Influences of marbling levels on water holding capacity, juiciness, and tenderness of pork loin and Thai consumer responses

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Abstract – Water holding capacity and Thai consumer responses (n=389) on juiciness and tenderness of pork *Longissimus dorsi* (LD) muscles with different marbling levels were investigated. At 24-h postmortem, fifteen pork LD muscles were visually evaluated and categorized into three marbling levels as low (score=1-2), medium (score=3-4), and high (score=5-6) according to US National Pork Board (2011) marbling standard. At 48-h postmortem, pH, drip, thawing, and cooking losses and Warner Bratzler Shear Force (WBSF) were evaluated. For consumer evaluation, each LD was cut into ten 3.5-cm thick steaks, cooked (180.0±5.0°C) in EO-42K broiler ovens (Sharp Corporation, Japan) to 71.0±1.0°C internal temperature (Testo 176T4, Testo Inc., Germany), cut into 1.3-cm^3 cubes, and kept warm at 54.0±1.0°C. Tenderness and juiciness were rated using a nine-point hedonic scale (9=extremely like and 1=extremely dislike). The experiment was in Completely Randomized Design. Influences of marbling levels were analyzed using General Linear Model. Treatment means differences were separated using PDIFF. Marbling levels affected ($p<0.05$) drip and cooking losses, but did not affect pH, thawing loss, and WBSF ($p>0.05$). Low marbling LD had more drip (3.5%) and cooking losses (22.6%) than high marbling (1.9% and 19.2%, respectively). For tenderness, consumers preferred high marbling LD more than ($p<0.05$) low, but rated their juiciness similarly ($p>0.05$).

Key Words – marbling, pork quality, consumer perception

I. INTRODUCTION

It is generally accepted that an increase in the amount of marbling has a positive influence on meat quality and eating quality of pork [4]. Marbling has also been shown to influence tenderness. But the extent to which marbling positively contributes to tenderness varies [4, 5]. It was reported that marbling within the range of 2.0 to 4.0% was optimal for pork palatability [14]. However, it is still controversial whether marbling has some influences on the water holding capacity and WBSF of meat. Some studies showed a significant decrease in WBSF for beef [8] and drip loss [7] for pork LD muscles with advancing marbling score, whereas others noted no differences in WBSF among marbling groups [5, 11]. The influences of marbling levels on eating quality of pork and consumer perception had not been investigated in Thailand. It is, therefore, our interest in investigating water holding capacity and tenderness of pork LD muscles with different marbling levels and the responses of Thai consumers on their juiciness and tenderness.

II. MATERIALS AND METHODS

Fifteen LD muscles were fabricated from left side of Duroc castrated male carcasses (approximately 110.0±10 kg slaughtered weight) at a commercial packing plant (Lopburi, Thailand). At 24-h postmortem, each LD was separated between approximately the 10th and 11th rib, visually evaluated, and categorized into three marbling levels as low (score=1 or 2), medium (score=3 or 4), and high (score=5 or 6) by industry trained personnel, with visual color ranged between 3 and 4, based on the US National Pork Board [10] marbling and color standard. After marbling and color evaluation, each LD was individually vacuum-packaged (Ultravac 2100, UltraSource, USA) in a polyvinylidene chloride vacuum bag and dipped into hot water (85.0±0.5°C) for 2 sec (Ultra shrink 2818, UltraSource, USA). Subsequently, all samples were packed in stylofoam containers with ice (0.9±0.6°C, EBI 20, Ebro data logger, Germany) and transported to Meat Technology Research Network Center (Bangkok, Thailand). Upon arrival, vacuum packaged LD muscles were stored in a walk-in chiller (1.6±0.4°C, EBI 20, Ebro data logger, Germany). At 48-h postmortem, ultimate pH (SevenGo^{TM} pH meter SG2, Mettler Toledo, Germany), drip, thawing, and cooking losses and WBSF were evaluated. A 2.0-cm thick steak was cut from each LD muscle, immediately weighed, and placed on a hook attached on the lid of a sealed plastic container with no contact to the container. After 48 h of chill storage (1.6±0.4°C, EBI 20, Ebro data logger, Germany), samples were removed from the containers and reweighed. Drip loss was expressed as a percentage of the initial weight [2]. For thawing loss, cooking loss, and WBSF, each LD was cut into a 5.0-cm thick steak, individually vacuum packaged (K-Nylon/LLDPE, Packmart, Thailand), and frozen (-20.0°C) until evaluation. On the evaluation day, samples were thawed overnight at 1.6±0.4°C (EBI 20, Ebro data logger, Germany), removed from vacuum bags, and reweighed for expression of thawing loss. Each sample was placed in a sealed high density polyethylene bag and cooked at 80.0°C (Labec water bath, Laboratory Equipment PTY. LTD, Australia) until internal temperature reached 71.0±1.0°C (Testo 176T4, Testo Inc., Germany). After cooling to 30.0±1.0°C in a running tap water, sample was then removed from the bag and weighed. Cooking loss was calculated by difference and expressed as a percentage of the initial weight [6, 13, 15]. Each sample was then cut across and along the muscle fibers into eight pieces of 1x3x1-cm^3 muscle cubes and assessed for WBSF using an Instron Universal Testing Machine Model 2519-104 (Instron Corporation, USA), equipped with a 50.0 kg load cell and 200 mm/min shearing rate [3]. For consumer evaluation, each frozen 3.5-cm thick LD steak, was thawed overnight at 2.0±2.0°C, and cooked in electronic broiler ovens (EO-42K, Sharp Corporation, Japan) at 180.0±5.0°C until an internal temperature reached 71.0±1.0°C (Testo 176T4, Testo Inc., Germany). Each cooked LD steak was cut into 1.3-cm^3 cubes and kept warm at 54.0±1.0°C (Labec water bath, Laboratory Equipment PTY. LTD, Australia) until serving. Consumer acceptability on tenderness and juiciness of LD muscles were evaluated using a nine-point hedonic scale, where 9 is extremely like, 5 is neither like nor dislike, and 1 is extremely dislike. The experimental design was a Completely Randomized Design. Influences of marbling levels on water holding capacity parameters, WBSF, and consumer perception were analyzed using General Linear Model (GLM). Treatment means differences were separated using PDIFF.

III. RESULTS AND DISCUSSION

Effect of marbling levels on pork water holding capacity parameters and WBSF.

From Table 1, No differences in pH values were observed among pork LD with different marbling levels ($p>0.05$). However, both medium (pH=5.65) and high (pH=5.68) marbling LD tended ($p=.09$) to have higher pH values than low marbling (pH=5.60). Similar results on pH values were reported [11], where three marbling levels were categorized by modification from the US National Pork Producer Council [10] and intramuscular fat analysis.

For water holding capacity parameters, our results showed that marbling levels did not ($p>0.05$) affect thawing loss, but it influenced ($p<0.05$) drip loss and cooking loss of pork LD. Low marbling LD muscles had more ($p<0.05$) drip loss (3.5%) and cooking loss (22.6%) than high marbling (1.9% and 19.2%, respectively). However, no differences ($p>0.05$) were observed between medium and high marbling with respect to drip loss and cooking loss. These observations might partially be explained by the tendency ($p=0.09$) for low pH values in the low marbling category LD observed in our results. A negative correlation between marbling levels and drip loss ($r = -0.46$) as well as cooking loss ($r = -0.41$) has been reported [5].

For tenderness, the influence of marbling levels was not (p>0.05) observed instrumentally when measured by WBSF. Although not statistically significant, we did find that WBSF for high marbling LD (4.07 kg) was lower (p>0.05) than those from low (4.44 kg) and medium (4.52 kg) marbling LD. Similarly, previous studies [5, 11] reported no influences of marbling levels on instrumental tenderness measurements.

Table 1 Influences of marbling levels on water holding capacity parameters, WBSF, and consumer (n=389) responses on tenderness and juiciness of pork *Longissimus dorsi* muscles

parameter	marbling category			SEM	p-value
	low (n=15)	medium (n=15)	high (n=15)		
pH value	5.60	5.65	5.68	0.11	0.09
drip loss (%)	3.45^{a}	2.88^{ab}	1.93^{b}	1.29	0.01
thawing loss (%)	3.67	2.89	2.83	1.43	0.22
cooking loss (%)	22.62^{a}	20.31^{b}	19.22^{b}	2.72	0.01
WBSF[1] (kg./cm^2)	4.44	4.52	4.07	0.79	0.26
tenderness[2]	6.6^{b}	6.5^{b}	6.9^{a}	1.82	0.03
juiciness[2]	6.3	6.2	6.5	1.82	0.17

a b Lsmeans in a row and marbling category with different superscripts differ (p<0.05).

[1] WBSF = Warner Bratzler Shear Force

[2] Consumer tenderness and juiciness responses rated on a 9-point hedonic scale (9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely)

Effect of marbling levels on consumer evaluation for juiciness and tenderness.

Instrumental measurements on juiciness and tenderness should be more meaningful, if consumer responses were investigated. From our study, the responses of 389 Thai consumers who liked to eat pork with ages ranging from 18 to more than 65 years old were recruited from different locations in Bangkok and Bangkok suburbs. Surprisingly, consumer evaluation indicated no difference (p>0.05, Table 1) in average juiciness liking scores of LD muscles among the three marbling categories. In contrast to our results, a study by [4] reported that marbling affected consumer evaluation (n=150) for pork juiciness. But an evaluation by trained panelists, no influence of marbling levels on pork juiciness was observed [11]. For tenderness evaluation, Thai consumers preferred high marbling LD (average liking score = 6.9) more than (p<0.05) the low (6.6) and medium (6.5) level marbling LD. This might indicate that consumers could detect the slight difference in WBSF we found in this study, although not statistically significant. Consumer tenderness evaluation was previously reported to be positively associated with marbling levels [4]. However, another study [9] found no influences of intramuscular fat contents on consumer evaluation for both juiciness and tenderness. By trained panelist evaluation, influence of marbling levels on hardness of pork was reported [11], but Cannata *et al.* (2010) [5] did not find an influence of marbling levels on tenderness. According to Smith and Carpenter (1974) cited by Savell and Cross (1988) [12], "based on strain theory, as marbling is deposited in the perivascular cells inside the walls of the perimysium or endomysium, the connective tissue walls on either side of the deposit are thinned, thereby decreasing their effective width, thickness, and strength". However, Aberle *et al.* (2012) [1] stated that "intramuscular lipids have been credited to make meat more tender, but little research showed a strong positive influence on tenderness". They added that "it was more likely that some lipids acted as lubricant in mastication, thus improving perceived tenderness".

IV. CONCLUSION

Pork LD muscles with high marbling levels resulted in lower drip loss and cooking loss. But this effect was not observed on consumer perceived juiciness. Although no influence of marbling was found on WBSF statistically. Consumers, however, preferred high marbling pork than low and medium. The effects of marbling levels on Thai consumer responses on juiciness and tenderness of pork LD were similar to some previous findings.

ACKNOWLEDGEMENTS

The author would like to thank Betagro Safety Meat Packing Company Limited for data collection permission and the Meat Technology Research Network Center, Department of Animal Production Technology and Fisheries, Faculty of Agricultural Technology, KMITL, Thailand for research facility support.

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