Improvement of Chemical and Sensory Properties of Sheep Meat by Kiwi Powder Treatment

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Abstract

Kiwi (*Actinidia chinensis* planch or *Actindia deliciosa*) is a climbing vine with fuzzy edible fruit belonging to the actinidiacea family. The high levels of vitamin C, E and K, dietary fibers, phenols, flavonoids, and antioxidants present in the green meat of kiwi fruit can reduce the risk of different disorders such as cancer and cardiovascular disease. It also increases resistance to many other diseases. The aim of this study was to evaluate the possible effects of 15% kiwi powder on protein changes, degree of hydrolysis, peptide chain length, pH, cooking loss, and sensory evaluation of sheep meat to tender it. To prepare the meat for treatment, it was cut into 3 cm cubic pieces by a clean knife and immersed in kiwi powder mixture. It was subjected to different tests at time periods of 4, 12 and 24 hours. The control sample was untreated pure sheep meat pieces. The results were analyzed by SPSS software and paired-sample T Test. According to the findings, protein content and peptide chain length decreased significantly with time, while the degree of hydrolysis and cooking loss increased significantly (after 24h) ($p<0.05$). The highest general acceptance score was for the 24-hour treatment. By adding kiwi powder, based on the amount of actinidine enzyme present, the solubility level of meat proteins increases and its sensory and mechanical properties are improved.

Key words: *Kiwi, Sheep meat, Texture properties.*

Introduction

The most important nutritional requirements of humans is protein, and the most significant and valuable sources of proteins and minerals is Red meat and its products (Hinkel,2010). Red meat has a great importance in human diet due to its high protein content, and a proper and balanced composition of the most essential nutrients such as amino acids, fatty acids, vitamins and minerals (Mohamadi and Bolandi,2017). In addition, meat quality plays a crucial role in market acceptance. Five factors taste, texture, juiciness, appearance and color effect the quality of meat. The main objective of modern food technology is to manufacture new food products with features acceptable to consumers (Mohamadi and Bolandi,2017). The annual cost of the

200-300 million dollars meat in the united states shows the importance of this industry (Karimi and Oghabi,2008). In recent years, meat tenderness has been one of the most important factors in meat selection by consumers rapid cooling of the carcass using cold air has been utilized to reduce microbial growth on the carcass surface and to minimize weight loss resulting from water evaporation from meat tissue On the other hand, rapid cooling has an adverse effect leading to muscle shortening and firmness of the meat. The undesirable effects of rapid cooling on the tenderness of meat has been reported for three decades (Karimi and Oghabi,2008).

several studies have been carried out on the factors affecting the meat tenderness after slaughtering the livestock. Generally, five factors taste, texture, juiciness, appearance and color effect the quality of meat. Among these factors, consumers consider texture as the most important factor (Karimi and Oghabi,2008).

Kiwi (*Actinidia chinensis* planch or *Actindia deliciosa*) is a climbing vine with fuzzy edible fruit belonging to the actinidiacea family. This plant is native to china and Taiwan, and is used in the therapy of mental depression, diabetes, jaundice, urinary stones and joint inflammation (Enminger A.H and Enminger M.J.E.,1986). The green meat of kiwi fruit is a healthy food source and contains high levels of vitamin C, E and K, dietary fibers, phenols, flavonoids, and antioxidants. The fresh fruit of kiwi contains 100 to 400 mg per 100 g of vitamin C and 8 to 14% carbohydrates. Its acidity is 1 to 2, which is mainly due to the presence of citric acid (Feeneny and Whitaker,1986; Mailler,1998).

Kiwi fruit is a rich source of proteolytic enzymes that can be used in the elevation of meat tenderness (Whitaker,1969). One of the enzymes extracted from the edible kiwi fruit is Actinidine with a molecular weight of 30000 Dalton. It belongs to the sulfidryl protease family, which includes papain and papain-like enzymes used in meat treatment process (Carne and Moor, 1973;Lewis and Lub,1988).

In this study, the treatment of sheep meat with kiwi fruit powder is investigated and its effects on protein changes, texture, water displacement, degree of hydrolysis, peptide chain length, pH, cooking loss and sensory properties of meat are evaluated.

Materials and methods

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Fresh meat was prepared from the sheep thigh. Kiwi (*Actinidiaceae chinensis*) fruit was purchased from a local shop in the shirazcity. Poly ethylene containers for storing and treating meat, and plastic for packing the containers were prepared.

After washing and peeling, the kiwi fruits were cut by a special cutter into slices 6-8 mm thick. They were immersed in 1% citric acid for 5 minutes, and rinsed in distilled water. Their surface moisture was removed with a paper towel and dried in the oven at 65 °C until their moisture contentreached a minimum. The dried kiwi fruit was milled in to a fine powder (Carncel *et al*.,1973). To treat meat, 5 g of this powder was mixed with 15 ml distilled water.

The sheep meat was cut into 3 cm cube pieces by a sharp knife . About 600 g of this chopped meat was set aside to be used as the control, and the rest (about 1800 g) was immersed in kiwi powder mixture. The control and treatment samples were immediately packaged in containers, covered with thermo plastic and kept at 0-4 °C in a refrigerator to be tested later. The tests were performed at 4, 12 and 24 hours after treating the meat.

Protein measurements were performed using completely automatic Kjeldal digestion method (Analyzer unit 2300) (AOAC,2005).To measure the degree of hydrolysis, 5 ml of the meat sample was mixed with 5 ml of 20% trichloroacetic acid. After stirring for 5 minutes, it was centrifuged at 3200 rpm for 10 minutes. The level of protein was measured in the solution phase and the degree of hydrolysis was calculated using the following equation (Fonkwe and Singh,1996):

$$DH=100\times\frac{\text{Proteins dissolved in 10\% solution of TCA}}{\text{Total solution of sample proteins}}$$ (Aktas and Kaya,2001)

The peptide chain length was calculated using the following formula (Kristinsson and Rasco,2000):

$$\text{Peptide chain Length}=\frac{10}{\text{Hydrolysis degree}}$$ (AOAC,2005)

The cooking loss was determined by weighing the meat before and after baking at 90 °C for 10 minutes (Emadzadeh *et al.*,2017).

For the sensory tests, samples were prepared using dry baking method (Zeola *et al*,2003). Taste, color and overall acceptance were evaluated by 6 sensory evaluators. Taste referees were trained to improve the ability to recognize sensory traits and they were asked to evaluate the samples using a nine-point hedonic test (Emadzadeh *et al.*,2017).

Statistical Analysis

All experiments were carried out in a completely randomized design with 3 replications. Statistical analysis was performed using descriptive statistics and paired-sample T Test in SPSS software (version 18).

Results

The findings of this study are shown in tables 1 and 2.

Table 1. Changes in Protein level, Degree of Hydrolysis, Peptide Chain Length, pH and Cooking loss during the treatment of sheep meat with kiwi powder

samples	Protein	Hydrolysis degree	peptide chain length	pH	cooking loss
The Control (pure meat)	18.59^{a}	3.55^{d}	28.405^{a}	5.61^{a}	36.647^{d}
Meat treated with kiwi powder for 4 hours	17.99^{b}	4.21^{c}	23.893^{b}	4.85^{b}	59.246^{a}
Meat treated with kiwi powder for 12 hours	17.143^{c}	4.793^{b}	20.95^{c}	4.58^{b}	54.123^{b}
Meat treated with kiwi powder for 24 hours	16.6^{d}	5.477^{a}	18.323^{d}	4.527^{b}	45.32^{c}

No significant difference (p>0/05) is indicated by similar letters.

Table 2. Sensory evaluation of sheep meat after treatment with kiwi powder

samples	Taste (Score)	Color (score)	General acceptance (score)
The Control (pure meat)	3.667^{d}	9.0^{a}	4.333^{d}
Meat treated with kiwi powder for 4 hours	7.0	7.333^{b}	5.0^{c}
Meat treated with kiwi powder for 12 hours	8.33^{a}	5.3^{c}	5.667^{b}
Meat treated with kiwi powder for 24 hours	5.0^{c}	6.33^{d}	8.23^{a}

No significant difference (p>0/05) is indicated by similar letters.

Discussion

The findings of sheep meat treatments are presented in table 1. As seen, the kiwi fruit treatment had a significant effect on meat, and the levels of protein in experimental samples showed a significant difference with each other ($p<0.05$). With time passing, the level of protein declined in the treated meat samples. The decrease observed in the level of protein is due to the conversion of proteins to dissolved nitrogen during meat maintenance (Lehmann and Aubourg, 2007). Adding salt and proteases to meat creates high ionic strength in the environment, which dissolves and creates distance between the protein fibers leading to an increase in the solubility of proteins. The soluble portions of the sarcoplasmic proteins are better open from each other.

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Along with the rise in ionic strength, the degree of dissolution of myofibril proteins also increases due to the exchange between the decomposed ions and the proteins polar groups.With proteolytic enzymes activity, proteins are broken and converted into units with a smaller molecular weight. The results of other researchers indicate high levels of protein hydrolysis in meat (Kristinsson and Rasco,2000;Ovissipour *et al*.,2010)confirming the results of this study.

According to the results shown in Table1, the treated samples had significant differences at 5% level ($p<0.05$). With passing time, the degree of hydrolysis increases. In a study on the interaction effects of the papain enzyme activity and the duration of its action on myofibril proteins, it was found that by increasing the activity of the enzyme with time, its effect on the degree of hydrolysis is increased (Motamedzadegan *et al*.,2009). The results of many other studies also show that increasing hydrolysis time cause increases the degree of hydrolysis (Cao *et al.*,2008; Kristinsson and Rasco,2000;Ovissipour *et al*.,2010;Shahidi *et al*., 1995).

According to the information in table 1, the sheep meat treatments had significant difference at 5% level ($p<0.05$). With increasing time, the peptide chain length was reduced. In the study on the effect of papain enzyme on the approximate mean peptide chain length obtained from the Kilka fish hydrolysis, Motamedzadegan *et al*. (2009) reported that this property is not affected by temperature, rather it is a second-degree function of the enzyme activity and its time effect. In general, by increasing the activity of proteolytic enzymes, it is possible to elevate the production efficiency of soluble nitrogen (soluble protein) (Kristinsson and Rasco,2000). The results of this study indicate that the peptide chain length average is influenced by the activity of the enzyme and the duration of its effect.

As seen in Table 1, there is significant differences among cooking loss results of all treated samples ($p<0.05$). The lowest amount of cooking loss was related to the control (36/647), and the highest amount belonged to the meat sample treated for 4 hours (59/246). The main reason for cooking loss is the loss of materials present in meat resulting from wrinkling of the muscle, the denaturation of proteins as well as a significant reduction in water storage capacity of the meat (Marcos *et al.*,2010). The amount of cooking loss increased up to 4 hours after the addition of kiwi powder, but a downward trend was observed with increasing time. Thomson *et al.* (1996) examined the changes in beef during five day period, and stated that the amount of cooking loss increases in the first four days after slaughtering .

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Addition of kiwi powder improves the sensory properties of sheep meat. Based on the amount of force needed to cut the meat samples, below 24-hour treatment, duration required for baking is reduced significantly due to the tenderness and adequate juiciness of the meat. According to the results observed in table 2, the treatment caused significant differences in sensory properties of meat samples ($p<0.05$). The highest color scores was related to the control sample and the lowest was related to the meat treated with kiwi powder for 24 hours. It is likely that the reduction of pH to the isoelectric point of meat proteins increases the redness of the specimens due to the equalization of the positive and negative loads as well as the minimum amplitude force between protein molecules (Desmond and Troy,2001; Hinkle,2010). However, below the isoelectric point, the redness of the specimens decreases due to the denaturation of the sarcoplasmic proteins (Aktas and Kaya,2001; Onenc *et al*.,2004;Serdaroglu *et al*.,2007).

The highest score of taste was related to meat sample treated with kiwi powder for 12 hours, and the lowest was related to the control (table 2). Also, the most general acceptance score belonged to meat sample treated for 24 hours. Since the quality of food is evaluated by three characteristics of texture, juiciness and flavor (Monson et al.,2004, Warriss,2000), increasing the general acceptance score of sheep meat in 24 hours was predictable.

Conclusion

With passing time, kiwi fruit powder added to sheep meat exerted significant effects on its characteristics, including protein level, peptide chain length, degree of hydrolysis, cooking loss and different sensory properties. Considering these positive effects, research to find suitable laboratory and applicable methods to purify kiwi fruit protease enzymes is necessary.

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