TPMC	Y=0.27+0.5065X	.00	0.59	sig. but weak[7]
Spring	SA	TPMC	Y=1.15+0.3889X	.00	0.38	sig. but weak[7]
Summer	SA	TPMC	Y=0.22+0.4821X	.00	0.40	sig. but weak[7]
Fall	SA	TPMC	Y=2.19+0.2543X	.01	0.33	sig. but weak[7]

[1] Simple regression analysis.
[2] Aroma score was from absent or excellent (1), fair (5), to extremely poor (9).
[3] Standard plate count agar at 5°C±1°C incubation for 7 days. Logarithm of data was used for statistical calculation. The unit of counts is per sq. am..
[4] P value was checked by residual plot.
[5] r is correlation coefficient.
[6] RA: raw meat aroma; SA: simmered aroma; TPMC: total psychrotrophic microorganisms count.
[7] The relationahips were significant but the correlations were weak. Significant means the higher the psychrotrohic count , the poorer the aroma.

Table 14. The relationships between the meat aroma and total microbial count for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Aroma(Y)[2]	Total microbial[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	RA[6]	TAMC[6]	Y=-1.84+0.7397X	.00	0.65	sig. but weak[7]
Winter	RA	TAMC	Y=-1.11+0.6363X	.00	0.61	sig. but weak[7]
Spring	RA	TAMC	Y=-2.91+0.8763X	.00	0.70	sig. but weak[7]
Summer	RA	TAMC	Y=-5.21+1.1589X	.00	0.73	sig. but weak[7]
Fall	RA	TAMC	Y=-0.26+0.5419X	.00	0.59	sig. but weak[7]
Full year	SA[6]	TAMC	Y=1.36+0.3512X	.00	0.38	sig. but weak[7]
Winter	SA	TAMC	Y=0.25+0.5075X	.00	0.59	sig. but weak[7]
Spring	SA	TAMC	Y=0.95+0.4113X	.00	0.39	sig. but weak[7]
Summer	SA	TAMC	Y=0.14+0.4875X	.00	0.38	sig. but weak[7]
Fall	SA	TAMC	Y=1.99+0.2767X	.01	0.35	sig. but weak[7]

1 Simple regression analysis.
2 Aroma score was from absent or excellent (1), fair (5), to extremely poor (9).
3 Standard plate count agar at 20°C±1°C incubation for 3 days. Logarithm of data was used for statistical calculation. The unit of counts is per sq. am..
4 P value was checked by residual plot.
5 r is correlation coefficient.
6 RA: raw aroma; SA: simmered aroma; TAMC: total aerobic microorganisms count.
7 The relationships were significant but the correlation were weak. Significant means the higher the total aerobic count, the poorer the aroma it had.

Table 15. The relationships between the meat aroma and pseudomonads count (on King's B medium) for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Aroma(Y)[2]	Pseudomonads[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	RA[6]	PK[6]	Y=-1.39+0.6800X	.00	0.61	sig. but weak[7]
Winter	RA	PK	Y=-0.79+0.5949X	.00	0.54	sig. but weak[7]
Spring	RA	PK	Y=-1.68+0.7052X	.00	0.60	sig. but weak[7]
Summer	RA	PK	Y=-4.45+1.0749X	.00	0.74	sig. but weak[7]
Fall	RA	PK	Y=-0.03+0.5112X	.00	0.56	sig. but weak[7]
Full year	SA[6]	PK	Y=1.50+0.3326X	.00	0.37	sig. but weak[7]
Winter	SA	PK	Y=0.49+0.4763X	.00	0.54	sig. but weak[7]
Spring	SA	PK	Y=1.45+0.3403X	.01	0.34	sig. but weak[7]
Summer	SA	PK	Y=0.11+0.5197X	.00	0.45	sig. but weak[7]
Fall	SA	PK	Y=2.16+0.2553X	.01	0.32	sig. but weak[7]

1 Simple regression analysis.
2 Aroma score was from absent or excellent (1), fair (5), to extremely poor (9).
3 King et al.(1954). King's B medium at 20°C±1°C incubation for 3 days. Logarithm of data was used for statistical calculation. The unit of counts is per sq. am..
4 P value was checked by residual plot.
5 r is correlation coefficient.
6 RA: raw meat aroma; SA: simmered aroma; PK: pseudomonads count on King's B medium.
7 The relationahips were significant but the correlation were weak. Significatn means the higher the pseudomonads count , the poorer the aroma.

Table 16. The relationships between the meat aroma and pseudomonads count (on CFC medium) for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Aroma(Y)[2]	Pseudomonads[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	RA[6]	PCFC[6]	Y=-1.25+0.6796X	.00	0.64	sig. but weak[7]
Spring	RA	PCFC	Y=-2.30+0.8103X	.00	0.69	sig. but weak[7]
Summer	RA	PCFC	Y=-4.26+1.0711X	.00	0.75	sig. but weak[7]
Fall	RA	PCFC	Y=0.42+0.4632X	.00	0.56	sig. but weak[7]
Full year	SA[6]	PCFC	Y=1.64+0.3172X	.00	0.36	sig. but weak[7]
Spring	SA	PCFC	Y=1.01+0.4095X	.00	0.41	sig. but weak[7]
Summer	SA	PCFC	Y=-0.21+0.5415X	.00	0.48	sig. but weak[7]
Fall	SA	PCFC	Y=2.33+0.2375X	.01	0.33	sig. but weak[7]

[1] Simple regression analysis.
[2] Aroma score was from absent or excellent (1), fair (5), to extremely poor (9).
[3] Mead and Adams (1977). CFC medium at 25°C±1°C incubation for 2 days. Logarithm of data was used for statistical calculation. The unit of counts is per sq. am..
[4] P value was checked by residual plot.
[5] r is correlation coefficient.
[6] RA: raw meat aroma; SA: simmered aroma; PCFC: pseudomonads count on CFC medium.
[7] The relationahips were significant but the correlations were weak. Significant means the higher the pseudomonads count, the poorer the aroma.

Table 17. The relationships between the meat aroma and fluorescent pseudomonads count[1] for commercially-processed fryers purchased and held refrigerated 6 days in four seasons1.

Season	Aroma(Y)[2]	Fluor.pseu.[3] count(X)	Equation	P value[4]	r[5]	Relationship
Full year	RA[6]	FP[6]	Y=-0.46+0.6141X	.00	0.63	sig. but weak[7]
Spring	RA	FP	Y=-0.91+0.6483X	.00	0.64	sig. but weak[7]
Summer	RA	FP	Y=-2.84+0.9400X	.00	0.74	sig. but weak[7]
Fall	RA	FP	Y=0.85+0.4431X	.00	0.56	sig. but weak[7]
Full year	SA[6]	FP	Y=2.14+0.2690X	.00	0.33	sig. but weak[7]
Spring	SA	FP	Y=1.46+0.3594X	.00	0.40	sig. but weak[7]
Summer	SA	FP	Y=0.76+0.4429X	.00	0.44	sig. but weak[7]
Fall	SA	FP	Y=2.64+0.2148X	.01	0.31	sig. but weak[7]

1 Simple regression analysis.
2 Aroma score was from absent or excellent (1), fair(5), to extremely poor (9).
3 King et al.(1954). King's B medium at 20°C±1°C incubation for 3 days. Logarithm of data was used for statistical calculation. The unit of counts is per sq. am..
4 P value was checked by residual plot.
5 r is correlation coefficient.
6 RA: raw aroma; SA: simmered aroma; FP: fluorescent pseudomonads count .
7 The relationships were significat but the correlation were weak. Significant means the higher the fluorescent pseudomonads count, the poorer the aroma.

although the correlation coefficients were still low. The raw aroma and microbial counts had greater correlations than simmered aroma, but there were no differences for the different microbial counts. The meat flavor was positively related to raw and simmered aroma (Table 18, 19). The poorer the aroma, the poorer the flavor of meat and skin.

Overall, the microbial counts were all negatively related to the flavor and aroma qualities. The more microorganisms, the poorer the flavor and aroma of poultry. Knabel et al. (1987) suggested that initial total aerobic counts did not correlate well with shelf life, whereas the initial numbers of fluorescent pseudomonads showed a strong negative correlation (r=-0.86) with shelf life. In the current study, most of the total aerobic count was accounted for by psychrotrophs, i.e. pseudomonads.

Raw sliminess detected by panelists had a relationship with microbial count ($p< 0.05$)(Table 20). The higher the microbial counts, the more sliminess was detected by the panelists; however, the correlations between them were all weak ($r<0.50$). The pseudomonads on the CFC medium seemed to have a higher correlation than other microbial counts. The narrow range of microbial counts may be the reason for the weak correlations in analyses of sliminess and microbial counts as well as other relationships. Raw sliminess and cooked meat flavor were negatively correlated; as the more sliminess, the poorer the flavor (Table 21). The slime smear method had a positive relationship ($p< .05$) to the raw sliminess score by panelists, total aerobic organism count, total

Table18. The relationships between the meat flavor and raw aroma for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Flavor(Y)[2]	Aroma(X)[3]	Equation	P value[4]	r[5]	Relationship
Full year	WFL[6]	RA[6]	Y=3.06+0.1784X	.00	0.38	sig. but weak[7]
Winter	WFL	RA	Y=3.69+0.0271X	.00	0.06	not significant
Spring	WFL	RA	Y=3.33+0.1299X	.01	0.31	sig. but weak[7]
Summer	WFL	RA	Y=2.83+0.2539X	.00	0.50	sig. but weak[7]
Fall	WFL	RA	Y=2.36+0.2988X	.00	0.57	sig. but weak[7]
Full year	DFL[6]	RA[6]	Y=3.26+0.1388X	.00	0.31	sig. but weak[7]
Winter	DFL	RA	Y=3.48+0.1086X	.07	0.24	not significant
Spring	DFL	RA	Y=3.63+0.0769X	.25	0.15	not significant
Summer	DFL	RA	Y=2.72+0.2505X	.00	0.51	sig. but weak[7]
Fall	DFL	RA	Y=2.80+0.2166X	.00	0.44	sig. but weak[7]
Full year	SFL[6]	RA[6]	Y=3.15+0.2192X	.00	0.39	sig. but weak[7]
Winter	SFL	RA	Y=3.28+0.2363X	.01	0.37	sig. but weak[7]
Spring	SFL	RA	Y=3.11+0.2413X	.01	0.31	sig. but weak[7]
Summer	SFL	RA	Y=2.23+0.45145X	.00	0.61	sig. but weak[7]
Fall	SFL	RA	Y=3.05+0.2063X	.00	0.41	sig. but weak[7]

[1] Simple regression analysis.
[2] Flavor score was from excellent (1), moderate (5), to extremely poor (9).
[3] Raw aroma score was from absent or excellent (1), fair (5), to extremely poor (9).
[4] P value was checked by residual plot.
[5] r is correlation coefficient.
[6] WFL: white meat flavor; DFL: dark meat flavor; SFL: skin flavor; RA: raw aroma.
[7] The relationships were significant but the correlation were weak. Significant means the poorer the aroma was judged to be, the poorer the flavor.

Table 19. The relationships between the meat flavor and simmered aroma for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Flavor(Y)[2]	Aroma(X)[3]	Equation	P value[4]	r[5]	Relationship
Full year	WFL[6]	SA[6]	Y=2.91+0.2097X	.00	0.36	sig. but weak[7]
Winter	WFL	SA	Y=3.56+0.0543X	.44	0.11	not significant
Spring	WFL	SA	Y=3.15+0.1656X	.01	0.34	sig. but weak[7]
Summer	WFL	SA	Y=2.71+0.1996X	.00	0.47	sig. but weak[7]
Fall	WFL	SA	Y=2.28+0.3085X	.00	0.51	sig. but weak[7]
Full year	DFL[6]	SA[6]	Y=2.97+0.2042X	.00	0.36	sig. but weak[7]
Winter	DFL	SA	Y=3.25+0.1531X	.04	0.28	sig. but weak[7]
Spring	DFL	SA	Y=3.14+0.1890X	.01	0.31	sig. but weak[7]
Summer	DFL	SA	Y=2.59+0.2999X	.00	0.48	sig. but weak[7]
Fall	DFL	SA	Y=2.65+0.2457X	.00	0.53	sig. but weak[7]
Full year	SFL[6]	SA[6]	Y=2.82+0.2951X	.00	0.42	sig. but weak[7]
Winter	SFL	SA	Y=2.90+0.3065X	.00	0.38	sig. but weak[7]
Spring	SFL	SA	Y=2.14+0.4627X	.00	0.51	sig. but weak[7]
Summer	SFL	SA	Y=2.01+0.5360X	.00	0.58	sig. but weak[7]
Fall	SFL	SA	Y=2.87+0.2419X	.00	0.42	sig. but weak[7]

[1] Simple regression analysis.
[2] Flavor score was from excellent (1), moderate (5), to extremely poor (9).
[3] Simmered aroma score was from absent or excellent (1), fair (5), to extremely poor (9).
[4] P value was checked by residual plot.
[5] r is correlation coefficient.
[6] WFL: white meat flavor; DFL: dark meat flavor; SFL: skin flavor; SA: simmered aroma.
[7] The relationships were significant but the correlation were weak. Significant means the poorer the aroma was judged to be, the poorer the flavor.

Table 20. Relationships between the raw sliminess and microbial counts for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Sliminess(Y)[2]	Microbial count(X)	equation	P value[3]	r[5]	Relationship
RS[4]	TPMC[4]	Y=8.30-0.3103X	.00	-0.43	sig. but weak[6]
RS	TPAC[4]	Y=8.42-0.3230X	.00	-0.43	sig. but weak[6]
RS	PK[4]	Y=8.19-0.2917X	.00	-0.40	sig. but weak[6]
RS	PCFC[4]	Y=8.53-0.3373X	.00	-0.48	sig. but weak[6]
RS	F.P.[4]	Y=8.03-0.2905X	.00	-0.45	sig. but weak[6]

1 Simple regression analysis.
2 Raw sliminess score was from extreme (1), moderate (5), to none (9).
3 P value was checked by residual plot.
4 RS: raw sliminess; TPMC: total psychrotrophic microbial count; TAMC: total aerobic microbial count; PK: pseudomonads on King's medium; PCFC: pseudomonads on CFC medium; F.P.: fluorescent pseudomonads.
5 r is correlation coefficient.
6 The relationships were significant but the correlations were weak. Significant means the higher the microbial count, the greater the raw sliminess was judged to be by the panelists.

Table 21. The relationships between meat flavor and raw eliminess detected by panele for commercially-processed fryers purchased and held refrigerated 6 days in four seasons[1].

Season	Flavor(Y)[2]	Sliminess(X)[3]	Equation	P value[4]	r[5]	Relationehip
Full year	WFL[6]	RS[6]	Y=5.41-0.2786X	.00	-0.39	sig. but weak[7]
Winter	WFL	RS	Y=4.70-0.1550X	.06	-0.25	not significant
Spring	WFL	RS	Y=5.44-0.2688X	.00	-0.44	sig. but weak[7]
Summer	WFL	RS	Y=6.49-0.4448X	.00	-0.49	sig. but weak[7]
Fall	WFL	RS	Y=5.37-0.3055X	.00	-0.44	sig. but weak[7]
Full year	DFL[6]	RS[6]	Y=4.76-0.1615X	.00	-0.23	sig. but weak[7]
Winter	DFL	RS	Y=4.22-0.0551X	.54	-0.08	not significant
Spring	DFL	RS	Y=4.55-0.1051X	.28	-0.14	not significant
Summer	DFL	RS	Y=6.16-0.4078X	.00	-0.46	sig. but weak[7]
Fall	DFL	RS	Y=4.98-0.2211X	.00	-0.41	sig. but weak[7]
Full year	SFL[6]	RS[6]	Y=5.57-0.2603X	.00	-0.38	sig. but weak[7]
Winter	SFL	RS	Y=5.45-0.2143X	.09	-0.23	not significant
Spring	SFL	RS	Y=5.98-0.3237X	.02	-0.30	sig. but weak[7]
Summer	SFL	RS	Y=8.07-0.6715X	.00	-0.51	sig. but weak[7]
Fall	SFL	RS	Y=5.49-0.2726X	.00	-0.41	sig. but weak[7]

[1] Simple regression analysis.
[2] Flavor score was from excellent (1), moderate (5), to extremely poor (9).
[3] Raw sliminess score was from extreme (1), moderate (5), to none (9).
[4] P value was checked by residual plot.
[5] r ie correlation coefficient.
[6] WFL: white meat flavor; DFL: dark meat flavor; SFL: ekin flavor; RS: raw eliminess.
[7] The relationehips were significant but the correlations were weak. Significant means the greater the eliminess, the poorer the flavor.

aerobic psychrotroph count, pseudomonads and fluorescent pseudomonads (Table 22). Those birds that were positive in the slime smear test indeed had higher total aerobic counts, total psychrotrophic counts, pseudomonads and fluorescent counts and more sliminess in panel tests. Other researchers found that, regardless of the storage temperature, off-odor and slime did not appear until the numbers of organisms reached certain levels; at 10^7 there was weak activity to produce off-odor and slime which became stronger at 4-5 x 10^7 (Ayres et al., 1950; Jay and Shelef, 1978). From our analyses, the slime smear test was a rapid and acceptable method to estimate the microbial condition of birds. Although it cannot exactly determine the number of microorganisms, it can be the first step to screen the birds as acceptable or not.

The surfaces of fresh poultry stored in an environment of high humidity are very susceptible to the growth of aerobic bacteria such as pseudomonads. Vacuum packaging and CO_2-atmosphere storage are effective in delaying the spoilage of poultry (Thomas et al., 1984). In this method, a specific atmosphere environment is provided with CO_2 being most frequently used. CO_2 is effective in depressing the growth of psychrotrophs, including pseudomonads (Addis, 1986).

It is believed that the "general poultry flavor" is contributed by the protein fraction of meat and "species flavor" was from the lipid fraction (Addis, 1986). Adamcic et al. (1970) indicated that the pigmented

Table 22. Relationships between slime smear test and raw sliminess judged by panelists and microbial counts[1].

Slime smear	positive mean[2]	positive var.[3]	positive n	negative mean[2]	negative var.[3]	negative n	P value	Relationship
RS[4]	5.60	0.865	158	6.20	0.405	90	.00	Positive[5]
TPMC[4]	8.58	0.533	158	6.85	1.173	90	.00	Positive[6]
TAMC[4]	8.31	0.543	158	6.97	1.092	90	.00	Positive[6]
PK[4]	8.64	0.604	158	7.04	1.213	90	.00	Positive[6]
PCFC[4]	8.57	2.667	127	6.69	1.284	65	.00	Positive[6]
F.P.[4]	8.08	1.178	126	6.39	1.588	61	.00	Positive[6]

[1] Pooled *t* test. A randomized experimental design was used.

[2] Mean=$\Sigma x/n$.

[3] Var.(sample mean)=$\Sigma(x_i-x)^2/n-1$.

[4] RS: raw sliminess; TPMC: total psychrotrophic microbial count; TAMC: total aerobic microbial count; PK: pseudomonads on King's medium; PCFC: pseudomonads on CFC medium; F.P.: fluorescent pseudomonads.

[5] Positive of RS means those that were positive on the slime smear test had greater sliminess detected by panels than those that were negative.

[6] Positive of TPMC, TAMC, PK, PCFC, F.P. means those that were positive on the slime smear test had higher counts than those that were negative.

pseudomonads are the most proteolytic of the common types of psychrotolerant spoilage bacteria causing deterioration of poultry at refrigeration temperature. Some researchers have concluded that volatile sulfides, mainly produced by fluorescent pseudomonads, are the main cause of off-odor associated with spoiled poultry (Thomas and McMeekin, 1984; Bowman et al., 1983). However, the understanding of meat flavor is still far from complete.

Future study

Future research needs include: inhibition of growth of pseudomonads, further investigation of the potential of controlled atmosphere packaging and identification of compounds which produce off-odor and off-flavor.

The growth of pseudomonads is the main cause of spoilage of poultry. They are introduced by water, air, equipment, people and other birds during processing. From killing, scalding, evisceration, chilling, grading, to cut-up, all offer an opportunity for the pseudomonads to contaminate the birds. Research is needed to identify the best method for every step in the poultry processing plant to decrease the incidence of pseudomonads and extend the shelf life. Selected chemical or physical treatments may be ways to decrease the number of pseudomonads on the carcasses. Reseach efforts may identify some species of bacteria which can be surface-added to enhance the good flavor of poultry and inhibit the growth of pseudomonads on the

carcasses. It may be possible through genetic engeneering to develop a strain of *Pseudomonas* which will compete well at 3°C but not produce the compounds identified with spoilage.

Controlled atmosphere storage (CAS) has been used for poultry since about 1978 (Addis, 1986). Some researchers found that CAS can eliminate ice and water spillage and increase payload about 5% for chicken. CAS can double the shelf life as compared to the ice pack. However, it is currently more expensive. Continued studies on CAS are needed. A new method, vacuum skin package (VSP), was used in meat products (Salett and Labell, 1988). It follows the close contours of each meat cut, which virtually eliminates the oxygen in the final packages and maximizes product shelf life.

Flavor is the product of the volatile constituents which act, either independently or in combination, to produce a highly characteristic aroma of the foodstuff plus taste. The analysis of flavor includes isolation, separation and identification of components. Studies can be conducted to increase the stability and intensity of the general and specific flavor of poultry meat using chemical or physical modifications.

The goal of the higher quality of poultry products is one where research has a potential impact on poultry technology. We can expect future advances in extending shelf life and promoting flavor quality.

SUMMARY

Raw, commercial fryers from several Oregon and out-of-state processors were purchased over a one year period from retail markets in four cities in Oregon and analyzed microbially and for sensory characteristics. From both the microbial numbers and palatability factors, most of the fryers stored at 3°C for six days after purchase from the retail markets had desirable qualities. There were no significant effects of season on microbial counts or sensory scores. However, there was a trend to higher counts of total aerobic organisms, total psychrotrophic organisms and pseudomonads on King's medium in Summer and Fall seasons.

The flavor of cooked meat and skin did not have a significant relationship to the intensity. However, the aroma of raw and simmered meat had a significant ($p < 0.05$) relationship with intensity of the aroma. The quality of the aroma of raw meat had a high correlation ($r=-0.88$) with the intensity. Relationships between microbial counts and flavor of cooked meat and skin and aroma of raw and simmered meat were all significant, but the correlation coefficients were weak. Counts on CFC medium and King's medium were highly correlated ($r > 0.96$), although King's medium had a significantly ($p < 0.05$) higher pseudomonads count. CFC was more selective for pseudomonads than King's medium in the current study. The slime smear test had a significant ($r < 0.05$) relationship to the sliminess score by the panelists and to microbial

counts. It was a rapid test to screen the birds as acceptable or not.

Further research is need on: Inhibition of growth of pseudomonads, further investigation of the potential of controlled atmosphere packaging and identification of compounds which produce off-odor and off-flavor.

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APPENDIX

Name:_____
Date: _____
Product:_____

A. 1. Sensory evaluation of raw chicken meat.
Please evaluate each sample for aroma, intensity of aroma and sliminess.

	Aroma[1]		Intensity[2]		Sliminess[3]
Code	_ _ _ _ _ _		_ _ _ _ _ _		_ _ _ _ _ _
Absent or excellent	_ _ _ _ _ _	Very strong	_ _ _ _ _ _	Extreme	_ _ _ _ _ _
Present and very good	_ _ _ _ _ _	Below very strong-above strong	_ _ _ _ _ _	Large to extreme	_ _ _ _ _ _
Good	_ _ _ _ _ _	Strong	_ _ _ _ _ _	Large	_ _ _ _ _ _
Below good-above fair	_ _ _ _ _ _	Below strong-above moderate	_ _ _ _ _ _	Moderate to large	_ _ _ _ _ _
Fair	_ _ _ _ _ _	Moderate	_ _ _ _ _ _	Moderate	_ _ _ _ _ _
Below fair-above fair	_ _ _ _ _ _	Below moderate-above slight	_ _ _ _ _ _	Slight to moderate	_ _ _ _ _ _
Poor	_ _ _ _ _ _	Slight	_ _ _ _ _ _	Slight	_ _ _ _ _ _
Very poor	_ _ _ _ _ _	Below slight-above absent	_ _ _ _ _ _	Just detectable	_ _ _ _ _ _
Extremely poor	_ _ _ _ _ _	Absent	_ _ _ _ _ _	None	_ _ _ _ _ _

1 Coded as abxent or excellent-1, fair-5, extremely poor-9.
2 Coded as very strong-1, moderate-5, absent-9.
3 Coded as extreme-1, moderate-5, none-9.

Name:_____
Date: _____
Product:_____

A. 2. Sensory evaluation of simmered chicken meat
Please evaluate each sample for aroma and intensity of aroma.

	Aroma[1]		Intensity[2]
Code	_____		_____
Absent or excellent	_____	Very strong	_____
Present and very good	_____	Below very strong-above strong	_____
Good	_____	Strong	_____
Below good-above fair	_____	Below strong-above moderate	_____
Fair	_____	Moderate	_____
Below fair-above fair	_____	Below moderate-above slight	_____
Poor	_____	Slight	_____
Very poor	_____	Below slight-above absent	_____
Extremely poor	_____	Absent	_____

[1] Coded as abxent or excellent-1, fair-5, extremely poor-9.
[2] Coded as very strong-1, moderate-5, absent-9.

Name:_____
Date: _____
Product:_____

A. 3. Sensory evaluation of cooked chicken meat and skin.
Please evaluate each sample for flavor and intensity of flavor.

	Flavor[1]		Intensity[2]
Code	_____		_____
excellent	_____	Very strong	_____
Present and very good	_____	Below very strong-above strong	_____
Good	_____	Strong	_____
Below good-above fair	_____	Below strong-above moderate	_____
Fair	_____	Moderate	_____
Below fair-above fair	_____	Below moderate-above slight	_____
Poor	_____	Slight	_____
Very poor	_____	Below slight-above absent	_____
Extremely poor	_____	Absent	_____

[1] Coded as abxent or excellent-1, fair-5, extremely poor-9.
[2] Coded as very strong-1, moderate-5, absent-9.