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TEXTURE PROFILE, WATER HOLDING CAPACITY, ANTIOXIDANT ACTIVITY AND LIPID OXIDATION OF BEEF DURING RETAIL DISPLAY FROM CATTLE FED TOTAL MIXED RATION SUPPLEMENTED WITH *Capsicum frutescens* L. AND *Curcuma longa* L. POWDERS

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ABSTRACT: This study aimed to elucidate the effects of supplementation of *Capsicum frutescens* L. or chili pepper (ChP) and *Curcuma longa* L. or turmeric (T) powders combination in total mixed ration (TMR) on texture profile, water holding capacity (WHC) and oxidative stability of beef during days 0, 5 and 10 of retail display. The experiment was carried out on 16 crossbred bulls (Brahman and Charolais) of about 2 years in age. The bulls were randomly assigned to 4 dietary treatment groups as follows: 1) TMR as control, 2) TMR + 1%ChP powder, 3) TMR + 1%T powder, and 4) TMR supplemented with a mixed powder of 1%ChP + 1%T, over a 6 months feeding period. The results revealed that the hardness and gumminess of control beef were higher than other groups, and the cohesiveness of beef from cattle fed a mixed powder of 1%ChP + 1%T was lower than other groups (P<0.05). Regarding WHC, the results showed that, on days 0 and 5 of storage, the control group meat had higher cooking losses than either the 1%T or a mixture of 1%ChP + 1%T groups (P<0.05). Also, on 0 and 5 days of retail display, the 1%ChP + 1%T group showed the highest antioxidant activity when compared to other groups (P<0.05). As for the lipid oxidation in beef, on day 5 of storage MDA level in control beef was higher than the 1%T or a mixture of 1%ChP + 1%T groups (P<0.05). It can be concluded that the combination of chili pepper and turmeric powder in TMR can improve texture, water holding capacity, and oxidative stability of beef during refrigerated storage.

Keywords: Beef, Chili pepper, Cooking loss, Oxidative stability, Texture profile, Turmeric powder.

INTRODUCTION

In livestock production, antibiotics play an important role in the protection of animals against infectious diseases, and in the treatment of diseases. In addition, it is well known that the antibiotics supplemented in animal feeds can serve also as antimicrobial growth promoters (AGPs) that enhance productivity and profitability (Cheng et al., 2014). However, excessive use of antibiotics may have detrimental impacts on both livestock and human health, so many countries have banned the use AGPs in animal feed (Brown et al., 2017). This leads to considering medicinal herbs that could improve animal productivity as alternatives to antibiotics. Previously, countless studies have demonstrated the use of medical plants as feed additives to improve livestock production (Hashemi and Davoodi, 2011; Hanczakowska et al., 2015; Kuralkar and Kuralkar, 2021). Moreover, there have been recent studies aiming to use combinations of different natural bioactive substances in farm animals, to benefit from the synergistic effects of multi-herbal feed additives (Giannenas et al., 2018). In this regard, chili pepper (*Capsicum frutescens* L.) and turmeric (*Curcuma longa* L.) seem to be good candidates to substitute for antibiotics in animal feed, due to their bioactivities and medicinal properties, and the fact that these are commonly used in cuisines all over the world corroborates the absence of safety concerns (Gurnani et al., 2016; Verma et al., 2018; Akbar et al., 2019).

Chili pepper, also known as Bird's eye chili, is widely cultivated throughout the tropical countries, especially in Thailand. It is a beneficial source of nutrients, minerals, and phytochemicals, and has substantial prospects for developing food additives (Otunola et al., 2010). The phytochemicals in chili pepper, especially capsaicinoids, carotenoids, and saponins, contribute its antibacterial, antidiabetic, antifungal, anticancer, and antioxidant activities (Chinnkar and Jadhav, 2023). Turmeric is an herbal plant that belongs to the Zingiberaceae (ginger) family. It is widely used as a spice, food preservative, and coloring agent in tropical areas, especially in south-east Asia. Moreover, it has been used extensively by traditional medicine all over the world. It is a major source of curcumin, a yellow bioactive component with many biological actions, including anti-inflammatory, antioxidant, anticarcinogenic, antimutagenic, anticoagulant, antifertility,

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antidiabetic, antibacterial, antifungal, antiprotozoal, antiviral, antifibrotic, antivenom, antiulcer, hypotensive, and hypocholesteremia activities (Verma et al., 2018).

Previously, several studies have shown synergistic effects of chili pepper and turmeric powder in animal feed on production performance and health of animals, especially in poultry (Adegoke et al., 2018; Sanwo et al., 2020). However, whether there is such synergy in ruminants is still largely unknown. This study is a continuation of prior work that assessed the effects of chili pepper and turmeric powder supplementation in total mixed ration (TMR) in beef cattle, on growth performance and fresh meat quality, and this study aimed to investigate the beef during refrigerated storage for effects on texture, water holding capacity (WHC), and oxidative stability.

MATERIALS AND METHODS

Experimental animals, treatments and feed

The 16 crossbreds of beef cattle used in this experiment had approximately 450 kg body weights and were about 2 years of age. The cattle were mixed breeds of Brahman and Charolais (60% or more of Charolais bloodline). Before starting the experiment, the cattle were raised from about 250 kg weight by feeding with concentrate and roughage from the local area for 6-8 months, until the body weight reached 450 kg. All 16 bulls were castrated and randomly assigned to 4 experimental groups (4 replicates in each group) according to a Completely Randomized Design (CRD) as follows: 1) TMR without herbal supplements (control), 2) TMR supplemented with 1%Chili pepper (ChP) powder, 3) TMR supplemented with 1% turmeric (T) powder, and 4) TMR supplemented with 1%ChP + 1%T powder. Chili pepper and turmeric powders were produced with quality control of the herbal raw materials by the Ban Khao Na Nai community enterprise group (herbal production group) in Ton Yuan sub-district, Phanom district, Surat Thani province, Thailand. The feeding trial was carried out at Phatthalung College of Agriculture and Technology, Phatthalung, Thailand. The cattle were fed with TMR according to NRC (1984) as shown in Table 1. The trial period was 6 months, during which all the beef cattle were fed *ad libitum* 2 times daily (at 8.00 am and 3.30 pm) and had free access to water.

Table 1 - Ingredients of total mixed ration (TMR) in the experiment

Ingredients	%
Acacia leaves	2.4
Napier grass	24
Cassava	23.6
Molasses mixed with yeast	7.1
Soybean meal	11.5
Salt	1.0
Sea shell powder	1.5
Oil palm meal	28.4
Urea	0.5
Chemical composition (% of dry matter)	
Crude protein	10.8
Total digestible nutrients (TDN)	69.0

Meat samples

After the 6 months of feeding trial, the cattle were transported to an abattoir in Phatthalung province, Thailand. The animals were fasted before transport and slaughtered according to common practices, i.e. stunning, bleeding, de-hiding, eviscerating, and cooling. Determination of texture profile, antioxidant activity, and lipid oxidation was performed on the *Longissimus dorsi* (LD) muscles and a simulation of retail display was conducted by wrapping the meat samples with oxygen permeable foil and displaying them at 4°C under fluorescent light for 24 h per day, with sampling at 0, 5, and 10 days.

Analysis of water holding capacity (WHC)

The WHC of the beef from LD was determined at 24 h *post mortem* in terms of the cooking loss. The beef samples were cooked in a water bath controlled at 90 °C for 15 minutes. Each sample was weighed before and after cooking. The amount of cooking loss was calculated using the difference between the weight before and after cooking, then expressed as percentage of the pre-cooked weight.

Texture profile analysis (TPA)

The texture profile of beef from LD was measured at 24 h *post mortem* by using a texture analyzer, Brookfield model CT3, with a capacity of 10 kg. The beef LD muscles were cooked in a water bath at 90°C for 15 minutes, then they were cut into 1x1x1 cm sample size. The measurement was performed in 3 replicates for each type of sample. The texture profile of the beef was summarized in terms of hardness, cohesiveness, springiness, gumminess, and chewiness.

Antioxidant activity analysis

Antioxidant activity of beef was analyzed at 0, 5, and 10 days of display at 4°C by using a 2, 2–diphenyl–1–picrylhydrazyl (DPPH) assay according to the method of Wang et al. (2019) based on the principle that DPPH is a free radical generator. Briefly, 2.5 g of beef was mixed and homogenized with 7.5 ml of ethanol. The homogenates were extracted on a shaker for about 10 minutes at room temperature and then centrifuged at 1,800 rpm for 10 minutes. Subsequently, the supernatants were collected. Then 0.5 ml of supernatant from each sample was added to 3.5 ml of 0.1 mM DPPH in ethanol, mixed and stored in dark at room temperature for 20 minutes. The absorbance was measured at 517 nm by using a spectrophotometer. Ethanol was used as a blank. DPPH scavenging activity was calculated as follows:

DPPH Scavenging activity (%) = $(1 - As/Ac) \times 100$

Here Ac is the absorbance of the control (DPPH in ethanol solution without sample) and As is the absorbance of the sample.

Lipid oxidation analysis

Lipid oxidation was evaluated in LD muscle samples on days 0, 5 and 10 of display during cold storage. The lipid oxidation in beef was assessed from the thiobarbituric acid reactive substances (TBARS) determined according to the standard method of Tarladgis et al. (1960). The secondary product of lipid oxidation, malondialdehyde (MDA), was measured at 532 nm by using a spectrophotometer and expressed as µg MDA per g meat.

Statistical analysis

The data were analyzed in SPSS Statistics program using the general linear model procedure to evaluate the influences of experimental treatments. Means were compared using Duncan's multiple range test and differences were considered significant at $P<0.05$.

Ethical statement

All animal procedures in this study were approved by the Institutional Animal Care and Use Committee, Prince of Songkla University (Approval project no. 2564–15–090).

RESULTS AND DISCUSSION

Meat texture profile and cooking loss

Effects of chili pepper and turmeric powder supplementation in TMR on texture profile of beef LD are shown in Table 2. The results show that the hardness and gumminess of the control group were higher than of the groups supplemented with herbal powders in TMR ($P<0.05$). Moreover, the cohesiveness of LD muscle from beef fed with 1%ChP + 1%T powder was lower than those of the others ($P<0.05$). However, the springiness and chewiness of beef among all treatment groups had no significant differences ($P>0.05$).

The influences of herbal powder in TMR on WHC in terms of cooking loss (%) of beef from LD are indicated in Figure 1. The results reveal that on days 0 and 5 of cold storage the control group had a higher cooking loss from meat than either 1%T or 1%ChP + 1%T groups ($P<0.05$). However, on day 10 of display, there was no longer any significant difference in cooking loss among the dietary treatment groups ($P>0.05$).

Eating quality or palatability of meat comprises 3 main properties, which are texture, juiciness and flavor/odor (Warriss, 2010). Juiciness is related to water retention or WHC, which is determined as the ability of meat to retain its own water and can be described in drip, purge, weep, and exudate or cook losses. Juicy meat may be perceived as more tender than a less juicy meat (Warriss, 2010). Bejerholm and Aaslyng (2004) stated that the cooking loss is well correlated with juiciness of meat, and depends on the cooking temperature. In addition, the study of Hughes et al. (2014) shows a strong positive correlation between the cooked meat tenderness and meat juiciness, while this may vary between different muscles. These agree with the present study, in which the meat tenderness was related to the cooking loss. In this study, the results showed that the herbal supplementation resulted in a lower cooking loss and more meat tenderness in accordance with Li et al. (2022), who found that herbal tea residue improves meat quality by reducing cooking loss and shear force in finishing steers.

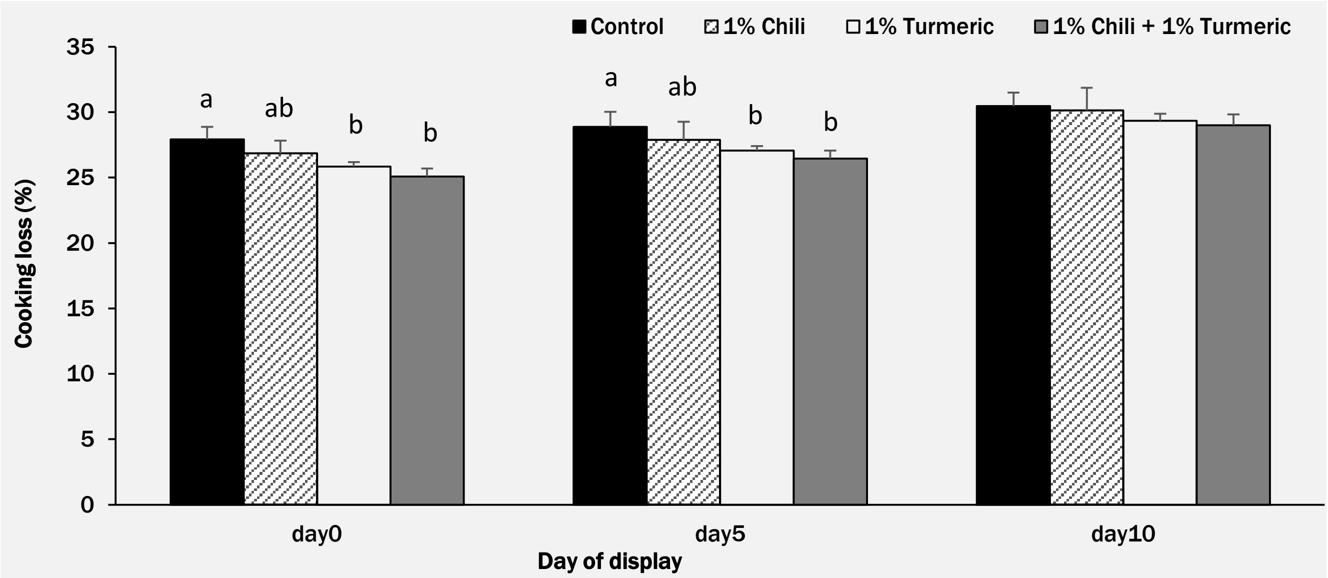

Figure 1 - Mean values of cooking loss (%) from beef during cold storage, compared by dietary treatment. Error bars represent standard deviations. a,b; Means with different superscripts are significantly different at P<0.05, compared for the same sampling day.

Table 2 - Effects of chili pepper and turmeric powders supplementation in total mixed ration (TMR) on meat texture profile of beef cattle

Items \ Level of herbal powder in TMR	0	1% chili pepper	1% turmeric	1% chili pepper +1% turmeric	SEM	P-value
Hardness (g)	4590.3^{a}	2557.5^{b}	2123.0^{b}	1624.3^{b}	375.37	0.01
Cohesiveness (%)	0.51^{b}	0.51^{b}	0.59^{a}	0.41^{c}	0.02	<0.01
Springiness (mm)	4.75	8.83	4.23	4.78	0.86	0.21
Gumminess (g)	2317.50^{a}	1222.50^{b}	1248.25^{b}	656.75^{b}	201.60	0.01
Chewiness (mJ)	104.90	107.68	51.80	29.80	13.05	0.06

a,b,c; Means within a row with different superscripts differ significantly (P<0.05).

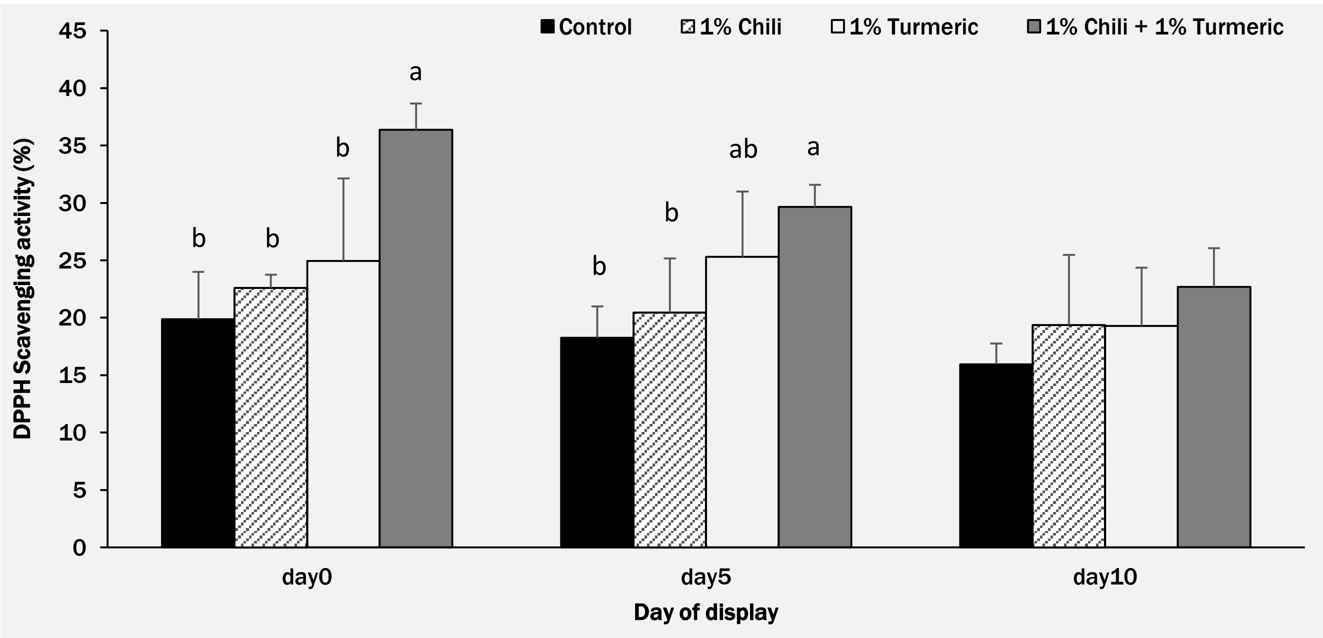

Figure 2 - Mean values of DPPH scavenging activity (%) in beef during cold storage, compared by dietary treatment. Error bars represent standard deviations. a,b; Means with different superscripts are significantly different at P<0.05, compared for the same sampling day.

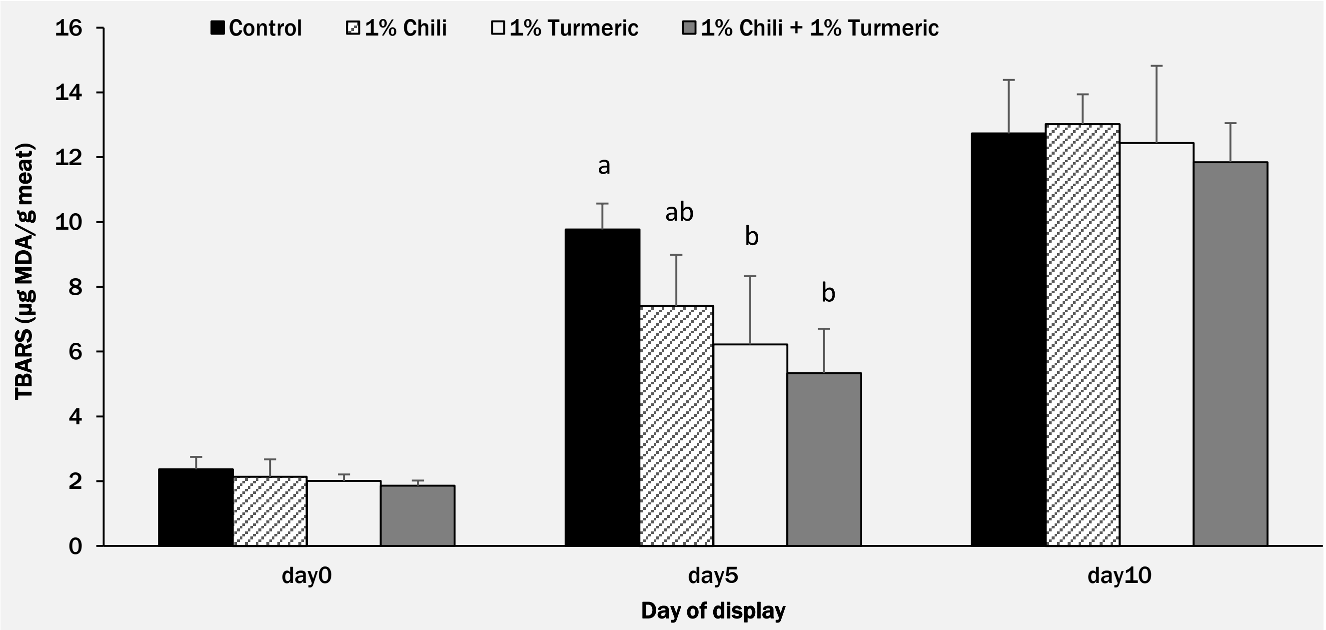

Figure 3- Mean values of lipid oxidation (μg MDA per g meat) in beef during cold storage, compared by dietary treatment. Error bars represent standard deviations. [a,b]: Means with different superscripts are significantly different at P<0.05, compared for the same sampling day.

Antioxidant activity and lipid oxidation in meat

Effects of chili pepper and turmeric powder in TMR on antioxidant activity in beef during cold storage are shown in Figure 2. On days 0 and 5 of retail display, it was observed that the experimental group with the highest antioxidant activity was that supplemented with 1%ChP along with 1%T powder, when compared to other groups (P<0.05). However, antioxidant activity in beef on day 10 of cold storage did not significantly differ across the experimental groups (P>0.05).

Results of lipid oxidation in beef during cold storage are indicated in Figure 3. From the experiment, it was found that on day 5 of retail display the amount of MDA (μg MDA/g Meat) in beef without herbal supplementation was higher than in either the group supplemented with 1%T or that supplemented with 1%ChP + 1%T in TMR (P<0.05). However, on days 0 or 10 of display there were no significant differences among the groups (P>0.05).

Lipid oxidation is a major cause of deterioration in meat quality. Meat tends to be susceptible to oxidation due to its high concentration of fats. Oxidative deterioration in meat results in discoloration, off flavor/odor, formation of toxic compounds, poor shelf life stability, and nutrient and drip losses (Morrissey et al., 1998; Contini et al., 2014). The current study found that beef from animals that received herbal plants, especially mixed herbs, had more antioxidant activity and less lipid oxidation. This is in line with Giannenas et al. (2018) who found that a combination of different herbal extracts could have synergistic effects to improve antioxidant activity and reduce lipid oxidation in meat of broilers, attributing this to the phenolic compounds. Also, Hanczakowska et al. (2015) indicated that the herbal extracts significantly improved meat oxidative stability. This may suggest that phytochemicals from plants were absorbed by the animals, consequently increasing the antioxidant activity of tissues, and could prevent lipid oxidation through quenching free radicals or through activation of antioxidant enzymes like superoxide dismutase, catalase, glutathione peroxidase, and glutathione reductase (Frankič et al., 2009).

CONCLUSION

The dietary supplementation of 1%chili pepper and 1%turmeric powders, especially their synergistic combination, had a positive influence on meat palatability, in terms of juiciness and tenderness, antioxidant activity, and lipid oxidation in beef, during refrigerated storage.

DECLARATIONS

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Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Authors' contribution

This work was performed with contribution of all authors. O. Pimpa designed the experimental procedures. F. Sresomjit and R. Bochuai performed the experiments. U. Pastsart interpreted the data and prepared the manuscript. All authors read and approved the final manuscript.

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Conflict of interests

The authors declare that they have no conflicts of interest.

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