

**UTILIZATION OF CITRUS FRUIT WASTE FOR  
DEVELOPMENT OF CHICKEN MEAT ROLL**

**BY  
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[2008AS205M]**

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**COLLEGE OF ANIMAL SCIENCES  
CHAUDHARY CHARAN SINGH HARYANA AGRICULTURAL  
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## **CERTIFICATE-I**

This is to certify that the thesis entitled “**Utilization of citrus fruit waste for development of chicken meat roll**”, submitted for the degree of Master of Veterinary Science in the subject of Livestock Products Technology to the Chaudhary Charan Singh Haryana Agricultural University, Hisar is a bonafied research work carried out by **Mahender Singh**, Admission No. **2008AS205M** under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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**CERTIFICATE - II**

This is to certify that the thesis entitled “**Utilization of citrus fruit waste for development of chicken meat rollö**”, submitted by **Mahender Singh**, Admission No. **2008AS205M** to the Chaudhary Charan Singh Haryana Agricultural University, Hisar, in partial fulfillment of the requirement for the degree of master of veterinary science in the subject of livestock products technology has been approved by the studentø advisory committee after an oral examination of the same.

**HEAD OF THE DEPARTMENT**

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Place: Hisar

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Date:

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Meat is very good source of high quantity and quality of proteins and is known for its satiating characteristics. It is also an excellent source of minerals and vitamins (Chan, 2004; Biesalski, 2005). Some of these nutrients (iron, vitamin B<sub>12</sub>, folic acid) are not present or have inferior bioavailability in other foods (Arihara, 2006). Unfortunately, due to high amount of saturated fatty acids and cholesterol, its reputation has somewhat diminished as these are associated with health problems like cardiovascular diseases, some types of cancer, obesity etc. (Fernandez-Gines *et al.*, 2005). Diet having meat is rich in energy and deficient in dietary fibre. Epidemiological studies have demonstrated a relationship between energy rich diet and chronic diseases (Best, 1991; Kaferstein and Clugston, 1995).

With increasing consumer awareness about relationship between diet and health, emphasis now- a- days is on development of functional foods. There are many strategies for development of functional meat products. Incorporation of functional ingredients during processing of meat is one of them (Jimenez-Colmenero *et al.*, 2001). Such ingredients include vegetable proteins, fibres, antioxidants, probiotics and prebiotics (Arihara, 2006). Dietary fibre has the potential of reducing risk of chronic heart diseases, colorectal cancer, diabetes etc. (Pins *et al.*, 2001; Jenkins *et al.*, 2002; Bingham *et al.*, 2003). Dietary fibres are also useful for their functional and technological properties in utilization of agricultural byproducts (Thebaudin *et al.*, 1997). Fibre increases cooking yield due to water binding properties and improves texture (Cofrades *et al.*, 2000). Dietary fibre from oats, wheat, soybeans, apples, pear and citrus fruits has been used in formulation of meat products (Fernandez-Gines *et al.*, 2005; Jimenez-Colmenero *et al.*, 2006).

Citrus (orange, lemon, grape fruit etc.) is an important fruit which has a prominent place among popular and extensively grown tropical and subtropical fruits. Its wholesome nature, multifold nutritional and medicinal values have made it important, sometimes indispensable in several parts of the world. Citrus is primarily valued for the fruit, which is either eaten as fresh fruit, processed into juice or added to dishes, beverages and chicken products . Processing of citrus fruits produces considerable quantity of byproducts in form of peel and pulp. These contain higher amount of soluble dietary fibre than cereals (Fernandez-Lopez *et al.*, 2004). Consumption of both soluble and insoluble fibre is important in lowering blood cholesterol level and prevention of intestinal cancer. Citrus fruit consumption has been associated with lower risk of colorectal (Levi *et al.*, 1999), oesophageal

(Levi *et al.*, 2000; Chen *et al.*, 2002), stomach (McCullough *et al.*, 2001) cancers and stroke (Joshipura *et al.*, 1999; Feldman, 2001). Citrus fruit also appear to be associated with improved blood lipid profile (Kurowska *et al.*, 2000) and improved survival in the elderly (Foretes *et al.*, 2000).

Additionally, citrus fibre has associated bioactive compounds (flavonoids, polyphenols, carotene etc.) with antioxidant properties which may exert higher health promoting effect than fibre itself (Nagy and Attaway, 1992; Marin *et al.*, 2002). Today, there is strong evidence that supports the role of polyphenols in prevention of age related diseases (Bastiaretto *et al.*, 2006). Very little work has been reported on utilization of citrus fibre in meat products (Fernandez-Gines *et al.*, 2004 and 2005; Fernandez-Lopez *et al.*, 2007).

Hence, this study was carried out for development of chicken meat rolls by incorporating citrus fruit peel and pulp with following objectives.

**Objectives**

1. Standardization of chicken meat rolls with different levels of fibre from citrus fruit waste.
2. Assessment of nutritional composition, physico-chemical characteristics and acceptability of chicken meat rolls.

Rapid urbanization, fast pace of life and women employment have resulted into high consumption of processed foods. Convenience meat products are important segment of processed food sector. Meat is a concentrated nutrient source and is traditionally considered essential for growth due to its high quantity and quality of proteins, availability of B complex vitamins and minerals. However, image of meat has somewhat diminished today because of its fat, saturated fatty acids and cholesterol content which have been related to cardiovascular diseases, cancer, obesity etc. (Fernandez-Gines *et al.*, 2005). Moreover, processed meat products have added fat and salt. Epidemiological studies have demonstrated a relationship between energy dense diet and range of chronic diseases (Best, 1991; Kaferstein and Clugston, 1995). Hence, in recent past efforts have been made to alter the formulation of meat products by modifying the lipids and fatty acid content and / or by adding functional ingredients such as edible fibre, vegetable proteins, unsaturated fatty acids, vitamins, calcium, phytochemicals etc. (Jimenez-Colmenero *et al.*, 2001).

Meat is deficient in dietary fibre which is very important from health point of view. Various reports have revealed that fibre intake reduces the risk of colon cancer, obesity and cardiovascular diseases (NCI 1984; Eastwood 1992; Johnson and Southgate 1994) and generally promotes a healthier life style (Kritchevsky, 2000). According to the American Dietetic Association, the current recommended fibre intake for adults ranges from 25 to 30 g/day and the insoluble / soluble fibre ratio should be 3: 1.

### **2.1 Dietary fibre**

The term dietary fibre includes several complex substances. According to American Association of Cereal Chemists "Dietary fibre is the remnants of edible parts of plant or analogues carbohydrates that are resistant to digestion and absorption in human small intestine". Dietary fibre promotes beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and /or blood glucose attenuation (AACC, 2001).

## Dietary fibre constituents

Fibre constituent	Principal groupings	Fibre component /sources
Non starch polysaccharides and oligosaccharides	Cellulose	Cellulose plants (vegetable, sugar beet, various brans)
	Hemicellulose	Arabinogalactans, $\beta$ -glucans, arabinoxylans glucuronoxylans, xyloglucans, galactomannans, pectic substances
	Polyfructoses	Inulin, oligofructans
	Gums and mucilages	Seed extracts (galactomannans ó guar and locust bean gum), tree exudates (gum acacia, gum karaya, gum tragacanth), algal polysaccharides (alginates, agar carrageenan), psyllium
Carbohydrate analogues	Pectins	Fruits, vegetables, legumes, potato, sugar beets
	Resistant starches and maltodextrins	Various plants such as maize, pea, potato
	Chemical synthesis	Polydextrose, lactulose, cellulose derivatives
	Enzymatic synthesis	Neosugar or short chain fructooligosaccharides, transgalactooligosaccharides, levan, xanthan gum, oligofructose, xylooligosaccharide, guar hydrolyzate, curdlan
Lignin	Lignin	Woody plants
Substances associated with non starch polysaccharides	Waxes, cutin, Suberin	Plant fibres
Animal origin fibres	Chitin, chitosan, collagen, chondroitin	Fungi, yeasts, invertebrates

(Tunland and Meyer, 2002)

For dietary purpose, fibre is categorized into insoluble and soluble fibre. Insoluble fibres such as cellulose and lignins increase the bulk, accelerate bowel transit and have laxative effect. Soluble fibres like pectins, starches and gums are digestible fibre. They produce viscous solution that delays gastric emptying and absorption from small intestine. They are fermented in colon and their metabolites play a role in colon health (Verma and Banerjee, 2010). Whole grains are a major source of insoluble fibre (Welsh *et al.*, 1994; Slavin *et al.*, 1997) and soluble fibres are present in high level in fruits, beans and vegetables (Anderson *et al.*, 1994).

Various cereals, fruits and vegetables have been tried for increasing the fibre content of meat products. Fruits fibres have better quality due to their higher soluble fibre content, water and oil holding capacity, colonic fermentability, lower phytic acid content and caloric value (Figuerola *et al.*, 2005). Besides dietary fibre, carotenoids, polyphenols, tocopherol, vitamin C and others which are present in fruits also contribute to health benefits (Schieber *et al.*, 2001). Waste generated from orange, apple, peach etc. has a great potential for use in processed meat products due to high fibre and other physiological benefits.

## **2.2 Composition of citrus by product**

### **Proximate composition**

The genus citrus encompasses several orange types *i.e.* sweet and sour oranges, tangerines (mandarins), tangors and tangelos. Each species or hybrid cross has one or more varieties (Peterson, *et al.*, 2006). *Kinnow* or tangerine (*Citrus reticulata*) is a citrus fruit variety grown in north Indian states mainly Punjab, Haryana and Rajasthan (Devatkal, *et al.*, 2010). Citrus is the one of the most important fruits of the world and is utilized as fresh or for juice extraction. Its processing produces a considerable amount of waste in the form of peel and pulp. These are rich source of dietary fibre and bioflavonoids which have various health benefits.

Grigelmo-Miguel and Martin-Belloso (1999) reported that fruits and greens residue after juice extraction showed total dietary fibre content in the range 35.8-58.8g/100g, on dry matter basis, whereas, orange waste contained 37.8g/100g total dietary fibre on dry matter basis. Soluble dietary fibre was much higher in fruits than cereal bran. Residue after juice extraction from orange contained 7.9, 0.5, 2.9 and 82.4g/100g (dry matter) protein, fat, ash and carbohydrates, respectively.

Gorinstein *et al.* (2001) reported that citrus fruits contained higher dietary fibre in peel (about 65%) than peeled fruits. Total dietary fibre content was 2.43-2.54 and 1.29-1.34g/100g (wet basis) for peels and peeled citrus fruits respectively.

Both insoluble and soluble fibres were observed to be higher in peels than peeled fruits.

Moisture, ash and crude fibre content of lemon albedo was 65.7, 2.96 and 30%, respectively (Aleson-Carbonell *et al.*, 2004). The pH was 4.53 which were attributed to the presence of organic acids.

Figuerola *et al.* (2005) indicated that orange fibre obtained from orange residue (peel and pulp collectively) contained 64.3% total dietary fibre. Protein, lipid and ash content were reported to be 6.70, 0.89 and 2.71% respectively.

Composition of mandarin peels was assessed as 2.16% protein, 11.15% ether extract, 4.06% ash, 7.14% crude fibre and 75.49% carbohydrate on dry weight basis by Magda *et al.* (2008).

### **Polyphenols**

Polyphenols are getting attention now a day for their antioxidant, anticarcinogenic and anti-inflammatory properties (Marin *et al.*, 2002).

Citrus fibre has been stated to be better than other dietary fibres due to the presence of associated bioactive compounds (flavonoids, polyphenols, carotenes etc.) with antioxidant properties (Nagy and Attaway, 1992; Marin *et al.*, 2002).

During HPLC analysis of orange fibre, Fernandez-Lopez *et al.* (2007) detected numerous peaks, which matched with phenolic compounds. Eriocitrin, neoeriocitrin, rutin, luteolin-7-O-glucoside, hesperidin, diosmin, poncirin, hesperetin and neodiosmin were found to be present. The highest peak on the chromatogram was identified as hesperidin.

Peterson *et al.* (2006) reported that sweet orange contained less total flavanones as 17 mg total flavanone aglycones /100g edible fruit or juice whereas, tangerines (mandarins) and tangors contained higher amounts (23 and 25 mg aglycones/100g edible fruit or juice, respectively), however, all these varieties provided similar types of flavanones. Tangerines averaged the most hesperidin at 19 mg/100g juice while oranges and tangors averaged 15mg/100g juice hesperidin.

Peels of fruits contain more polyphenols than fruit itself (Belitz and Grosch, 1999; Sun *et al.*, 2002; Kroyer, 2009).

Gorinstein *et al.* (2001) also observed that total polyphenol content in orange peels was significantly higher (179 mg/100g fresh fruit) than in peeled fruits (154 mg/100g fresh fruit).

Mehta and Bajaj (1984) showed that polyphenolic content of peels of *Citrus reticulata* was 225 mg/100g.

Oboh and Ademosun (2006) studied the sundried peels of orange, grape, shaddock and tangerines. They found that orange peels had the highest total

polyphenol content (3.2 mg/g) and other citrus peel including tangerine had a total polyphenol content of 2.9 mg/g each.

Magda *et al.* (2008) reported that dry mandarin peels contained 780mg/100g and orange peel had 670 mg/100g polyphenols.

Total polyphenolic contents of *kinnow* rind powder was observed to be around 3000µg/g (Devatkal *et al.*, 2010) and 3157.8µg/g (Devatkal and Naveena, 2010).

### **2.3 Composition of meat products as affected by fibre**

Several factors such as sex, age, feed, species, breed, management and processing affect the composition of meat. Addition of non meat ingredients to meat during processing changes the composition of meat products. Agro industry waste has entirely different composition from meat and hence results in drastic deviation in meat composition.

Garcia *et al.* (2002) observed that when orange fibre was added in low fat pork sausages, moisture content of the fibre containing sausages increased. They attributed it to the higher water retention ability of these fibres. It was observed that with addition of 1.5% orange fibre, moisture content of low fat (6% fat) sausages increased from 65.5 to 67.1% and correspondingly there was decrease in protein, fat and ash contents.

Fernandez-Gines *et al.* (2003) used raw orange albedo in dried form at 0.5, 1, 1.5 and 2% concentrations in bologna. There was no change in chemical composition up to 1% level, but higher level of addition (2%) resulted in decrease in moisture and fat content. Ash and fibre content increased.

In another study, Fernandez-Gines *et al.* (2004) incorporated raw fresh lemon albedo in bologna sausages. Moisture, protein, ash and fibre content of sausages increased but fat content decreased. Fibre concentration increased from zero to 1.93% at 10% raw lemon albedo.

Addition of lemon albedo in non fermented dry cured sausages decreased fat and protein and increased moisture and ash content (Aleson-Carbonell *et al.*, 2004). Increase in moisture content was attributed to high water retention ability of albedo which was mainly due to presence of pectins in lemon albedo. It was observed that as the level of albedo increased, fibre content increased in sausages and up to 19.1g/kg fibre was reported in sausages with 100g/kg albedo.

Incorporation of orange dietary fibre (1%), along with rosemary and thyme essential oil in mortadella decreased its moisture and fat content and increased ash content (Viuda-Martos *et al.*, 2010).

## **Nitrite**

Nitrates and nitrites are utilized in the formulation of meat products for providing cured meat colour, as antioxidant and for reducing the heat resistance of *Clostridium* during canning. Maximum permissible limit of nitrites is 200 ppm in finished product. Residual nitrite reacts with amines to form nitrosamines which are considered as carcinogenic in nature. Therefore, prime concern has been to reduce the level of residual nitrite in finished products.

Some polyphenolic compounds show a high protection against nitrite ion and prevent nitrosamines and nitrosamide formation in foods (Krishnaswamy, 2001; Garrote *et al.*, 2004).

Aleson-Carbonell *et al.* (2004) observed that residual nitrite level in non fermented dry cured sausages which was 16.66 mg/kg reduced to 0.22 mg/kg on addition of lemon albedo (100 g/kg). The level decreased as the albedo concentration increased. It was reported to be due to the reaction of nitrite with active bio-compounds present in the albedo.

Incorporation of raw orange albedo in bologna sausages progressively decreased the residual nitrite level. As the level of albedo increased, nitrite level decreased from 22.03 (control) to 8.56 mg/kg (Fernandez-Gines *et al.*, 2003) and from 29.18 (control) to 11.90 mg/kg (Fernandez-Gines *et al.*, 2004).

Fernandez-Lopez *et al.* (2007) also showed a reduction in level of residual nitrite level in dry cured sausages added with orange fibre during dry curing period. Residual nitrite level decreased in mortadella added with citrus fibre (Viuda-Martos *et al.*, 2010).

## **2.4 Fibre and physico-chemical properties of meat.**

### **pH**

The pH of muscle falls after slaughter due to production of lactic acid. It has profound effect on functional properties and keeping quality of meat. Addition of non meat ingredients changes the pH of meat products depending upon the source of plant material.

Aleson-Carbonell *et al.* (2004) reported that when lemon albedo was added in non fermented dry cured sausages, pH decreased due to acidic nature of the albedo owing to the organic acids present in raw albedo.

Fernandez-Gines *et al.* (2004) observed that the pH of raw lemon albedo (4.53) increased to 5.02 on cooking. The pH of bologna sausage containing raw albedo did not differ from that of control. They suggested that cooking favours the leaching out of organic acids present in albedo that increased its pH. As cooking process itself increases meat pH, probably due to the breaking down of the cellular

buffer and release of free fat (Schweigert, 1994), they suggested that lemon albedo decreased the pH, but the cooking process reversed this effect.

Addition of dried orange fibre at 10, 15 and 20g /kg level in dry cured fermented sausage decreased pH during curing process. With increasing concentration of fibre, pH decreased progressively (Fernandez-Lopez *et al.*, 2007).

Goat meat patties having *kinnow* rind powder extract had lower pH (6.02) as compared to control (6.23). It was attributed to acidic pH of extracts by Devatkal *et al.* (2010).

On the other hand, Fernandez-Gines *et al.* (2003) observed no difference in pH of citrus fibre added bologna from control.

### **Thiobarbituric acid (TBA) value**

Oxidation of lipids in meat and meat products causes significant decline in organoleptic properties of meat during storage. Oxidative rancidity is commonly assessed by employing TBA assay. Many plant foods such as green tea, rosemary extract, grapes, citrus fruits etc. are known to possess ingredients which have antioxidant properties. Ascorbic acid, tocopherols, tea catechins, polyphenols have been shown to prevent lipid oxidation in meat products (Devatkal *et al.*, 2010).

Polyphenolic extract from citrus peels caused a marked reduction in lipid oxidation in various organs *in vitro* (Oboh and Admosun, 2006).

Fernandez-Gines *et al.* (2003) reported that TBA value increased faster during storage of control bologna than in samples with citrus fibre, which could be due to the presence of fibre associated compounds such as flavonoids, polyphenols and carotenes with antioxidant properties (Gabor, 1988; Wang *et al.*, 1996).

Aleson-Carbonell *et al.* (2004) formulated non fermented dry cured sausages with lemon albedo and found that TBARS values increased in all the samples during drying. But the increase in TBARS values of sausages with albedo was lower than control sample. Higher the albedo concentration, lower was the TBARS value at the end of storage. They suggested that this behaviour indicated the protective effect of albedo against the oxidation process due to associated bioactive compounds.

Antioxident properties of orange fibre was also noticed in dry cured fermented sausages as TBARS values were lower in treated samples with orange fibre than in control samples (Fernandez-Lopez *et al.*, 2007).

Addition of orange and mandarin peel powder to biscuits reduced the oxidative rancidity in biscuits as their peels contained high anti radical efficiencies (Magda *et al.*, 2008).

Devatkal and Naveena (2010) indicated that salt increased the TBARS value of raw ground goat meat but *kinnow* rind powder and pomegranate rind powder countered the pro-oxidant effect of salt during refrigerated storage.

*Kinnow* rind powder extract showed excellent radical scavenging activity and its addition to goat meat patties resulted in lower increase of TBARS value during storage (Devatkal *et al.*, 2010).

### **Cooking loss**

Addition of fibre to meat products is known to reduce the cooking loss due to its water retention property. Grigelmo-Miguel and Martin-Belloso (1999) stated that peach dietary fibre had the ability to retain water in frankfurters leading to lower cooking loss during heating.

Dietary fibres increase cooking yield due to their water and fat binding properties and improve texture in cooked meat products (Cofrades *et al.*, 2000).

### **Shear press value**

Tenderness of meat products is an important sensory attribute which influences the acceptability of the product by the consumer.

Garcia *et al.* (2002) observed that dry fermented sausages added with peach, apple and orange fibres showed reduced hardness due to the ability of fibre to reduce losses and retention of moisture.

Aleson-Carbonell *et al.* (2004) reported that shear press value increased during drying process of non fermented dry sausages. Presence of lemon albedo decreased the shear press value at the end of drying which was due to binding of moisture by added fibre during drying process.

## **2.5 Sensory properties**

Various qualities like aroma, flavour, colour, appearance, texture, tenderness and juiciness influence the palatability of meat products. Availability of plethora of processed foods has made the sensorial acceptance of the product by consumer even more pertinent for development of new products. Most suitable non meat additive is the one which does not impart undesirable sensory changes in meat besides providing desirable processing characteristics.

Addition of dietary fibre in the meat matrix contributes to maintain its juiciness (Chevance *et al.*, 2000).

Garcia *et al.* (2002) reported that when orange fibre was added in low fat (6% fat) fermented sausages at 1.5% level, texture of the sausages improved and was most similar to the control. Incorporation of orange fibre decreased the hardness of low fat sausages. Overall acceptability score of low fat (6%) sausages increased on addition of orange fibre, though the score was still lower than full fat

sausages. Adverse effect of fat reduction was minimized by additives of orange fibre.

Bologna sausages with 0.5 to 2% concentration of dried citrus fibre showed increase in lightness and yellowness. Product was harder and springiness and chewiness decreased (Fernandez-Gines *et al.*, 2003).

Fernandez-Gines *et al.* (2004) reported that odour and taste were not affected on addition of raw lemon albedo in bologna sausages. Albedo addition (raw and cooked) caused an increase in hardness and decrease in juiciness. Increased hardness and decreased juiciness were higher in bologna with raw albedo than cooked albedo. Decrease in juiciness was related to the proportional reduction of fat. Albedo was responsible for decrease in redness and increase in lightness and yellowness which was attributed to white component of albedo.

Dry cured sausages with dried orange fibre (5 to 20g/kg) showed increase in lightness (Fernandez-Lopez *et al.*, 2007). They attributed it to lower pH of treated samples and its effect on meat protein structure, thus modifying light reflection. Samples added with fibre showed higher redness and yellowness values. Presence of carotene (yellow compound) contributed to yellowness.

## **2.6 Patent research**

Mills and Tarr (1992) invented a procedure for deriving fibre from citrus pulp. The patent was assigned to Procter and Gamble Company vide patent no US005162128A. The pulp after juice extraction was washed, dried and jet milled to produce pulp fibre having particle size of less than 50 microns. This fibre is used by the company to produce fruit juice beverage.

The present investigation was conducted in the Department of Livestock Products Technology, College of Animal Sciences, CCS Haryana Agricultural University, Hisar. This chapter contains relevant information pertaining to research design and methodological steps used in the investigation.

### **3.1 Materials**

#### **3.1.1 Broiler chickens**

Broiler birds of same age (6 weeks) and reared under similar feeding and managerial conditions were obtained from the Animal Farm of the College of Animal Sciences, CCS HAU, Hisar.

#### **3.1.2 Additives and spice mix**

Sodium chloride, sodium tripolyphosphate, sodium nitrite and spice mix (developed in laboratory) were used in appropriate amounts as indicated later.

#### **3.1.3 Peel and pulp of *kinnow***

Peel and pulp were procured separately from a local juice shop in Hisar. Seeds were removed from pulp and then peel and pulp were washed thoroughly with clean water. Water was removed from peel and pulp by squeezing in muslin cloth. They were ground separately in food processor and stored in deep freezer till further use.

### **3.2 Methods**

#### **3.2.1 Slaughter of birds**

The birds were slaughtered and dressed as per the standard procedure in the slaughter house of the department. Carcasses were washed thoroughly and deboned manually after trimming of fat and connective tissue. Deboned meat was frozen for 24 h and then minced in an electrical mincer and used for product preparation.

#### **3.2.2 Preparation of chicken rolls**

Following ingredients were added to minced meat for control and treatments. Control rolls contained sodium chloride (2%), sodium tripolyphosphate (0.5%), sodium nitrite (150 ppm) and spice mix (2%). Treatments consisted of addition of fresh peel and pulp at 5, 7.5 and 10% levels each, besides other additives which were used in control in similar concentrations. After mixing of additives and *kinnow* waste, meat mince was thoroughly chopped in food processor. Emulsion was stuffed in autoclavable beakers and cooked in an autoclave at 121°C for 15 min. Product was packed in polythene bags and stored at 4±1°C for 15 days. Cooked chicken rolls were subjected to chemical, physico-chemical, microbiological and sensory quality

evaluation. Samples were drawn at 3 day intervals for analysis of relevant parameters during storage.

### 3.2.3 Analysis

#### 3.2.3.1 Proximate composition

Proximate composition was determined by following the standard methods of AOAC (1995).

#### Moisture

Minced sample (30 g) was weighed in dried aluminium dish and kept in hot air oven with lid removed at 100-105°C for 16-18 h. After cooling in dessicator, loss in weight was calculated as moisture of the sample.

#### Protein

##### Reagents

- (i) H<sub>2</sub>SO<sub>4</sub> (conc.)
- (ii) HCl (0.01 N)
- (iii) Boric acid solution (4%)
- (iv) NaOH solution (40%)
- (v) Catalyst : Copper sulfate and potassium sulfate (1:9)
- (vi) Mixed indicator: Two grams of methyl red and one gram of bromocresol green were dissolved in 1000 ml ethanol and stored in dark brown bottle.

#### Procedure

One gram of meat sample and 20 ml of conc. H<sub>2</sub>SO<sub>4</sub> were transferred to a Kjeldahl flask. A pinch of catalytic mixture was added and digestion was carried out till the appearance of blue green clear solution. After cooling, volume was made to 100 ml with distilled water. Five ml of aliquot was rendered alkaline by mixing with 15 ml of 40% NaOH solution and was distilled. Liberated ammonia was collected in a conical flask containing 10 ml of boric acid solution and 2-3 drops of mixed indicator. Contents of flask containing boric acid were titrated against 0.01N HCl.

$$\text{Protein (\%)} = \frac{\text{Amount of 0.01 N HCl used} \times 0.00014 \times 100 \times 6.25 \times 100}{\text{Weight of sample} \times \text{ml of aliquot}}$$

#### Ether extract (fat)

One gram of sample was taken in a previously weighed extraction thimble (made up of Whatman filter paper No. 1). Extraction of the sample was done in Soxhlet's extraction apparatus for 6-8 h by using petroleum ether (boiling point 60-80°C). The thimble after extraction was taken out, dried in open air and then in hot

air oven at about 100°C for 1 h the loss in weight following extraction and drying was recorded and per cent ether extract was calculated.

### **Ash**

One gram of sample was taken in a dried and weighed silica crucible. It was heated on a hot plate till smoking ceased and the sample became thoroughly charred. Charred sample was then kept in a muffle furnace at 600°C for 1 h. Crucible was cooled in a dessicator and weighed. Ash was calculated as the difference between weight of empty crucible and weight after ashing.

### **3.2.3.2 pH**

Method of Trout *et al.* (1992) was followed for determining the pH of the meat samples.

Meat sample (10 g) was blended with 50 ml distilled water for 1 min using pestle and mortar. The pH was recorded by dipping the electrodes of pH meter directly in the suspension.

### **3.2.3.3 Cooking loss**

Weight of rolls before and after cooking was recorded and loss was expressed in percentage.

### **3.2.3.4 Shear press value**

Force needed to shear one cm<sup>3</sup> piece of roll was recorded using Warner Bratzler Shear Press (Salter Model No. 235 6S). Values were expressed in kg/cm<sup>3</sup>.

### **3.2.3.5 Polyphenols**

Method of Swain and Hills (1959) was adopted to assess polyphenol content of samples.

### **Principle**

Folin-Denis reagent produces a blue colour with polyphenolic substances. Tannic acid is used as a standard and the results are expressed as tannic acid equivalent.

### **Reagents**

- (i) Folin-Denis reagent: To 750 ml water in a beaker, 100g sodium tungstate, 20 g phosphomolybdic acid and 50 ml phosphoric acid were added. It was refluxed for 2 h, cooled and volume made to 1litre with distilled water.
- (ii) Saturated sodium carbonate solution: To 100 ml water, 45 g anhydrous Na<sub>2</sub>CO<sub>3</sub> was added, dissolved at 70-80°C and left overnight to cool. Super saturated solution with Na<sub>2</sub>CO<sub>3</sub> crystals was obtained. It was filtered through glass wool.

- (iii) Tannic acid standard solution: Tannic acid (100 mg) was dissolved in 1 litre distilled water. Fresh solution was prepared for each determination.
- (iv) Methanol - HCl: Concentrated HCl (10 ml) was pipetted in about 100 ml methanol and volume made to 1 litre with methanol.

### **Procedure**

Defatted sample (200 mg) and 100ml methanol-HCl were added in 250 ml round bottom flask. Contents were refluxed for 2 h and allowed to cool. Extract was filtered through Whatman No. 40 filter paper into a 100 ml volumetric flask and the volume was made up with methanol-HCl after a few washings (this extract can be stored for 2 days under refrigeration).

### **Estimation**

To 0.2 ml extract in a test tube, 7.5 ml distilled water was added. After adding 0.5 ml Folin-Denis reagent it was stirred to achieve vortex. One ml saturated sodium carbonate solution was added to it and final volume was made to 10 ml with distilled water. It was again stirred with vortex and allowed to stand for 30 min and absorbance was read at 760 nm (colour is stable up to 40 min). For standard curve zero to one ml standard tannic acid solution was pipetted at interval of 0.2 ml in 20 ml test tube containing 7.5 ml distilled water. Polyphenols were expressed as mg tannic acid equivalent/g sample.

#### **3.2.3.6 Nitrite Content**

Nitrite content of the sample was estimated as per the method of ISI (1984).

### **Principle**

The test portion is extracted with hot water, proteins precipitated and filtered. In the presence of nitrite, the filtrate develops a red colour on addition of sulphanilamide hydrochloride and N-1-naphthylethylenediamine dihydrochloride. Nitrite is then estimated photometrically at a wavelength of 538 nm.

### **Reagents solutions for precipitation of proteins**

- (i) Reagent I: Potassium ferrocyanide trihydrate (106 g) was dissolved in water and diluted to 1000 ml.
- (ii) Reagent II: Zinc acetate dehydrates (220 g) and 30 ml of glacial acetic acid were dissolved in water and diluted to 1000 ml.
- (iii) Saturated borax solution: Disodium tetraborate decahydrate (50 g) was dissolved in 1000 ml of tepid water and cooled to room temperature.
- (iv) Standard sodium nitrite solution: Sodium nitrite (1 g) was dissolved in water and diluted to 1000 ml in volumetric flask. Five ml of the above solution was further diluted to 1000 ml in volumetric flask. A series of secondary standard solutions were prepared by diluting 5, 10 and 20 ml

of standard solution to 100 ml with water. These secondary solutions contained 0.25, 0.5 and 1.0 µg of nitrite/ml. (secondary standard solutions were prepared fresh on day of use).

#### **Colour Reagent**

- (i) Solution I: Sulphanilamide (2 g) was dissolved by heating on a water bath in 800 ml of distilled water. Hundred ml of HCl was added while stirring. It was diluted to 1000 ml with distilled water.
- (ii) Solution II: N-1-naphthylethylenediamine dihydrochloride (0.1 g) was dissolved and diluted to 100 ml with distilled water.
- (iii) Solution III: Diluted 445 ml of HCl to 1000 ml with distilled water. Solutions were stored in well stoppered brown bottles in refrigerator for not more than one week.

#### **Deproteination**

Homogenized sample (10 g) was added to the conical flask followed by successively 5 ml of saturated borax solution and 100 ml of water of at least 70°C. Flask was heated on boiling water bath for 15 min with repeated shaking. Flask was allowed to cool to room temperature and successively 2 ml of reagent I and 2 ml of reagent II were added. Contents were mixed thoroughly after each addition. Contents were transferred to 250 ml volumetric flask. It was allowed to stand for 30 min at room temperature and then diluted to 250 ml with water. Contents were mixed and filtered through filter paper.

#### **Determination**

In a test tube, 10 ml of filtrate was pipetted. To it, 10 ml of solution I, followed by 6 ml of solution III were added mixed and solution was left for 5 min at room temperature in the dark. Now 2 ml of solution II was added, mixed and the solution was left for 3 min at room temperature in the dark. After 20 min, optical density of the solution was measured at 538 nm.

#### **Calibration curve**

In test tubes, 10 ml of each of the three sodium nitrite standard solutions were added. To each tube colour solutions I, III and II were added and proceeded as described above.

Nitrite content of the sample was expressed as milligrams of sodium nitrite/kg.

#### **3.2.3.7 TBA value**

TBA, value was determined according to the method of Witte *et al.* (1970).

#### **Reagents**

- (i) 1.1.3.3 Tetra ethoxy propane (stock solution).

TEP (0.31 ml) was diluted to 100 ml with 95% ethyle alcohol. Strength of solution was 3 mg/ml.

- (ii) TEP (working standard solution). Stock solution (0.1 ml) was diluted to 100 ml with distilled water. Strength of the solution was 3µg/ml.
- (iii) Thiobarbituric acid reagent (1 mg/ml).
- (iv) Trichloroacetic acid (20%)

### **Extraction**

Minced meat (5 g) was blended for 3 min with 25 ml of 20% TCA. Slurry was kept for 10 min. It was filtered through Whatman No. 42 filter paper. Five ml TBA reagent was added to 5 ml of sample aliquot (filtrate). After mixing the contents, tubes were kept in a boiling water bath for 35 min. Optical density was measured at 532 nm spectrophotometrically. Blank was run simultaneously. For standard curve 1, 2, 3, 4, 5 ml of working standard solution were used.

### **3.2.3.8 Crude fibre**

Crude fibre of the sample was assessed as per the method of AOAC (1995).

### **Principle**

A fat free sample is treated with boiling H<sub>2</sub>SO<sub>4</sub> and subsequently with boiling NaOH. The residue after subtraction of the ash is regarded as fibre.

### **Reagents**

- (i) HCL (1%) v/v
- (ii) H<sub>2</sub>SO<sub>4</sub> stock solution (10%) v/v: Conc. H<sub>2</sub>SO<sub>4</sub> acid (55 ml) was diluted to 1 litre.
- (iii) H<sub>2</sub>SO<sub>4</sub> working solution: Diluted 125 ml of the stock solution to 1 litre.
- (iv) NaOH stock solution (10%) w/v: Dissolved 100g NaOH in water and diluted to 1 litre.
- (v) NaOH working solution (1.25%): Diluted 125 ml of the stock solution to 1 litre.
- (vi) Antifoam (2%): Silicon antifoam in CCl<sub>4</sub>.

### **Procedure**

Fat free dried sample (2 g) was weighed in 1 litre tall beaker and 200 ml 1.25% hot H<sub>2</sub>SO<sub>4</sub> and few drops of antifoam were added. It was heated to boiling within 1 min in the crude fibre apparatus. Solution was kept boiling exactly for 30 min under bulb condensers. Contents of the beaker were filtered though Buchner funnel. Precipitates were washed back into the tall beaker with 200 ml of 1.25% NaOH. It was again brought to boiling point and boiled for exactly 30 min.

Matter was transferred to the sintered crucible by means of boiling water. It was washed twice with alcohol and then thrice with acetone. It was dried at 100°C to

constant weight. Ashing was carried out in muffle furnace at 550°C for 1 h. Crucible was cooled in dessicator and weighed.

Calculation

$$\text{Crude fibre (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where,

$W_1$  = Weight of sample

$W_2$  = Weight of insoluble matter (weight of crucible + insoluble matter - weight of crucible).

$W_3$  = Weight of ash (crucible + ash - weight of crucible).

### 3.2.3.9 Sensory evaluation

A semi trained panel consisting of scientists and post graduate students evaluated the sensory attributes viz: colour, flavour, texture, tenderness, juiciness and over all acceptability of patties, using a 9-point Hedonic scale as below.

Score sheet for taste panel

<b>Name :</b>	<b>Date / Time:</b>
<b>Address:</b>	
<i>Data under 9-point hedonic scale</i>	Score
Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

Code	Colour	Flavour	Texture	Tenderness	Juiciness	Overall Acceptability

Please wash your mouth with clean water after testing each sample.

### 3.2.3.10 Microbiological evaluation

Microbiological status of the finally selected treatments was evaluated at 0, 3, 6, 9, 12 and 15<sup>th</sup> day of storage at refrigeration temperature. Total plate counts were estimated according to the method prescribed by APHA (1966).

**Procedure**

One gram sample was taken and ten fold serial dilutions were made by using peptone water (1 % peptone and 0.5 % sodium chloride). One ml of homogeneous suspension from each dilution was transferred to duplicate sterile petridishes with the help of sterile pipettes. About 20 ml sterilized, molten and cooled plate count agar medium was poured on each labelled petridish. They were rotated in a manner to facilitate uniform distribution of the material. Medium was allowed to solidify. Plates containing 30-300 colonies were selected for counting. Microbes per gram of samples were calculated by multiplying the number of colonies with respective dilution factor and converted to log cfu/g.

**3.2.3.11 Statistical analysis.**

Data were subjected to f-test by using OP STAT programme for finding out the significant difference in the mean values.

This chapter contains results of the chemical, physico-chemical, microbiological and sensory analysis of the *kinnow* peel and pulp added chicken meat rolls.

#### 4.1 Composition of *kinnow* peel and pulp

Peel of *kinnow* contained 78.72% moisture, whereas, pulp had 86.29% moisture content (Table 1). Protein content was very low both in peel and pulp i.e. around one per cent. Peel had significantly higher fat content (0.53%) than pulp (0.41%). Significantly higher ash content was observed in peel (1.16%) than pulp (0.92%). Crude fibre was almost double in peel (13.92%) than pulp (7.18%). Both peel and pulp showed acidic pH, but pH of pulp (4.31) was significantly lower than that of peel (4.84). Polyphenolic content estimated as total polyphenols (mg/g) was significantly higher in peel (2.58) than pulp (1.88).

**Table 1: Chemical composition (% wet basis) of *Kinnow* peel and pulp (n=6).**

	Peel	Pulp
Moisture	78.72±0.94 <sup>a</sup>	86.29±1.17 <sup>b</sup>
Protein	1.35±0.11	1.29±0.16
Fat	0.53±0.07 <sup>a</sup>	0.41±0.05 <sup>b</sup>
Ash	1.16±0.07 <sup>a</sup>	0.92±0.03 <sup>b</sup>
Crude fibre	13.92±0.97 <sup>a</sup>	7.18±0.13 <sup>b</sup>
pH	4.84±0.04 <sup>a</sup>	4.31±0.03 <sup>b</sup>
Polyphenols (mg/g)	2.58±0.07 <sup>a</sup>	1.88±0.06 <sup>b</sup>

Means with different superscripts in a row differ significantly ( $P \leq 0.05$ ).

#### 4.2 Proximate composition of chicken meat rolls

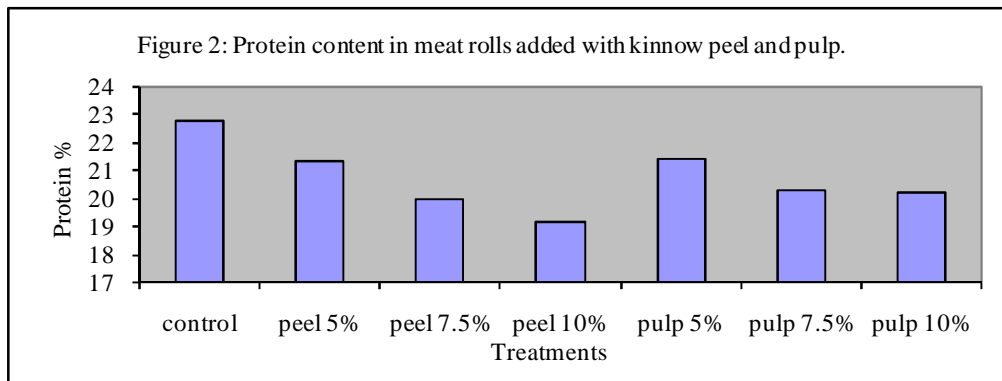
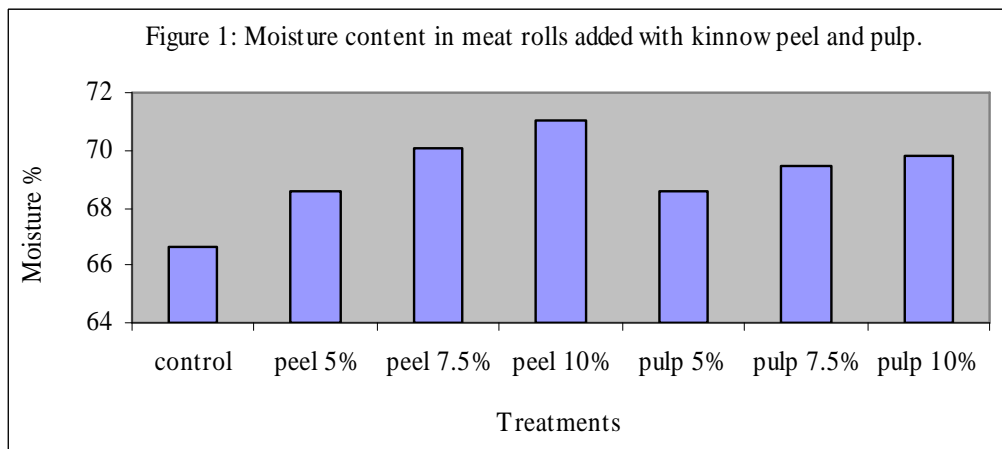
Proximate composition of peel and pulp added chicken meat rolls is presented in table 2 (Figure 1-5). Moisture content of control chicken rolls was 66.63% which increased significantly, on addition of peel and pulp. Chicken meat rolls with peel had higher moisture content than those with pulp. Highest moisture content (71.06%) was observed in chicken rolls with 10% peel. Protein content of chicken rolls which was 22.76% in control decreased on addition of peel and pulp. As the level of addition of peel and pulp increased, protein content decreased. Lowest protein content was observed in rolls with 10% peel incorporation. Fat

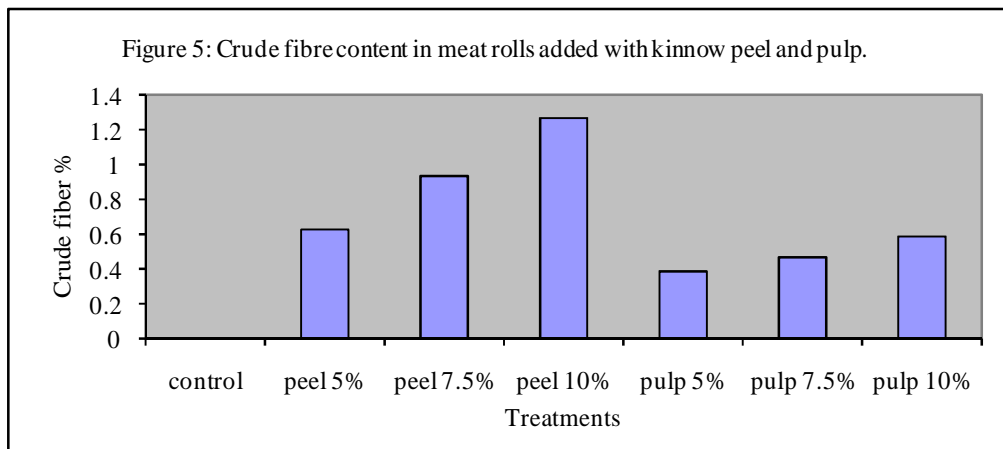
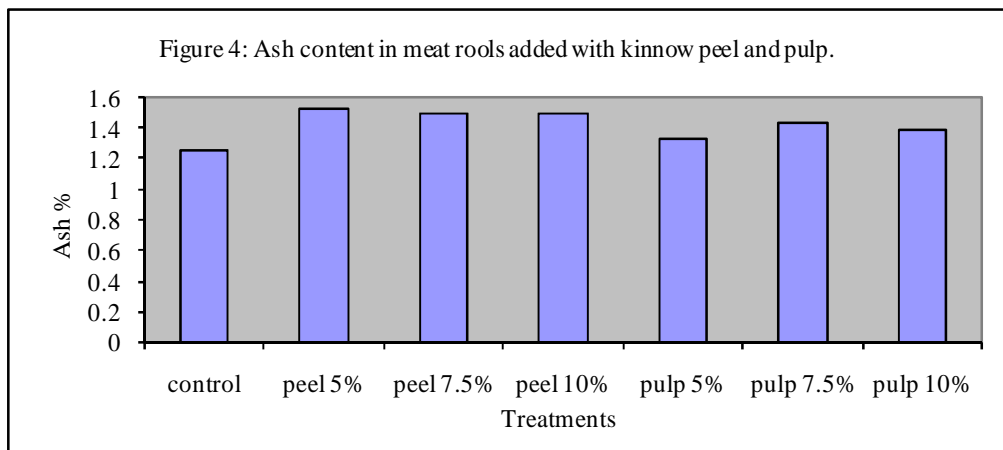
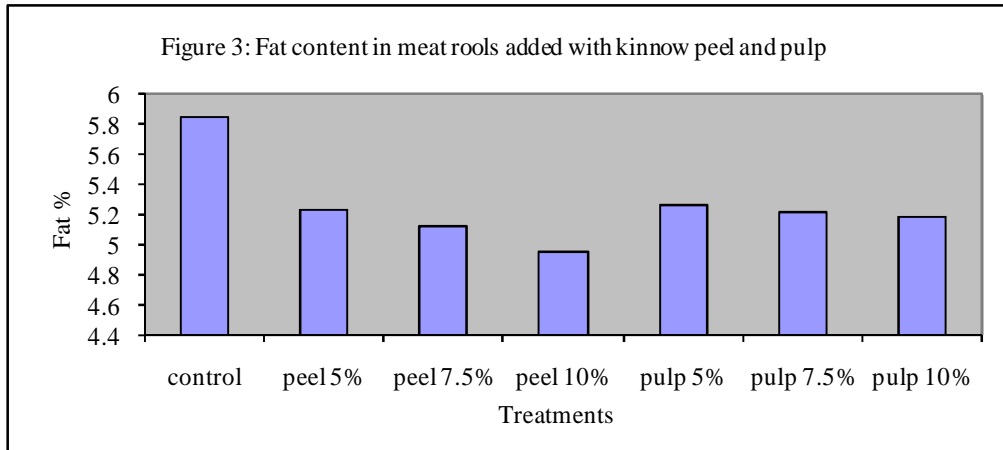
content decreased and ash content increased on incorporation of citrus waste. No crude fibre was observed in control rolls. Addition of both peel and pulp increased the fibre content of rolls. Chicken rolls with peel showed significantly higher crude fibre than those with pulp. Highest crude fibre i.e. 1.27% was observed in chicken rolls with 10% peel addition.

**Table 2: Proximate composition (% wet basis) of chicken meat rolls added with *kinnow* peel and pulp (n=6).**

Treatments	Moisture	Protein	Fat	Ash	Crude Fibre
Control	66.63±1.11 <sup>a</sup>	22.76±0.96 <sup>d</sup>	5.84±0.30 <sup>c</sup>	1.26±0.05 <sup>a</sup>	–
Peel 5%	68.61±0.81 <sup>b</sup>	21.32±0.79 <sup>c</sup>	5.23±0.13 <sup>b</sup>	1.52±0.09 <sup>d</sup>	0.63±0.04 <sup>d</sup>
Peel 7.5%	70.10±0.69 <sup>c</sup>	20.01±0.49 <sup>b</sup>	5.12±0.18 <sup>ab</sup>	1.49±0.12 <sup>d</sup>	0.93±0.06 <sup>c</sup>
Peel 10%	71.06±1.08 <sup>d</sup>	19.18±0.70 <sup>a</sup>	4.96±0.28 <sup>a</sup>	1.50±0.07 <sup>d</sup>	1.27±0.06 <sup>f</sup>
Pulp 5%	68.55±0.69 <sup>b</sup>	21.40±1.01 <sup>c</sup>	5.26±0.23 <sup>b</sup>	1.33±0.09 <sup>b</sup>	0.38±0.04 <sup>a</sup>
Pulp 7.5%	69.49±0.80 <sup>c</sup>	20.32±0.71 <sup>b</sup>	5.22±0.36 <sup>b</sup>	1.43±0.03 <sup>c</sup>	0.46±0.03 <sup>b</sup>
Pulp 10%	69.80±1.01 <sup>c</sup>	20.22±0.87 <sup>b</sup>	5.19±0.16 <sup>b</sup>	1.39±0.08 <sup>c</sup>	0.59±0.07 <sup>c</sup>

Means with different superscripts in a column differ significantly ( $P \leq 0.05$ ).





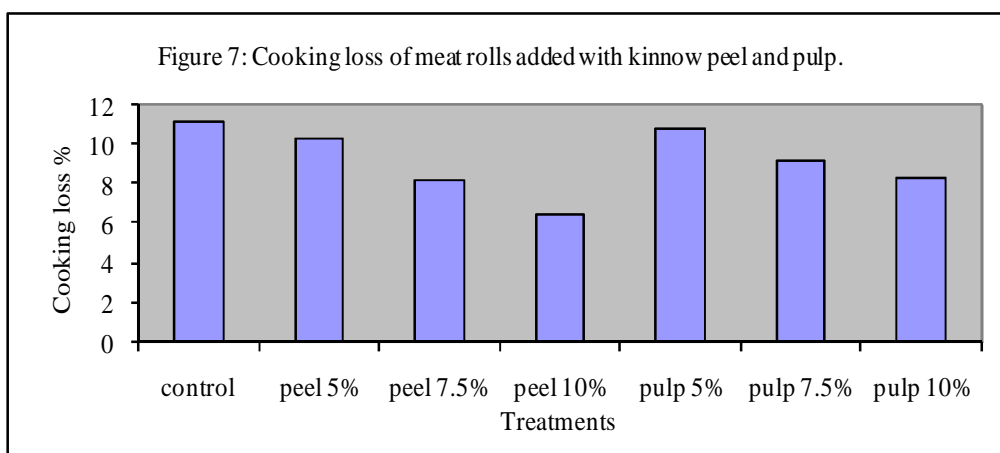
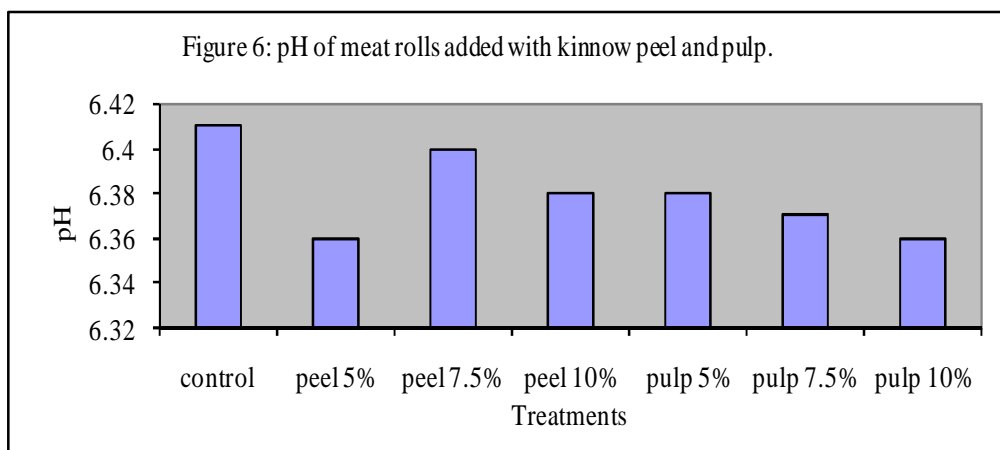
### 4.3 Physico-chemical properties

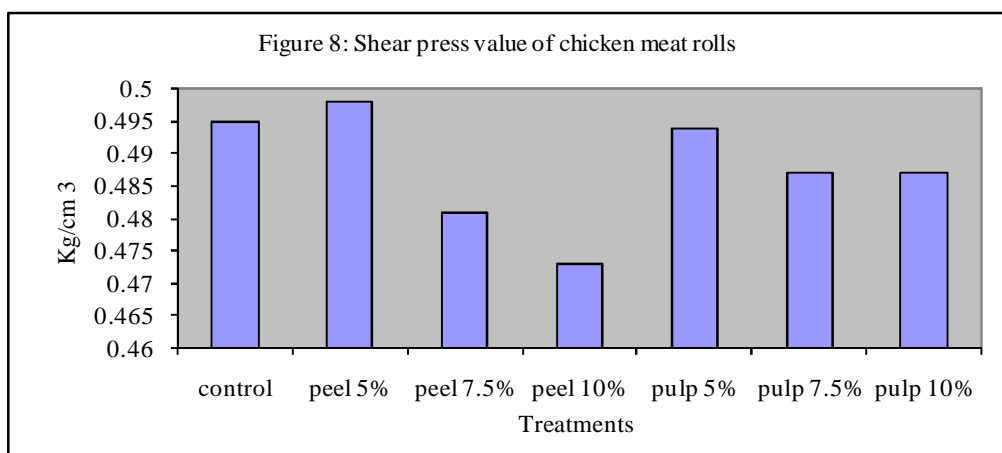
The pH of control chicken rolls was 6.41 (Table 3) (Figure 6). There was no significant difference in pH of treated chicken meat rolls either with peel or pulp.

**Table 3: Physico-chemical properties of chicken meat rolls added with *kinnow* peel and pulp (n=6).**

Treatments	pH	Cooking loss% (n=3)	Shear press value(kg/cm <sup>3</sup> )
Control	6.41±0.04	11.13±1.13 <sup>e</sup>	0.495±0.006 <sup>de</sup>
Peel 5%	6.36±0.10	10.25±1.05 <sup>de</sup>	0.498±0.013 <sup>e</sup>
Peel 7.5%	6.40±0.04	8.18±1.01 <sup>b</sup>	0.481±0.008 <sup>b</sup>
Peel 10%	6.38±0.10	6.42±0.53 <sup>a</sup>	0.473±0.004 <sup>a</sup>
Pulp 5%	6.38±0.05	10.76±0.61 <sup>e</sup>	0.494±0.007 <sup>cde</sup>
Pulp 7.5%	6.37±0.06	9.21±0.49 <sup>bcd</sup>	0.487±0.004 <sup>bc</sup>
Pulp 10%	6.36±0.04	8.30±0.93 <sup>bc</sup>	0.487±0.006 <sup>bc</sup>

Means with different superscripts in a column differ significantly ( $P \leq 0.05$ ).





Cooking loss of control chicken rolls was 11.13% (Table 3) (Figure 7). There was a decrease in cooking loss when peel and pulp of *kinnow* were added to chicken meat rolls. As the level of addition increased, cooking loss decreased. Peel was more effective in decreasing the cooking loss than pulp. Lowest cooking loss (6.42%) was observed in the chicken rolls added with 10% peel.

Shear press value of control chicken rolls which was 0.495 kg/cm<sup>3</sup> decreased as the level of fibre in rolls increased (Table 3) (Figure 8). Lowest shear press value i.e. 0.473 kg/cm<sup>3</sup> was noticed in 10% peel added chicken rolls. Shear press value was lower in peel added rolls than those with pulp.

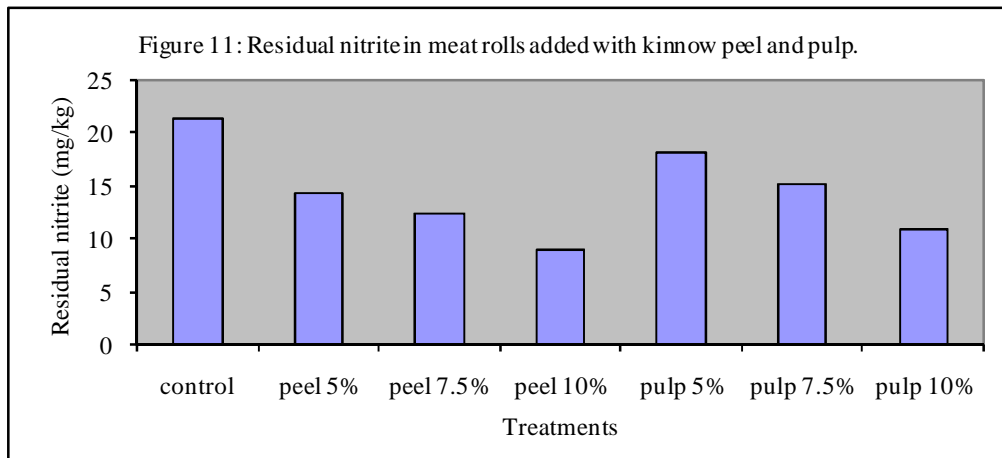
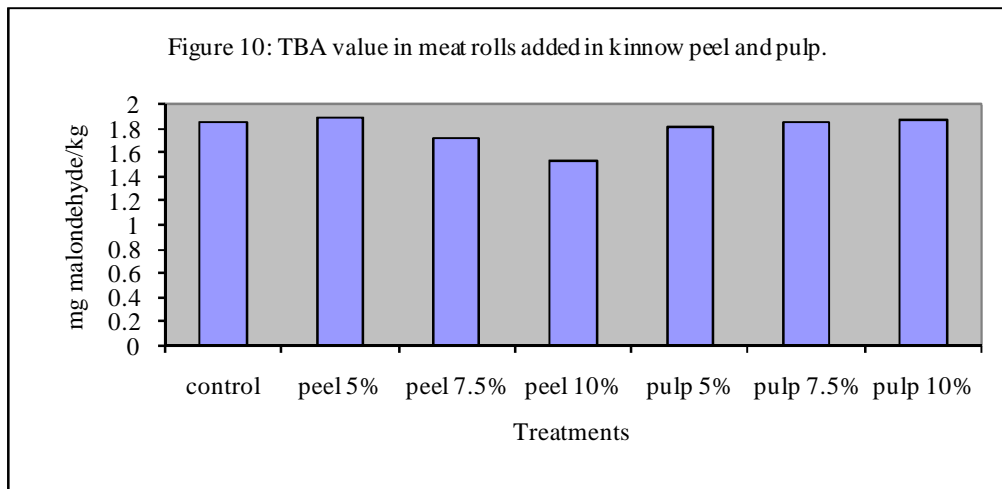
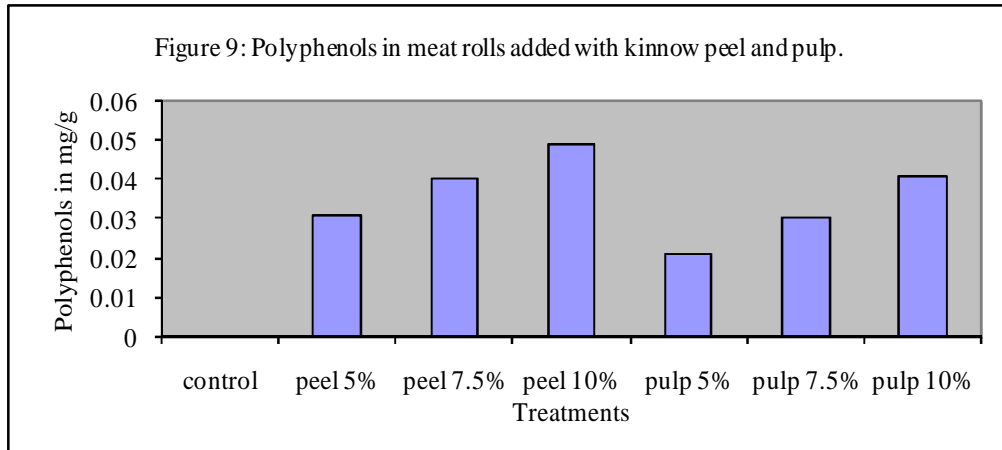
#### 4.4 Polyphenols, TBA value and residual nitrite in chicken meat rolls

Control chicken rolls did not show any polyphenolic content (Table 4) (Figure 9). Addition of both peel and pulp resulted in increase in polyphenolic content of rolls. As the level of addition increased, polyphenol content of rolls increased. Chicken rolls with peels showed significantly higher polyphenol content than with pulp. Highest polyphenol content (0.049 mg/g) was observed in 10% peel added chicken rolls.

**Table 4: Polyphenolic content, TBA value and residual nitrite level of *kinnow* peel and pulp added chicken meat rolls (n=6).**

Treatments	Polyphenols (mg/g)	TBA value (mg malondehyde/kg)	Residual nitrite (mg /kg)
Control	–	1.84±0.05 <sup>c</sup>	21.44±0.85 <sup>g</sup>
Peel 5%	0.031±0.004 <sup>b</sup>	1.89±0.07 <sup>c</sup>	14.38±0.39 <sup>d</sup>
Peel 7.5%	0.040±0.003 <sup>c</sup>	1.72±0.12 <sup>b</sup>	12.32±0.24 <sup>c</sup>
Peel 10%	0.049±0.003 <sup>d</sup>	1.53±0.09 <sup>a</sup>	9.06±0.18 <sup>a</sup>
Pulp 5%	0.021±0.002 <sup>a</sup>	1.82±0.16 <sup>bc</sup>	18.17±0.19 <sup>b</sup>
Pulp 7.5%	0.030±0.002 <sup>b</sup>	1.85±0.09 <sup>c</sup>	15.09±0.12 <sup>c</sup>
Pulp 10%	0.041±0.003 <sup>c</sup>	1.86±0.08 <sup>c</sup>	10.80±0.26 <sup>f</sup>

Means with different superscripts in a column differ significantly ( $P \leq 0.05$ ).



Control chicken rolls had TBA value of 1.84 mg malondehyde/kg (Table 4) (Figure 10). There was a decrease in TBA value but only after 7.5 and 10% level of peel addition. Lowest TBA value (1.53) was observed in 10% peel added chicken rolls.

Control chicken rolls were prepared after addition of sodium nitrite at 150 ppm in emulsion. After cooking, 21.44 mg/kg residual nitrite was observed in control chicken rolls (Table 4) (Figure 11). In treated rolls, level of residual nitrite decreased significantly. Residual nitrite level was lower in peel containing rolls than those having pulp. Lowest residual level i.e. 9.06 mg/kg was observed in 10% peel containing rolls.

#### 4.5 Sensory analysis of chicken meat rolls

Scores of colour, flavour, texture, tenderness, juiciness and overall acceptability of rolls have been presented in table 5. On addition of peel and pulp at 5, 7.5 and 10% levels, no significant difference were observed in texture, tenderness and juiciness of treated rolls. Decline in colour scores was observed on *kinnow* peel and pulp addition but it was non significant. Flavour scores showed significant decline in treated chicken rolls. Control rolls had flavour score of 8.50 which decreased to 6.50 after 7.5% and 10% addition of peels. Pulp containing rolls showed higher flavour scores than peel containing rolls. Overall acceptability score of control rolls was 8.33 which declined progressively and significantly as the level of peel increased. Overall acceptability scores of pulp added rolls did not differ significantly from control.

**Table 5: Sensory scores of chicken meat rolls with *kinnow* peel and pulp (n=6).**

Treatments	Colour	Flavour	Texture	Tenderness	Juiciness	Overall acceptability
Control	8.33±0.52	8.50±0.45 <sup>d</sup>	7.83±0.41	7.33±0.61	7.75±0.27	8.33±0.41 <sup>d</sup>
Peel 5%	8.00±0.32	7.33±0.82 <sup>bc</sup>	7.50±0.55	7.83±0.61	7.66±0.52	7.25±0.69 <sup>bc</sup>
Peel 7.5%	7.66±0.52	6.50±0.55 <sup>a</sup>	7.66±0.52	7.83±0.26	7.66±0.41	6.83±0.98 <sup>ab</sup>
Peel 10%	7.58±0.38	6.50±0.55 <sup>a</sup>	7.83±0.41	8.16±0.41	8.00±0.45	6.33±0.93 <sup>a</sup>
Pulp 5%	8.00±0.32	7.66±0.61 <sup>bc</sup>	7.66±0.52	7.58±0.38	7.66±0.41	8.33±0.51 <sup>d</sup>
Pulp 7.5%	7.66±0.52	7.66±0.82 <sup>bc</sup>	8.00±0.32	7.33±0.88	7.83±0.61	7.83±0.41 <sup>cd</sup>
Pulp 10%	7.66±0.61	7.33±0.82 <sup>bc</sup>	7.66±0.41	7.50±0.45	7.83±0.61	8.00±0.45 <sup>d</sup>

Means with different superscripts in a column differ significantly ( $P \leq 0.05$ ).

#### 4.6 Total plate count (TPC) of chicken meat rolls

Results pertaining to total plate count of control and treated chicken rolls stored at  $4 \pm 1^\circ\text{C}$  are presented in table 6. Control rolls had TPC of 3.63 log cfu/g on 0 day and it did not differ from treated rolls at 0 day or even up to 12 day of storage.

There was an increase in TPC during storage and it reached up to 5.98, 6.10 and 6.17 log cfu/g in control, 5% peel and 10% pulp containing rolls respectively on 12<sup>th</sup> day of storage.

**Table 6: Total plate count (log cfu/g) of chicken meat rolls with *kinnow* peel and pulp stored at 4±1<sup>0</sup>C (n=3).**

Day	Control	Peel 5%	Pulp 10%
0 Day	3.63±0.37 <sup>a</sup>	3.59±0.41 <sup>a</sup>	3.72±0.39 <sup>a</sup>
3 Day	4.01±0.38 <sup>ab</sup>	4.13±0.41 <sup>ab</sup>	3.98±0.57 <sup>a</sup>
6 Day	4.86±0.62 <sup>bc</sup>	4.79±0.33 <sup>bc</sup>	4.68±0.82 <sup>ab</sup>
9 Day	5.20±0.33 <sup>cd</sup>	5.34±0.41 <sup>cd</sup>	5.44±0.67 <sup>bc</sup>
12 Day	5.98±0.75 <sup>d</sup>	6.10±0.27 <sup>d</sup>	6.17±0.46 <sup>c</sup>
15 Day	–	–	–

Means with different superscripts in a column differ significantly (P≤0.05).

-Samples spoiled.

#### 4.7 Sensory scores during storage at 4±1<sup>0</sup>C

Results of sensory analysis of control and treated chicken rolls during storage are presented in table 7 (colour and flavour), table 8 (texture and tenderness) and table 9 (juiciness and overall acceptability).

**Table 7: Sensory scores of chicken meat rolls added with *kinnow* peel and pulp stored at 4±1<sup>0</sup>C (n=6).**

Day	Control	Peel 5%	Pulp 10%
<b>COLOUR</b>			
0 Day	8.33± 0.52	8.00±0.32 <sup>b</sup>	7.66±0.61 <sup>b</sup>
3 Day	8.50±0.82	8.33±0.41 <sup>b</sup>	7.66±0.82 <sup>b</sup>
6 Day	8.33±0.52	8.00±0.00 <sup>b</sup>	7.66±0.52 <sup>b</sup>
9 Day	7.83±0.82	7.83±0.32 <sup>ab</sup>	7.00±0.55 <sup>a</sup>
12 Day	7.83±0.52	7.33±0.82 <sup>a</sup>	7.00±0.55 <sup>a</sup>
<b>FLAVOUR</b>			
0 Day	8.50±0.45 <sup>bB</sup>	7.33±0.82 <sup>bcA</sup>	7.33±0.82 <sup>A</sup>
3 Day	8.50±0.45 <sup>bc</sup>	7.66±0.52 <sup>cB</sup>	7.08±0.38 <sup>A</sup>
6 Day	8.00±0.32 <sup>abB</sup>	7.33±0.88 <sup>bcA</sup>	7.33±0.68 <sup>A</sup>
9 Day	8.33±0.41 <sup>abB</sup>	7.00±0.55 <sup>abA</sup>	7.00±0.55 <sup>A</sup>
12 Day	8.00±0.00 <sup>abB</sup>	6.58±0.38 <sup>aA</sup>	7.00±0.49 <sup>A</sup>

Means with different small superscripts in a column and capital superscripts in a row in each group differ significantly (P≤0.05).

### Colour and flavour

Control chicken rolls had colour score of 8.33. Rolls added with peel and pulp did not show significant difference in colour scores from that of control when fresh and subsequently during storage up to 12 days. There was a significant decline in colour scores during storage of peel and pulp containing chicken rolls. Decline in colour scores of control rolls was non-significant.

Control rolls had significantly higher flavour score (8.50) than 5% peel (7.33) and 10% pulp (7.33) added chicken rolls. No significant difference was observed between flavour scores of 5% peel and 10% pulp added rolls. This pattern was maintained throughout the storage period. Significant decline was observed during storage in flavour scores of control and 5% peel added rolls. In 10% pulp added rolls, decline was non-significant up to 12<sup>th</sup> day.

### Texture and tenderness

No significant difference in texture scores was observed in control and treated rolls at 0 day and up to 12<sup>th</sup> day of storage. Storage up to 12 day also did not result any significant change in texture scores of control and treated rolls.

Tenderness score of 5% peel added rolls was 7.83 followed by 10% pulp (7.50) and control (7.33) rolls. Tenderness scores declined to 7.00 in control and to 6.83 in 10% pulp added rolls on 9<sup>th</sup> day of storage, whereas, score of 7.00 was observed on 12<sup>th</sup> day in 5% peel added rolls.

**Table 8: Sensory scores of chicken meat rolls added with *kinnow* peel and pulp stored at 4±1<sup>o</sup>C**

Day	Control	Peel 5%	Pulp 10%
<b>TEXTURE</b>			
0 Day	7.83±0.41	7.50±0.55	7.66±0.41
3 Day	7.66±0.52	7.66±0.52	7.92±0.49
6 Day	8.00±0.32	8.00±0.32	7.66±0.75
9 Day	7.66±0.52	7.62±0.58	7.00±0.55
12 Day	7.66±0.75	7.66±0.75	7.83±0.41
<b>TENDERNESS</b>			
0 Day	7.33±0.61 <sup>bc</sup>	7.83±0.61 <sup>b</sup>	7.50±0.45 <sup>d</sup>
3 Day	7.50±0.55 <sup>c</sup>	7.58±0.58 <sup>ab</sup>	7.33±0.61 <sup>cd</sup>
6 Day	7.08±0.74 <sup>abc</sup>	7.08±0.38 <sup>a</sup>	7.00±0.32 <sup>bc</sup>
9 Day	7.00±0.55 <sup>abc</sup>	7.08±0.49 <sup>a</sup>	6.83±0.41 <sup>b</sup>
12 Day	6.50±0.32 <sup>a</sup>	7.00±0.32 <sup>a</sup>	6.00±0.45 <sup>a</sup>

Means with different superscripts in a column in each group differ significantly (P≤0.05).

### Juiciness and overall acceptability

Juiciness scores of control (7.75), 5% peel (7.66) and 10% pulp (7.83) added rolls did not differ at either 0 day or during storage up to 12<sup>th</sup> day. In control and 10% pulp rolls, juiciness scores declined below 7.00 on 12<sup>th</sup> day, whereas, 5% peel rolls showed score of 7.00 even on 12<sup>th</sup> day of storage.

**Table 9: Sensory scores of chicken meat rolls added with *kinnow* peel and pulp stored at 4±1<sup>0</sup>C (n=6)**

Day	Control	Peel 5%	Pulp 10%
<b>JUICINESS</b>			
0 Day	7.75±0.27 <sup>c</sup>	7.66±0.52	7.83±0.61 <sup>c</sup>
3 Day	7.33±0.61 <sup>b</sup>	7.50±0.45	7.50±0.45 <sup>bc</sup>
6 Day	7.50±0.55 <sup>b</sup>	7.33±0.52	7.00±0.45 <sup>ab</sup>
9 Day	7.00±0.55 <sup>ab</sup>	7.00±0.45	7.00±0.45 <sup>ab</sup>
12 Day	6.58±0.32 <sup>a</sup>	7.00±0.77	6.83±0.61 <sup>a</sup>
<b>OVERALL ACCEPTABILITY</b>			
0 Day	8.33±0.41 <sup>cB</sup>	7.25±0.69 <sup>A</sup>	8.00±0.45 <sup>B</sup>
3 Day	8.50±0.45 <sup>cB</sup>	7.00±0.45 <sup>A</sup>	7.66±0.61 <sup>A</sup>
6 Day	8.00±0.32 <sup>bcC</sup>	7.00±0.45 <sup>A</sup>	7.66±0.52 <sup>BC</sup>
9 Day	7.66±0.52 <sup>b</sup>	7.33±0.52	8.00±0.32
12 Day	7.00±0.55 <sup>a</sup>	7.00±0.77	7.33±0.61

Means with different small superscripts in a column and capital superscripts in a row in each group differ significantly ( $P \leq 0.05$ ).

Overall acceptability was highest in control, followed by 10% pulp and 5% peel added rolls. This trend was maintained up to 6 days of storage. Thereafter, differences became insignificant and scores reached around 7.00 in all types of rolls.

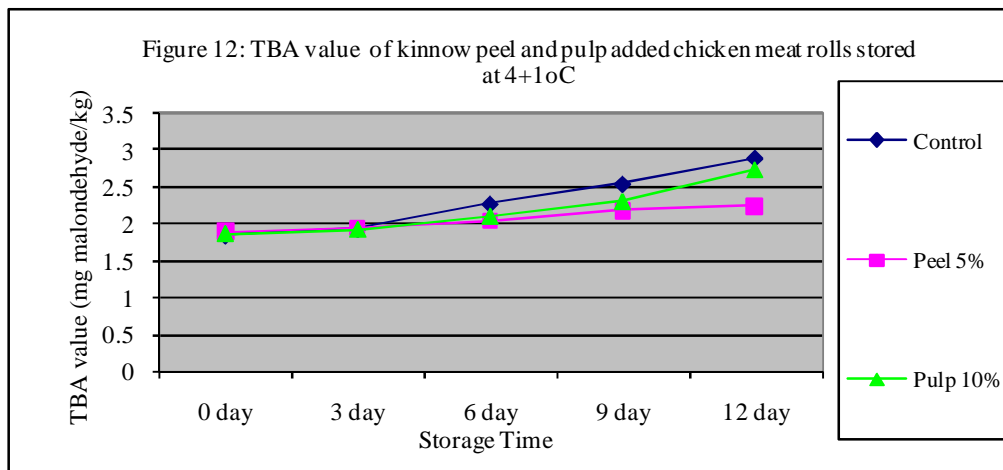
### 4.8 TBA values of chicken rolls during storage

There was no significant difference in TBA (Table 10) (Figure 12) value of control (1.84 mg malondehyde/kg), 5% peel (1.89) and 10% pulp (1.86) added rolls on 0 day. This trend was also apparent on 3<sup>rd</sup> day of storage. There was a significant increase in TBA values during storage and on 12<sup>th</sup> day, values increased to 2.89, 2.24 and 2.74 mg malondehyde/kg in control, 5% peel and 10% pulp added rolls, respectively.

**Table 10: TBA values (mg malondehyde/kg) of *kinnow* peel and pulp added chicken meat rolls stored at 4±1<sup>0</sup>C (n=6).**

Day	Control	Peel 5%	Pulp 10%
0 Day	1.84±0.05 <sup>a</sup>	1.89±0.07 <sup>a</sup>	1.86±0.08 <sup>a</sup>
3 Day	1.93±0.04 <sup>a</sup>	1.94±0.05 <sup>a</sup>	1.92±0.03 <sup>b</sup>
6 Day	2.27±0.09 <sup>b<sup>c</sup></sup>	2.03±0.04 <sup>b<sup>A</sup></sup>	2.10±0.04 <sup>c<sup>B</sup></sup>
9 Day	2.54±0.16 <sup>c<sup>C</sup></sup>	2.17±0.08 <sup>c<sup>A</sup></sup>	2.30±0.05 <sup>d<sup>B</sup></sup>
12 Day	2.89±0.10 <sup>d<sup>C</sup></sup>	2.24±0.05 <sup>d<sup>A</sup></sup>	2.74±0.07 <sup>e<sup>B</sup></sup>

Means with different small superscripts in a column and capital superscripts in a row differ significantly ( $P \leq 0.05$ ).



Results obtained after chemical, physico-chemical, microbiological and sensory analysis have been suitably discussed in this chapter.

### **5.1 Composition of peel and pulp**

Moisture content of pulp was significantly higher (Table 1) than peel indicating that substantial amount of moisture still remained after juice extraction. Higher fat content of peel was due to presence of oils. The low pH of both peel and pulp can be attributed to organic acids present in citrus fruits (Aleson-Carbonell *et al.*, 2004). Gorinstein *et al.* (2001) observed that citrus peel contained 65% higher dietary fibre than peeled fruits. Their finding corroborates this study where crude fibre content of peel was almost double to that of pulp. Peel had higher polyphenols than pulp. Similar level of polyphenols in citrus have earlier been reported (Mehta and Bajaj, 1984; Oboh and Ademosun, 2006; Devatkal *et al.*, 2010). Higher polyphenol content in peel than pulp has been reported earlier (Belitz and Grosch, 1999; Sun *et al.*, 2002; Kroyer, 2009).

### **5.2 Proximate composition of chicken meat rolls**

Significantly higher moisture content of fibre added chicken rolls (Table 2) was due to ability of the fibre to absorb and retain moisture. Similar observations have been reported by many workers (Garcia *et al.*, 2002; Fernandez-Gines *et al.*, 2004; Aleson-Carbonell *et al.*, 2004). Chicken rolls with peel showed higher moisture content than those with pulp because peel had higher fibre content resulting into more moisture retention. Decrease in protein and fat content in *kinnow* peel and pulp added rolls were due to quantitative increase in moisture content. Increase in ash content in treated rolls can be attributed to high inorganic matter of plant source. Presence of crude fibre in *kinnow* peel and pulp resulted in the detection of crude fibre in chicken rolls. As the level of peel and pulp increased, crude fibre in chicken rolls correspondingly increased. Peel added rolls showed higher fibre content due to higher fibre content of peel than pulp. Increase in fibre content in meat products due to incorporation of orange waste has been reported earlier (Fernandez-Gines *et al.*, 2003, 2004; Aleson-Carbonell *et al.*, 2004).

### 5.3 Physico-chemical properties

Although the pH of peel (4.84) and pulp (4.31) (Table 1) was quite low yet, no significant difference was observed in pH of control and treated rolls (Table 3). Similar observations have been observed by Fernandez-Gines *et al.*, (2004). They suggested that cooking favoured the leaching out of organic acids present in lemon albedo. As cooking process itself increases the pH due to breaking down of cellular buffer and release of free fat (Schweigert, 1994), probably peel and pulp decreased the pH but cooking countered the effect.

Decrease in cooking loss in fibre added rolls can be attributed to water retaining properties of fibre. Fibre is known to retain the moisture in meat products (Cofrades *et al.*, 2000; Garcia *et al.*, 2002). Aleson-Carbonell *et al.* (2004) attributed it to high water retention ability of pectin present in lemon albedo. Lower cooking loss in peel containing rolls than pulp added rolls in the present study is an indicator of water retaining ability of fibre as peel contained higher fibre content than pulp.

Decrease in shear press value in fibre added rolls can be attributed to high water retention ability of fibre. Similar results have been reported in dry fermented sausages (Garcia *et al.*, 2002) and non dry fermented sausages (Aleson-Carbonell *et al.*, 2004).

### 5.4 Polyphenols, TBA and residual nitrite in chicken rolls

Peel and pulp which were added to chicken rolls had a polyphenol content of 2.58 and 1.88 mg/g respectively (Table 1). This resulted in presence of polyphenols in chicken rolls (Table 4). As the level of addition increased, polyphenol content also increased in treated rolls. Due to higher polyphenolic content of peels, chicken rolls with peels showed more polyphenols than pulp containing chicken rolls.

There was a decline in TBA values of treated chicken rolls. This decrease can be attributed to presence of polyphenols which are known to have antioxidant properties (Wang *et al.*, 1996; Oboh and Ademosun, 2006; Devatkal *et al.*, 2010). Aleson-Carbonell *et al.* (2004) suggested that associated bioactive compounds present in lemon albedo were responsible for lower TBA values in fermented dry sausages.

Reduction in residual nitrite level of peel and pulp added rolls was observed. Some polyphenolic compounds show high protection against nitrite ions and prevent nitrosamines formation in foods (Krishnaswamy, 2001; Garrote *et al.*, 2004). Many workers have reported that residual nitrite level decreased in meat products due to presence of citrus byproducts (Fernandez-Gines *et al.*, 2003; 2004; Fernandez-Lopez *et al.*, 2007; Viuda-Martos *et al.*, 2010). Reduction in residual nitrite has been

attributed to reaction of nitrite with active biocompounds present in orange alebdo (Aleson-Carbonell *et al.*, 2004). In the present study, higher polyphenol content of peels resulted in significantly lower residual nitrite in peel than pulp containing chicken rolls.

### **5.5 Sensory analysis of chicken meat rolls**

Though the scores declined yet, no significant difference was observed in colour scores of control and treated chicken meat rolls (Table 5). Scores of treated rolls were still higher than 7.00 indicating moderate acceptability.

Texture of the treated products was not affected by addition of peel and pulp. Considerably high texture scores of 7.5 and above were observed in treated rolls indicating that fibre addition did not adversely affect the acceptability with regard to texture.

Tenderness and juiciness scores of treated rolls were almost equal to that of control, showing good acceptability of the *kinnow* fibre in chicken meat rolls. Shear press value (Table 3) indicated that tenderness increased yet the taste panelist were unable to perceive improvement in tenderness probably because chicken meat roll prepared in the present study was emulsion based and already very tender.

Flavour was adversely affected, especially in case of peel added rolls and scores decreased below 7.00 at 7.5 and 10% levels. Flavour scores of pulp added rolls were significantly higher than peel added rolls. It may be due to pungent flavour of oils present in peel.

Peel was acceptable up to 5% level and thereafter, overall acceptability score of rolls dropped below 7.00. On the other hand acceptability of pulp in rolls was up to 10% level. Reasons behind this may be the flavour, which is one of the most dominating characteristic in acceptance of meat products. Varied results have been indicated in literature on effect of fibre addition to meat products. Maintenance of texture similar to control sausages by addition of orange fibre has been reported by Garcia *et al.* (2002). Increase in hardness was reported by Fernandez-Gines *et al.* (2004). Based up on overall acceptability, chicken meat rolls with 5% peel and 10% pulp were selected for storage studies.

### **5.6 TPC of chicken meat rolls**

TPC of control and treated fresh rolls was around 3.5 log cfu/g (Table 6). No significant difference was observed among control, 5% peel and 10% pulp containing rolls on 0 day or even up to 12 day of storage. Organic acids present in raw peel and pulp might have leached out during cooking (as evident by similar pH of control and treated chicken rolls) and failed to exert any antibacterial effect. Proliferation of microbes was noticed in all types of chicken rolls during storage and

the TPC touched around 6 log cfu/g on 12<sup>th</sup> day of storage in control as well as treated chicken rolls. All the products were microbiologically acceptable up to 12<sup>th</sup> day, as the meat products are reported spoiled when microbial population exceeds 10<sup>-6</sup> or more (Frazier and Westhoff, 1978). Hence TPC, sensory analysis and TBA analysis were not carried out on 15<sup>th</sup> day.

### **5.7 Sensory analysis during storage at 4±1°C**

Sensory scores of chicken rolls during storage have been discussed in Table 7, 8 and 9.

#### **Colour and Flavour**

Although colour scores declined in all types of rolls yet, ultimate colour scores were above 7.00 i.e. moderately acceptable, indicating that all the chicken rolls were acceptable up to 12 days of storage with regard to colour (Table 7).

There was a significant decline in flavour of control rolls but still score was 8.00 i.e. liked very much on 12<sup>th</sup> day. In 5% peel added rolls, flavour score went below 7.00 on 12<sup>th</sup> day of storage (6.58) and were acceptable up to 9<sup>th</sup> day only, whereas, in case of 10% pulp added rolls, acceptable flavour score of 7.00 was observed even on 12<sup>th</sup> day. High concentration of plant compounds in peel may have deteriorated at a faster rate resulting in adverse flavour at 12<sup>th</sup> day.

#### **Texture and tenderness**

Texture of meat products is mainly dependent on type of meat, level of comminution, presence of fat, binders etc. As these factors remained constant through out storage, no significant decline was observed in texture of control as well as treated chicken meat rolls (Table 8).

No significant difference was observed in tenderness scores of control and treated chicken rolls. On storage, tenderness scores declined significantly in control as well as peel and pulp added rolls. Acceptable scores of around 7.00 were observed in control and 10% pulp added rolls on 9<sup>th</sup> day, whereas, 5% peel added rolls had score of 7.00 up to 12<sup>th</sup> day. Higher fibre content present in 5% peel than 10% pulp rolls was able to retain more water during storage, resulting into higher tenderness scores than control and pulp added rolls.

#### **Juiciness and overall acceptability**

Decline in juiciness was much faster (Table 9) during storage in control and 10% pulp added chicken meat rolls and scores declined below 7.00 which is considered acceptable score on 12<sup>th</sup> day. Juiciness score of 5% peel added rolls was still maintained up to 12<sup>th</sup> day (7.00) as no significant difference from control was observed from 0 day. It was probably due to higher fibre content of peel resulting into higher ability to retain moisture.

Overall acceptability scores were around 7.00 on 12<sup>th</sup> day of storage indicating that all the products were acceptable up to 12<sup>th</sup> day of storage. Although flavour scores of 5% peel added rolls were less than 7.00 on 12<sup>th</sup> day yet, good scores of juiciness and tenderness i.e. 7.00 contributed to overall acceptability of this product up to 12<sup>th</sup> day of storage.

#### **5.8 TBA values of chicken rolls during storage**

Increase in TBA value in all the products indicated the development of oxidative rancidity (Table 10). Oxidative deterioration in muscle lipids involves oxidation of polyunsaturated fatty acids. Hydroperoxides, the major initial oxidative products, decompose to form low molecular weight volatile compounds and affect flavour of the product. TBA values increased during storage and reached up to 2.89 in control to 2.24 in 5% peel and 2.74 mg malondehyde/kg in 10% pulp added rolls. Maximum increase was observed in control, followed by pulp and peel containing chicken meat rolls. Treated rolls showed significantly lower increase in TBA value than control chicken rolls. This effect can be attributed to presence of polyphenols in *kinnow* peel and pulp (Table 1) which are known to have antioxidant effect (Wang *et al.*, 1996; Oboh and Ademosun, 2006). Peel was more effective in retarding the development of oxidative rancidity during storage than pulp as rolls with 5% peel showed significantly lower TBA values than those with pulp. It can be attributed to higher polyphenolic content of *kinnow* peel than pulp.

A study was conducted to find out the effect of incorporation of *kinnow* (*Citrus reticulata*) waste on chemical, physico-chemical, microbiological and sensory characteristics of chicken meat rolls. Peel and pulp were incorporated at 5, 7.5 and 10% levels each. Product was stored at  $4\pm 1^{\circ}\text{C}$  for 15 days and samples were drawn at an interval of 3 days to assess the shelf life.

*Kinnow* pulp (after juice extraction) had higher moisture content than peel. Fat and ash content of pulp were lower than peel. Crude fibre content of peel was almost double than that of pulp. The pH and polyphenol content of peel were higher than pulp.

Addition of peel and pulp resulted in an increase in crude fibre content of chicken rolls. Highest fibre content (1.27%) was observed in rolls with 10% peel. Chicken rolls with peel and pulp showed higher moisture content than control due to water retention ability of fibre. Chicken rolls with peel had significantly higher moisture than those with pulp. Protein and fat content significantly declined in treated chicken meat rolls.

The pH of chicken meat rolls was unaffected by addition of peel and pulp. There was a decrease in cooking loss and shear press value of peel and pulp added chicken meat rolls as a result of moisture retention by fibre.

Increase in polyphenolic content in treated rolls resulted in lower TBA value and residual nitrite levels. Peel was more effective in reducing TBA value than pulp due to higher polyphenolic content.

Peel was acceptable organoleptically up to 5% and pulp up to 10% level of addition. Flavour of chicken rolls was adversely affected at higher level of peel (7.5 and 10%) addition.

Total plate count of control and treated chicken rolls did not differ significantly. Shelf life of all the types of chicken rolls was up to 12 days.

Sensory scores declined during storage but tenderness and juiciness were maintained in chicken rolls with 5% peel up to 12 days due to higher moisture retention. However, all the types of rolls i.e. control, with 5% peel and 10% pulp had overall acceptability scores of 7.00 and above up to 12<sup>th</sup> day of storage.

There was an increase in TBA value of all the chicken rolls during storage, indicating development of oxidative rancidity. However, polyphenols present in peel

and pulp were able to check the rise in TBA value of treated rolls during storage. Due to higher level of polyphenols, TBA value was lowest in peel added rolls followed by pulp added and control rolls on 12<sup>th</sup> day of storage.

It is concluded that addition of peel and pulp of *kinnow* (*Citrus reticulata*) increases the fibre and polyphenol content of chicken meat rolls resulting into improvement of processing characteristics and decrease in residual nitrite and oxidative rancidity. However, fresh peel and pulp do not substantially enrich the chicken rolls with fibre. Hence, their use in dried form may give improved result with regard to fibre enrichment.

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## ABSTRACT

Title of thesis : **“Utilization of citrus fruit waste for development of chicken meat roll”**

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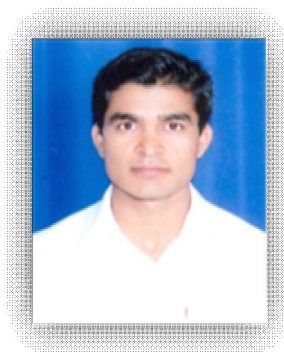
A study was conducted to assess the utility of *kinnow* (*Citrus reticulata*) waste in development of chicken meat rolls. Fresh peel and pulp of *kinnow* were incorporated at 5, 7.5 and 10% levels each. Chemical, physico-chemical, microbiological and sensory characteristic were evaluated. Product was stored at  $4\pm 1^{\circ}\text{C}$  for shelf life study. Peel had higher crude fibre and polyphenol content than pulp. Addition of peel and pulp increased the moisture, crude fibre and polyphenol content of chicken meat rolls. As a result of moisture retention ability of fibre, cooking loss and shear press value of treated chicken rolls decreased. Chicken rolls with peel and pulp showed lower residual nitrite level. Peel, due to its higher fibre and polyphenolic content was more effective in improving the processing characteristics of chicken rolls. Peel was acceptable organoleptically up to 5% and pulp up to 10% level of addition. Control and treated products (5% peel and 10% pulp added rolls) had overall acceptability scores of 7.00 and above up to 12<sup>th</sup> day of storage. Peel and pulp addition was able to check the rise in TBA value in treated products during storage. All the products were microbiologically acceptable up to 12<sup>th</sup> day. It is concluded that 5% peel and 10% pulp of *kinnow* in chicken meat rolls can be incorporated for improving the fibre and polyphenol content and processing characteristics of chicken meat rolls. However, peel and pulp in dried form may yield better result than fresh form, for further increasing the fibre content of meat product up to substantial level.

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