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Improvement of Rabbit Burger Quality by Dietary Supplementations with Orange Peel, Corn Silk Extracts, and Vitamin E in Growing Rabbits Diet

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ABSTRACT

The quality of rabbit meat burgers was evaluated after dietary supplementation with orange peel (OPE), corn silk (CSE) extracts, and Vitamin E (VE) in the growing rabbit diet compared with the control(CON).VE burger achieved the highest value of lightness (L*) and redness (a*) at 52.71 and 1.10 respectively. OPE burgers achieved a higher value of yellowness at 10.73. The total color difference (ΔE) was significantly high in CSE showing the highest dissimilar in color (2.41). CSE burger recorded significantly higher ($P<0.05$) cooking properties than the CON and OPE samples. The results of texture analysis reveal that burgers from rabbit meat supplemented with VE exhibited excellent texture parameters followed by CSE compared with OPE and CON. The highest chewiness and hardness were recorded by OPE. VE had the lowest value of TBA 0.41mg Malondialdehyde (MDA/kg sample). The highest value was reported in OPE at 0.45 MDA/kg. The highest score in overall acceptability was achieved by VE and CSE with no significant difference followed by CON and the lowest score was recorded by OPE.

Keywords: Orange peel, Corn silk, Vitamin E, rabbit burger, TBA

1. Introduction

The animals are susceptible to various types of stress, such as chemical, psychological, physical, dietary, and temperature aspects (Ngoula *et al*., 2017). Dietary antioxidants have been recognized as an effective method for maintaining the redox balance in Animals on farms that are subjected to oxidative stresses (Ponnampalam *et al*., 2022).

Incorporating antioxidants into the diets of livestock enhances the health, performance, and shelf life of meat products such as meatballs (Balestra & Petracci, 2019), and burgers (Mancini *et al.,* 2017a; Mancini *et al*., 2017b) these products are more susceptible to oxidation processes. Antioxidants can be added to animal feed or combined with processed meat to increase shelf life (Jiang and Xiong, 2016). Several studies have examined the impact of adding natural antioxidants to the diet of rabbits on their performance and the quality of their meat (Dal Bosco *et al*., 2012, 2014; Eid, 2008; Sgorlon *et al*., 2005; Zhang, *et al*., 2010). Nevertheless, none of these researches evaluated the impact of natural antioxidants on processed food products made from rabbit meat.

Nowadays, ready-to-cook and ready-to-eat food products have become major competitors in the food manufacturing industry, taking up an impressive market share. These products eliminate the need for time-consuming preparation. Rabbit meat is a suitable source for producing meat products with functional value because it has a high concentration of protein and amino acids, which are biologically valuable. Additionally, rabbit meat has a low-fat content and a high percentage of unsaturated fatty acids (Dalle Zotte and Szendrő, 2011). Nevertheless, rabbit meat is highly exposed to lipid oxidation

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and leads to generate an unpleasant taste more than other types of meat. As a result, the utilization of rabbit meat in processed products is extremely restricted (Petracci and Cavani, 2013).

Burgers are often consumed as quick lunches and have global recognition and popularity due to their quick cooking time (Mancini *et al*., 2020). Burgers are a delectable and convenient source of protein that can be prepared quickly without the need for extensive cooking or culinary preparation. In recent decades, numerous research projects have been carried out to improve the longevity of burgers and enhance the nutritional value (Mancini *et al*., 2017).

Burgers, as well as other meat products, have the potential to facilitate the reintroduction of rabbit meat into regular eating habits. Recently, there has been a focus on various types of meat utilized in protein burgers as a potential option to meet market demand. Furthermore, these combinations increase the significance of rabbit meat in the market, particularly in terms of its nutritional value, which is particularly beneficial for children and the elderly (Petracci *et al*., 2018).

This study aims to evaluate the impacts of dietary supplementation of growing rabbits with orange peel, corn silk extracts, and vitamin E on the quality parameters of their rabbit meat burgers compared with the control group.

2. Materials and Methods

Through our previous study, we found that feeding rabbits with orange peel and corn silk extract was a promising strategy for enhancing the quality of rabbit meat attributes for consumers and was very effective in improving the oxidative stability and sensory quality of rabbit meat. In this study, we fed rabbits with orange peel, corn silk extract, and Vitamin E compared with a control group and evaluated the quality (pH, color, cooking properties, texture, and sensory) of their rabbit meat burgers.

2.1. Animals and sampling

Meat was obtained from four equal groups each group contained five replicates (5 rabbits for each replicate). The first group served as the control group (without additives). The second group was given the basal diet with additions of Vitamin E (150 ppm) third, and fourth groups were given the basal diet with additions of orange peel, and corn silk extracts at a concentration of 150 ppm, respectively for 10 weeks.

After chilling for 24 h at 4 ± 0.5 °C, the carcasses were processed and the bones were removed using standard techniques (Blasco & Ouhayoun, 1996)**.** The rabbit meat of each group is finely minced.

2.2. Burger manufacture

Burgers were prepared from minced rabbit meat (loin and thigh); then the four minced rabbit meat groups (CON, OPE, CSE, and VE) were supplemented with 1% salt 1 % pepper, 1 % powder of garlic, 1 % powder of onion,0.5 % parsley, and 0.5% coriander further manually homogenized and shaped into burgers weighing 60 g ± 2.

Burgers were placed in individual Styrofoam trays, covered with polyethylene film, and kept at a temperature of 4±0.5°C until they were examined. Burgers were cooked on a grill at 163°C until they reached a temperature of 71±1ºC at the center of the burger, which was measured using thermocouples. The burgers have been turned every 4 minutes to avoid the formation of an excessive crust on the surface (AMSA, 1995)**.** Burgers were analyzed for the determination of pH, color parameters, TBA, cooking properties, texture, and sensory attributes.

2.3. pH assay

The pH values of rabbit meat burgers were determined using a 1:1 m/v ratio of minced burger to redistilled water (Wu *et al*.,2023).

2.4. Color parameters

The (lightness) L*, (redness) a*, and (yellowness) b* color parameters of different burger samples were measured with HunterLab MiniScan XE Plus spectrocolorimeter (Hunter Associates Laboratory, Reston, VN, USA) (Daszkiewicz and Janiszewski, 2020)

2.5. Cooking properties (Cooking yield, Shrinkage diameter loss %, and thickness reduction)

The cooking yield was assessed by measuring the weight of the burgers first before cooking and then measuring their weight again after cooking. The burgers were allowed to cool to ambient temperature after cooking and before weighing them.

% Cooking yield= 100- [(Raw burger weight(g) - Cooked burger weight (g) x 100/ Raw burger weight(g)]

The burgers' Shrinkage diameter loss percentage was calculated using the following formula:

$$\text{Shrinkage diameter loss \%} = \frac{\text{RD- CD}}{\text{(RD)}} \text{ X } 100$$

Where
RD = Raw burger diameter
CD = Cooked burger diameter

Thickness reduction was measured using the following equation:

$$\text{Thickness reduction \%} = \frac{\text{RT- CT}}{\text{(RT)}} \text{ X } 100$$

Where
RT = Raw burger thickness
CD = cooked burger thickness

2.6. Texture profile analysis

A Brookfield texture analyzer CT3 was used to conduct texture profile analysis (TPA) on cooked burgers. The samples were uniformly sliced into 2 × 2 × 2 cm dimensions and compressed at a crosshead speed of 1 mm/s until they reached 75% of their initial height. This compression was achieved using a cylindrical probe with a diameter of 10 cm, following a two-cycle sequence. The TPA properties that were determined include hardness (N), springiness (mm), cohesiveness, and chewiness (N*mm) (Claus, 1995).

2.7. Lipid oxidation (thiobarbituric acid reactive substances TBRAS)

The measurement of TBRAS of the samples was carried out by spectrophotometer method, expressed as milligrams of malonaldehyde per kilogram, following the procedure reported by Bozkurt and Erkman, (2004).

2.8. Sensory evaluation

Four groups of rabbit burger samples were cooked in a grill until their internal temperature reached 71°C, determined by using a portable thermocouple thermometer. After cooking, each burger was divided into separately wrapped wedges in aluminum foil and kept at 60°C until serving (Macfie et al., 1989). Sensory analysis was conducted by 20 panelists. Samples were evaluated by each panelist in a random sequence. They rated 6 parameters: appearance (20), color (20), odor (20), taste (20), texture (20), and overall acceptability (20). The panelists were given drinking water to wash their palates.

2.9. Statistical analysis

Three replicates were used in the experiments. The statistical findings were shown using mean ± standard error format. The experimental data were assessed using one-way ANOVA and Duncan multiple comparisons, with a significance level of $P \leq 0.05$ by SPSS 15.0 for the Windows Software Package (SPSS,2001).

3. Results and Discussion

3.1. Color parameters and pH

Color parameters (L*, a*, b*) of burgers were determined and it is observed that VE achieved the highest value of lightness at 52.71 followed by CSE at 51.62, while OPE was the lowest in lightness at 49.11. The results presented that VE achieved the highest redness value of 1.10, while the lowest value of redness was reported in CON and OPE at 0.56, and 0.53 respectively with no significant difference (P>0.05). OPE burgers achieved the higher value of yellowness at 10.73, while the CSE was the lowest at 7.60 however there was no significant difference (P>0.05) between CON and VE.

Table 1: Color parameters and pH of the uncooked (raw) burgers

Parameters	CON	VE	OPE	CSE
L	$50.64^{c} \pm 0.04$	$52.75^{a} \pm > 0.05$	$49.11^{d} \pm 0.01$	$51.62^{b} \pm 0.03$
a*	$0.56^{c} \pm 0.20$	$1.10^{a} \pm 0.10$	$0.53^{c} \pm 0.15$	$0.66^{b} \pm 0.10$
b*	$9.80^{b} \pm 0.03$	$9.80^{b} \pm 0.03$	$10.73^{a} \pm 0.03$	$7.60^{c} \pm 0.05$
ΔE	----	$2.17^{b} \pm 0.02$	$1.79^{c} \pm 0.04$	$2.41^{a} \pm 0.10$
pH	$6.00^{b} \pm 0.15$	$5.98^{b} \pm 0.10$	$6.04^{a} \pm 0.01$	$5.91^{bc} \pm 0.01$

CON: Control **VE:** Vitamin E **OPE:** Orange peel extract **CSE:** Corn silk extract
Mean values (± S.D.) followed by different letters in the row are significantly different (P ≤0.05)

The differences in L* may be linked to a reverse correlation between pH and lightness. Similar findings were stated by Mancini *et al*. (2015). The findings of our study regarding lightness and pH agree with previous research conducted by Dal Bosco *et al.* (2014) on rabbit meat and by Choe *et al*. (2011) on pork. These studies investigated the impact of natural antioxidants and storage time on meat quality, and both observed a decrease in lightness (L*) and an increase in pH during short storage periods. Burgers exhibited a significant reduction of a*value this may be attributed to the oxidation of the raw burgers. Multiple studies have seen decreases in the redness of ground meat over time, attributing these changes to the creation of metmyoglobin through the oxidation of myoglobin (Choe *et al*., 2011). The high redness index can be linked to the histological composition of the meat used in the burger preparation and the manufacturing procedure for the ground meat. The burgers were prepared using the hind legs meat, which includes muscles rich in red fibers and have a high level of oxidative activity **(**Ouhayoun & Dalle Zotte, 1993**)**. Grinding is a procedure that incorporates oxygen and leads to the formation of a bright red color associated with oxymyoglobin production **(**Mancini *et al.*,2015).

According to previous studies, higher levels of yellowness have been linked to the presence of free radicals. These radicals are formed when lipids undergo oxidation due to storage, thermal stress, or manipulation. The oxidation of haem caused by these radicals can lead to the discoloration of meat and meat products. The significant decrease in yellowness occurred due to alterations in the natural pigments linked to the enzymatic oxidation of phenolics (Ozturk and Dogan, 2019). The total color difference (ΔE) was significantly high in CSE showing the highest dissimilar in color (2.41).

pH of all burger samples ranged from 5.91 to 6.04. It was observed that there is a non-significant difference (P>0.05) between CON, VE, and CSE reported the lowest pH, whereas OPE recorded the highest. The pH increase can be attributed to two factors: The hydrolysis of proteins in meat causes increasing in ammoniacal nitrogen levels, leading to the alkalinization of the meat. Additionally, gram-negative bacteria break down proteins and amino acids, which causes high levels of ammoniacal nitrogen, amines, and other basic chemicals. (Karabagias *et al.*, 2011 and Rodríguez-Calleja *et al*., 2005). Results concluded that feeding rabbits with VE and CSE extract as dietary supplementations could improve the color and pH of a rabbit meat burger.

3.2. Cooking properties of rabbit burgers

The cooking yields, shrinkage (diameter loss), and thickness reductions for the control and all the burger samples are shown in Table (2). CS and VE burger achieved the highest cooking yield respectively 78.44% and 73.24%. There was no significant difference (P>0.05) between OPE and control samples.

Burger samples took the same trend in shrinkage (diameter loss) the lowest shrinkage was recorded by CSE at 19.90 % followed by VE at 23.14 and OPE at 24.22 while the highest shrinkage was observed

in CON at 25.35%.CSE had the lowest thickness reduction of 14.42% followed by VE at 15.33% while CON and OPE had the highest reduction at 20 .27 and 19.37 respectively.

Table 2: Cooking properties of rabbit meat burgers

Sample	Cooking yield %	Shrinkage (diameter loss)%	Thickness reduction %
CON	$72.12^{c} \pm 0.11$	$25.35^{a} \pm 0.03$	$20.27^{e} \pm 0.25$
VE	$73.24^{b} \pm 0.14$	$23.14^{c} \pm 0.02$	$15.33^{d} \pm 0.21$
OPE	$72.52^{c} \pm 0.37$	$24.22^{b} \pm 2.22$	$19.37^{b} \pm 0.40$
CSE	$78.44^{a} \pm 0.22$	$19.90^{d} \pm 1.64$	$14.42^{a} \pm 0.28$

CON: Control **VE:** Vitamin E **OPE:** Orange peel extract **CSE:** Corn silk extract
Mean values (± S.D.) followed by different letters in the column are significantly different ($P \leq 0.05$)

From the obtained results (Table 2), it could be noticed that the cooking yield percentage of rabbit burger samples CSE is significantly higher ($P<0.05$) than CON and OPE samples. Investigations on the incorporation of vitamin E into rabbit diets have shown positive effects on body weight, dressing percentage, and hot carcass weight, while also reducing drip loss in meat (Eiben *et al*., 2011). From the same results (Table 2), it could be shown that lower shrinkage was noticed in CSE burgers. shrinkage may be attributed to many factors such as the fat and moisture content and cooking temperature which may cause fluid evaporation (Bağdatli and Kundakci, 2016; Ayyash *et al*., 2019). OPE had lower cooking yield and higher shrinkage which led to a small, dry, and elastic burger .thickness reduction also takes the same trend.

3.3. Texture analysis profile

The meat's texture is influenced by many factors, including breed, sex, chemical composition, muscle fiber structure, food, pre-slaughter stress, carcass chilling conditions, and proper meat aging (Kozioł *et al*., 2016).

Table 3: Texture profile of rabbit meat burgers

Texture parameters	Hardness (N)	Springiness (mm)	Cohesiveness	Chewiness (N*mm)
CON	$19.50^{c} \pm 0.05$	$3.54^{a} \pm 0.44$	$0.78^{b} \pm 0.01$	$14.63^{c} \pm 0.02$
VE	$12.98^{a} \pm 0.02$	$3.54^{a} \pm 0.40$	$0.81^{c} \pm 0.01$	$9.96^{a} \pm 0.01$
OPE	$29.60^{d} \pm 0.05$	$3.69^{a} \pm 0.21$	$0.74^{a} \pm 0.01$	$21.78^{d} \pm 0.01$
CSE	$16.06^{b} \pm 0.06$	$3.65^{a} \pm 0.50$	$0.80^{c} \pm 0.01$	$12.33^{b} \pm 0.01$

CON: Control **VE:** Vitamin E **OPE:** Orange peel extract **CSE:** Corn silk extract
Mean values (± S.D.) followed by different letters in the column are significantly different ($P \leq 0.05$)

Table 3 shows the texture parameters of rabbit burger samples. It was observed that the highest hardness was recorded by OPE at 29.60 followed by CON at 19.50 while VE was the lowest hardness at 12.98.

The burger patties become harder when cooked due to the denaturation and aggregation of collagen, myosin, and actin proteins. This causes the protein matrix to shrink and fluids to be expelled or evaporated (Ismail *et al*., 2019). Additionally, this could be attributed to the relatively low-fat level found in rabbit meat.

Springiness is a significant measure for describing the texture of food and is associated with its capacity to regain its initial shape after being compressed. Consequently, a lack of cohesion would probably be associated with a lack of springiness (Souppez *et al.*, 2024). In our study, there is non-significant difference ($P>0.05$) in springiness between all samples.

Cohesiveness was the highest in VE and CSE, while was the lowest in OPE and CON. It is observed that chewiness exhibited a trend similar to hardness. The highest chewiness was recorded by OPE and was the lowest at VE followed by CSE and CON. Chewiness plays a role in enhancing consumer satisfaction with alternative meat products, as it provides an aggregated indication of the burger's mouthfeel (Souppez *et al.*, 2024).

The result reveals that burgers from rabbit meat supplemented with VE exhibited excellent texture parameters followed by CSE compared with OPE and CON.

3.4. Lipid oxidation (thiobarbituric acid reactive substances TBRAS)

TBA an indicator of lipid oxidation, was quantified as a milligram of malondialdehyde per kg of Burger. The TBA values of burgers are illustrated in Fig. (1). VE burgers had the lowest TBA value of 0.41mg Malondialdehyde (MDA/kg). OPE reported the greatest value at 0.45 MDA/kg. There was no statistically significant difference (P>0.05) between the TBA values of CSE and CON. The highest limit (0.9 mg MDA/kg) recommended by ES (2005) was not exceeded by the TBA in any of the samples.

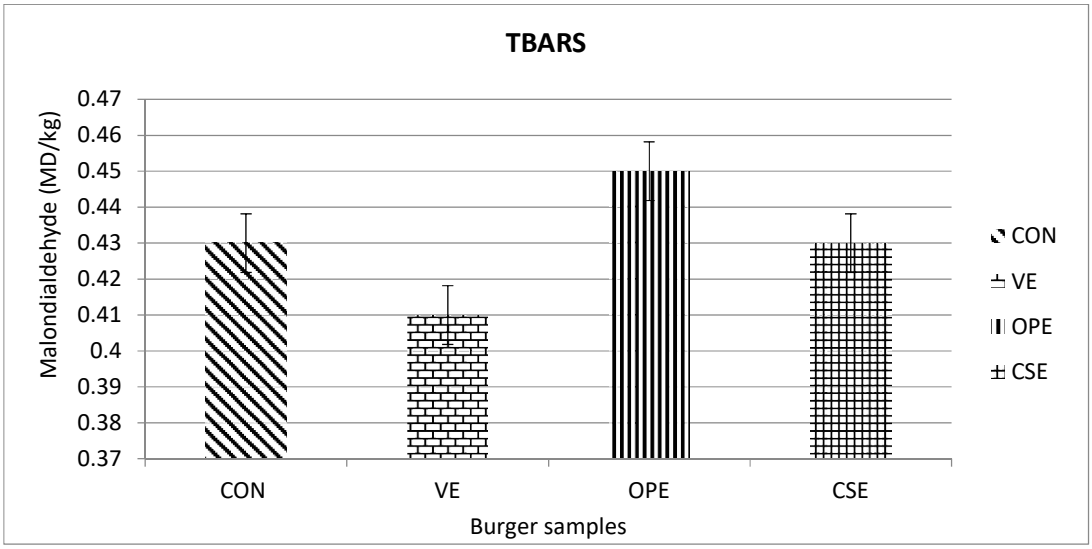

Fig 1: Thiobarbituric acid (TBA) values of rabbit burgers

The oxidation of lipids in rabbit meat has been demonstrated to be reduced by the addition of vitamin C and vitamin E to the diet under various storage conditions (Castellini *et al*., 2001). Generally, phenolic compounds and tannins, which are phytochemical compounds are present in herbs and spice extracts and perform as natural antioxidants (Gutiérrez-del-Río *et al*., 2021). Interestingly, the inclusion of antioxidants, such as vitamin E, in rabbit diets impacted the composition of tissue lipids with a high PUFA content and also improved the oxidative stability of meat. The oxidative stability of rabbit meat and meat products was improved through the use of various herbs, spices, essential oils, and feed additives (Kumar *et al*.2023).

3.5. Sensory evaluation of rabbit burgers

The sensory analysis results are reported in Figure 2. Burger quality has been evaluated by sensory factors such as appearance, color, odor, texture, taste, and overall acceptability. CSE has been recorded as the highest score of appearance while the OPE was the lowest this may be due to the lowest cooking yield, higher shrinkage, and thickness reduction of OPE.OPE recorded the lowest score in odor and taste but there was no significant difference between CON, CSE, and VE burgers in odor and taste scores.According to results from evaluating the sensory qualities and using instrumental evaluation to measure texture parameters and color, the panelists showed a preference for the CSE and VE samples and gave both samples higher scores in all parameters. The highest score in overall acceptability was achieved by VE and CSE with no significant difference followed by CON and the lowest score was recorded by OPE.

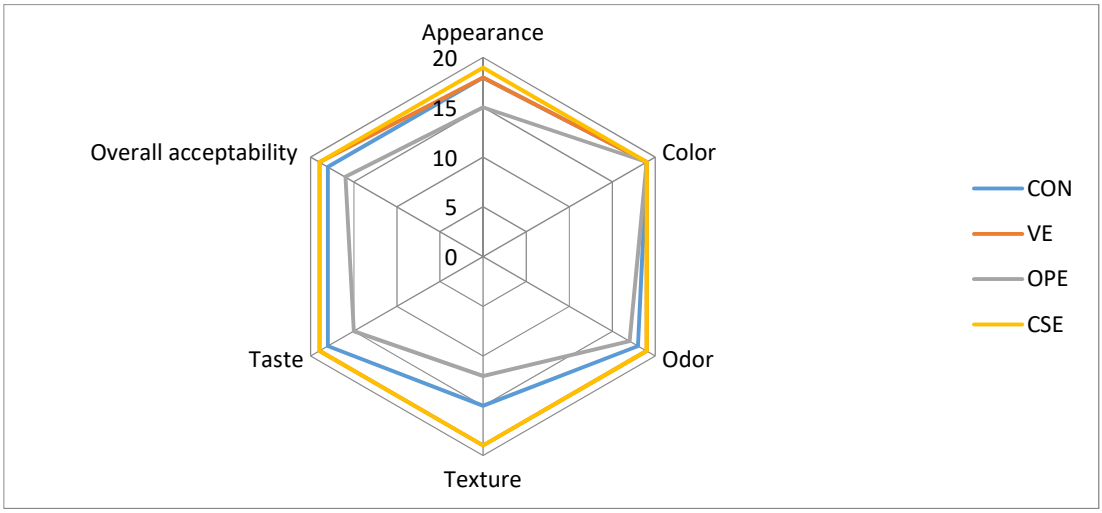

Fig 2: Sensory evaluation of rabbit burgers

4. Conclusions

The results of this study demonstrate supplementing VE and CSE in rabbit diets had significant effects on their burger quality, and improved antioxidant stability, while dietary supplementation with OPE increased the hardness and scored low cooking properties. Results revealed that VE and CSE burgers had significantly ($p< 0.05$) higher scores in cooking properties and all sensory parameters and these results are confirmed by the results obtained from instrumental evaluation. OPE burger scored the lowest score in the most sensory parameters.

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