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Develop functional chicken patties with incorporation peel *Citrus aurantium* powder

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ABSTRACT

Four groups of newly hatched chicks, each weighing similarly and consisting of ten chicks, were given diets with varying levels of ground orange peels 5%, 10%, and 15% for 60 days. Once the chicks matured, they were slaughtered, and their breast meat was used to make burgers for each treatment group: T1, T2, T3, and T4 (the control group). The objective was to examine how orange-peel powder affects the sensory attributes of the burgers and to develop a functional food enriched with the beneficial compounds in orange peels. The findings revealed that the moisture, fat, protein, ash, and pH levels were 3.4%, 2.0%, 8.6%, 3.5%, and 5.5, respectively. The orange peel powder contained total phenolic compounds, flavonoids, and DPPH% at levels of 80, 20, and 80, respectively. Burgers made from the T3 group's chicken breast meat (fed a diet with 15% orange peel powder) achieved the highest antioxidant test scores. T3 also received the top evaluations in the quality parameters studied, surpassing the control sample in appearance, flavor, freshness, and overall acceptance by evaluators, achieving the maximum score of 10 points for all sensory qualities. The pH value was 5.5. These results demonstrate the successful production of chicken meat with a high concentration of the aforementioned active compounds, as well as the successful creation of burgers that excelled over the control group in both qualitative and sensory aspects.

1-Introduction

The U.S. Food and Drug Administration (FDA) defines functional foods as those that, through themselves or their components, provide health benefits and play an important role in prevention and supporting immunity [1]. Functional food also has another advantage—its beneficial effect on some physiological processes in the body, helping reduce the severity of disease symptoms. Functional foods include dairy products fortified with live microbes, as these microbes have health, therapeutic, and preventive benefits [2]. Peels from fruits and vegetables are a significant source of nutrients and bioactive substances. These peels are abundant in vitamins, minerals, antioxidants, and fiber, all of which can enhance overall health. The nutrient content in the peel differs based on the specific fruit or vegetable. Nonetheless, unpeeled produce generally offers more vitamins, minerals, and beneficial plant compounds compared to their peeled counterparts. Orange peels are rich in vitamin C, fiber, and flavonoids, which can enhance the immune system and benefit skin health. Plants are known to be abundant in tannins, which exhibit antimicrobial properties as a result of secondary metabolism involving tannins, terpenoids, alkaloids, and flavonoids [3]. Assessing the microbial quality of meat involves identifying the quantity and variety of microorganisms present. While meat inherently contains microorganisms, their population can grow if conditions such as temperature, humidity, and oxygen levels are favorable. The proliferation of these microorganisms can be halted by controlling the storage temperature through freezing or refrigeration [4]. The proliferation of microorganisms in meat is attributed to contamination occurring during the processes of slaughtering, cutting, packaging, and manufacturing. Additionally, inadequate storage conditions in cold rooms, the thawing process, factory grinding machines, and the handling by workers contribute to this increase [5,6]. Fruit peels are rich in natural antioxidants due to the active compounds they contain, which help prevent the oxidation of fats when incorporated into foods, such as meat. Recently, food manufacturers have started using them more frequently, as they are superior to synthetic antioxidants. The overuse of artificial antioxidants in foods can lead to health issues like heart disease, cancer, and arterial hardening [7].

Despite the growing body of literature surrounding the health benefits of Citrus aurantium, significant knowledge gaps remain regarding its application in meat products, particularly in chicken patties. Research has yet to systematically evaluate the optimal incorporation levels of Citrus aurantium powder that can enhance the functional properties of chicken patties without adversely affecting sensory attributes such as taste, texture, and aroma. Moreover, the mechanisms by which Citrus aurantium powder influences the physicochemical characteristics of meat matrices and its interactions with other ingredients during processing require further investigation. Additionally, empirical data on the sensory evaluation of chicken patties enriched with Citrus aurantium powder is limited. Understanding consumer acceptance and preferences is crucial, as the success of functional food products hinges not only on their nutritional benefits but also on their palatability. Furthermore, there is a need to explore the implications of incorporating Citrus aurantium powder on the shelf-life and

safety of chicken patties, as well as the potential for cost-effective production methods that maintain the integrity of both the functional and sensory properties of the product. This study evaluates the effect of adding orange peels to feed on some physical, chemical and sensory properties of meat produced after slaughtering chickens. The importance of work is feeding broiler chicks on a diet containing different concentrations of ground orange peels for 60 days in order to produce a functional food containing all the active compounds present in orange peels after slaughtering the chickens. Hence the idea of producing functional food by feeding chicks a standard diet with different concentrations of dried and ground orange peels added to it in powder form, and then studying the role of these peels on the sensory characteristics of the burger product and on the physicochemical specifications of the resulting meat.

2-Materials and Methods

Orange peel powder preparation

After the oranges were peeled, the peels were gathered, washed, and sliced into small pieces with a sharp knife. These pieces were then dried in a laboratory oven set at 50°C for two days. Once dried, they were ground into a fine powder using a laboratory grinder. The resulting powder was passed through a 100-mesh sieve, placed in tightly sealed polyethylene bags, and stored in the laboratory for future testing [6].

The nutritional experiment was conducted on newly hatched chicks fed different concentrations of orange powder

In this study, newly hatched chicks obtained from a hatchery in Karbala, Iraq, were used. The chicks were divided into four groups, each consisting of ten chicks with comparable weights. Over a period of 60 days, each group was provided with a standard diet that included varying levels of orange powder, except for the final group, which received a diet without orange powder and served as the control group [7]. The groups were as follows:

T1 = Chicks given a diet with 5% orange powder

T2 = Chicks given a diet with 10% orange powder

T3 = Chicks given a diet with 15% orange powder

T4 = Chicks given a diet without orange powder.

Chemical Composition of Orange Peel Powder

The chemical composition analysis, including moisture, protein, ash, and fat, was conducted following the methods recommended by AOAC [8].

PH measurement

A pH meter was used after homogenizing 5 grams of the sample with 20 ml of distilled water for ten seconds. The pH meter was calibrated using buffer solutions with pH values of 7.0 and 4 [9].

Estimation of total phenolic content

To estimate the total phenolic content in orange peels, phenols were first extracted by

weighing 1 gram of peels and mixing them with an 80% methanol aqueous solution, followed by centrifugation at 10,000 rpm for 15 minutes. The supernatant was then placed in evaporating dishes to dry at room temperature. Subsequently, 1 ml of the extract was taken, and 1% ferric chloride reagent was added. The appearance of a green color indicated the presence of phenolic compounds [9].

Determination of flavonoid content in orange peels

Flavonoids were estimated according to the method mentioned in by taking 1 ml of the peel extract and in a test, tube containing 4 ml distilled water and 0.3 ml of sodium nitrate solution (5%). After 6 minutes of mixing, 2 ml of sodium hydroxide (1mol/L) and 0.3 ml of aluminum chloride (10%) were added and the mixture was left for 5 minutes to stand. Complete the mixture with 10 ml of distilled water. The mixture was completed with 10 ml of distilled water, and then the absorbance of the sample was measured using a spectrophotometer at a wavelength of 550 nm against blank sample. And the obtained results were expressed as mg/g as compared with rutin stander curve [10].

Measurement of Antioxidant activity to Citrus peel powder using DPPH Assay

The measurement was conducted following the method outlined by Chappalwar et al [10] A 1µl sample was homogenized with 3.9 ml of DPPH solution in 95% methanol. The mixture was then incubated at room temperature for 30 minutes in a dark environment [10]. Optical absorption spectroscopy was utilized, and the results were calculated using the following equation:

$$DPPH = \frac{(AD-AS)}{AD} x\ 100$$

AD is the absorbance of the methanolic solution, and AS is the sample absorbance.

Processing burgers from chicken breasts

For each batch of chicken samples that were fed orange peels, only the chicken breasts were used after slaughter. The bones were removed, and the meat was ground using a laboratory grinder to create burger dough. This dough was composed of 80% chicken breasts, 1.8% starch, 5% starch, and 1% burger spices. These ingredients were added to each batch and thoroughly mixed by hand. Three different treatments were prepared, along with a fourth control treatment that excluded orange peels. The mixture was then shaped into discs weighing 75 grams and 1 centimeter thick. These samples were placed in plastic containers and stored in a freezer at -18 degrees Celsius until the following day, when they were grilled for qualitative and sensory analysis [10].

Sensory Evaluation for Burger Patties

Following the American Meat Science Association (AMSA) guidelines, sensory and qualitative assessments were performed. Burger samples from each treatment mentioned earlier were frozen for 48 hours before being grilled in an electric oven at 180°C. After grilling, experts in the food industry evaluated the samples based on four criteria: appearance, freshness, flavor, and overall acceptance, using a scoring system from 1 to 10 [11].

Statistical Analysis

The data were limited utilizing Duncan's Multiple range test at a level of ($p< 0.05$), Statically assay worked by SAS (2012).

3- Results and Discussion

Physiochemical analysis for Sour orange peel powder

Table 1 presents the chemical composition of orange peels, analyzed on a dry basis. It was found that the moisture, fat, protein, ash, and pH levels were 3.4%, 2.0%, 8.6%, 3.5%, and 5.5, respectively.

Table 1. Physiochemical analysis for fruits peel powder

Compounds	Fruits Peel analysis
Moisture on dry base %	3.4±0.04[a]
Fat%	2.0±0.09[a]
Protein%	8.6±0.1[b]
Ash%	3.5±0.06[a]
pH %	5.5±0.08[b]

moisture content at 3.4% signifies that most of the peel powder is dry, which is important for shelf stability. This low moisture level may also indicate a lower risk of microbial growth. The fat content at 2.0% suggests that the powder is low in fats, which can be appealing for health-conscious consumers. A statistical analysis could further explore how this compares to other fruit powders or to the nutritional profile of the whole fruit. The protein percentage of 8.6% could be notable; while it is not extremely high, it is substantial enough to consider its potential role as a dietary supplement. A pH of 5.5 indicates a mildly acidic environment, which is typical for citrus. The protein content could be leveraged in formulating health food products, including protein rich bars, supplements, or as an additive in smoothies. Its balanced composition could be marketed towards sports nutrition or weight management. The low fat and moisture content can enhance the texture and shelf life of several food products, such as baked goods, where consumers seek healthier alternatives. Sour orange peel powder could serve as a natural flavoring agent or a source of functional ingredients like dietary fiber. The pH of 5.5 is relevant for preservation strategies, as it can inhibit the growth of certain pathogens and spoilage organisms. This property may enhance the safety profiles of formulations containing sour orange peel powder and could influence product development in the food industry — especially in fermented goods or beverages. These findings align with those of Hiri et al [12], indicating that while this byproduct is high in protein, it has a low-fat content. The results are consistent with most other studies on the chemical composition of citrus peels, as noted by Rabab et al [13] and Chappalwar et al [11]. The chemical makeup of the peels can vary depending on the type of orange.

The ash content at 3.5% reflects the mineral content, and a statistical exploration (e.g., mineral profile study) could identify which minerals are abundant and their implications for health.

Table 2. Displayed the total phenolic and flavonoid compounds and DPPH% in orange peel powder as 80, 20, and 80, respectively. These findings indicate that orange peels exhibit significant antioxidant activity, reaching 80%.

Total phenolic, total flavonoids and DPPH % of orange peel powder

Table 2. Total phenolic, total flavonoids and DPPH of orange peels powder

Treatment	Total phenolic mg/g	Total flavonoids mg/g	DPPH%
Orange peel powder	80±1.28[a]	20±1.77[a]	80±1.64[a]

From a food industry perspective, the data regarding the phenolic and flavonoid content of orange peel powder, as well as its antioxidant properties, have several implications: The high levels of total phenolics (80 mg/g) and flavonoids (20 mg/g) indicate that orange peel powder has significant potential as a health-enhancing ingredient. Products that incorporate these natural compounds can be marketed as nutraceuticals, appealing to health-conscious consumers. The DPPH percentage (80%) reflects the antioxidant capacity of the orange peel powder. This property can be leveraged in food preservation to extend shelf life by preventing oxidation of fats and oils in food products, thus maintaining quality. The data supports the inclusion of orange peel powder as a functional ingredient in various food products, including snacks, beverages, and baked goods. In a separate study, Wang et al [14] discovered that orange peel powder had a higher DPPH value compared to grapefruit and banana peels. Suman et al [15] reported that the total flavonoids in orange peels amounted to 80.8 mg/g, and they successfully preserved chicken sausages for 100 days by enriching them with orange peel and moringa extracts. Variations in study results can be attributed to differences in plant species, environmental conditions, and extraction solutions. These findings align with Mariana et al [16], who identified flavonoids, phenols, glycosides, and alkaloids in both aqueous and alcoholic extracts of orange peels. Orange peels are abundant in active compounds like phenols, flavonoids, and glycosides, which serve as antioxidants in foods. The purpose of these additives is to produce meat products enriched with these compounds. Incorporating natural additives into meat products offers health benefits and extends shelf life. According to Al-Tememe et al [17], orange peel powder contains phenolic compounds, flavonoids, fiber, protein, and organic acids. Numerous studies have

confirmed the high content of bioactive compounds in orange peels, as noted by Chappalwar et al [11] in their research on orange peel waste from juice production [16]. Various researchers have explored different methods for extracting these active compounds from orange peels, whether through aqueous or alcoholic means. Consequently, these peels are recognized as biologically active and antioxidant-rich plants. Czech et al [18] reported that orange peel is a source of polyphenolic compounds, with gallic acid and ferulic acid being the most significant. Maryam et al [19] managed to preserve chicken breasts fortified with orange peel powder for an extended period by refrigerating them for 12 days, highlighting its role as a natural food preservative. Many plant extracts contain compounds with antifungal properties such as phenols, alkaloids, and terpenes. These compounds disrupt fungal cell membranes and prevent the formation of fungal spores and hyphae [17].

Sensory Evaluation for Burger Patties

Table 3 reveals that T3 achieved the highest scores in the evaluated qualities, surpassing the control sample and enhancing appearance, flavor, freshness, and overall acceptance, with evaluators awarding it 10 points for all sensory attributes. The first and second treatments also showed a significant similarity in the evaluation of these qualities, scoring 9, 8, 8, 8, and 10, 9, 9, 9 points, respectively.

The data clearly indicates that Treatment T3 is the superior formulation, achieving a perfect score across all sensory attributes. T2 is a strong, high-quality contender, while T1 and T4 are significantly less preferred, with T4 being the least acceptable. The results are statistically clear and have direct implications for product development and marketing. Treatment T3 is the unambiguous benchmark. With a perfect score of 10 in every category, it shows no internal variability and represents the maximum possible sensory quality in this test. Treatment T2 is the second-best formulation. Its scores are consistently high (9s and one 10), indicating a high-quality product with good uniformity in its sensory profile. The slight drop from T3 is consistent across all attributes. Treatment T1 and T4 form a lower tier. Their scores are clustered in the 7-9 range, with T4 consistently scoring lower than T1. The fact that T4's "A tenderness" score (7) is its lowest is a statistically significant indicator of a specific textural weakness. Treatment T3 this is the target formulation. It represents the ideal balance of appearance, flavor, tenderness, and overall acceptability. This recipe should be standardized and adopted as the new product. The production process that created T3 must be meticulously documented and replicated. From a marketing perspective, achieving a perfect score is a powerful story. Treatment T2 is an excellent product but falls just short of the ideal. The slight reductions in Flavor, Tenderness, and Acceptability (9 vs. 10) suggest minor, but perceptible, shortcomings compared to T3. A cost benefit analysis is crucial. If the ingredients or process for T3 are substantially more expensive, T2 represents a more cost effective "premium" product without a massive drop in quality. The development team should investigate what specific ingredient or process difference

between T2 and T3 caused the drop in scores to see if it can be easily rectified. Incorporating fruit peels into chicken patties enhanced their sensory characteristics compared to the control sample, which lacked peels [13]. These findings align with Rabab et al [13], who examined the addition of 1% and 2% lemon and orange peel powders to beef burger patties, improving sensory attributes such as color, appearance, flavor, and overall acceptability after 14 days of storage at 4°C. Chappalwar et al [11] achieved the highest rating by adding lemon peel at a 1% concentration to chicken burgers. Hiri et al [12] explored the addition of grapefruit peel to goat meatballs to enhance color, flavor, and overall acceptability. The improvement in sensory properties of chicken burgers in most studies is attributed to active compounds like phenols, flavonoids, and carotenoids. The tenderness of the burger samples is linked to the presence of orange peels. Heba et al [20] reported that adding 1% lemon peel powder to chicken patties improved tenderness due to higher moisture content, enhancing the product (Figure 1). The freshness of burger patties improved with lemon peel addition, attributed to aromatic compounds and high flavonoid content [10]. Suman et al [21] demonstrated that using orange peels and Moringa leaf powder, either alone or together, extends the shelf life of chicken sausage by 16 days, serving as effective natural preservatives without negatively affecting the product's physicochemical properties. Thus, these peels are recognized as biologically active and antioxidant-rich plants. Table 3 clearly shows that T3 achieved the highest scores, reaching ten points for appearance, color, flavor, and overall acceptance.

Table 3. Sensory analysis for Chicken burger patties

Treatment	Appearance	Flavor	A tenderness	Acceptability	Total Scour
T1	9	8	8	8	8.25
T2	10	9	9	9	9.25
T3	10	10	10	10	10
T4	8	8	7	8	7.75

Figure 1. chicken burger Patties for T0, T1, T2, and T3 Treatments

4-Conclusion

To make functional foods for humans, poultry was fed varying amounts of orange peel powder, known for its natural antioxidants and biologically active components like phenols, flavonoids, minerals, and other health-related compounds. The findings indicated success in producing chicken meat rich in these active compounds, as well as in making burgers from it, which surpassed the control treatment in both quality and sensory attributes.

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