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# Nitrite residue and malonaldehyde reduction in *dendeng* — Indonesian dried meat — influenced by spices, curing methods and precooking preparation

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ABSTRACT

This research was conducted to reduce nitrite residue and malonaldehyde (MDA) content of dendeng through modifying the formulation of spices, curing technique and precooking preparation. The result showed that spiced fried dendeng was likely to contain high total phenolics and antioxidant activity. Wet cured dendeng combined with spices containing 2.0% coriander and 10.0% garlic and preparation by soaking before frying was effective to produce dendeng that had no detected nitrite residue and low MDA. In conclusion, the spice formulas used in this study could reduce nitrite residue and MDA level of dendeng, and the treatment prior to frying, by soaking the dendeng briefly in water, lowered MDA of non-spiced dendeng, but no effect of soaking was observed in spiced samples due to the very low MDA found in the samples.



## 1. Introduction

Dendeng, the Indonesian traditional dried meat, is commonly produced by using some spices and sugar at various levels. Therefore its flavour is sweet and spicy, and it is stable for several weeks at room temperature. The spices added in dendeng are coriander, garlic, galangal, pepper, tamarind, cinnamon, cumin and lime. The main spices were generally coriander, garlic and galangal. Pepper, tamarind, cinnamon, cumin and lime are the additional spices that are sometimes added by producers in dendeng industries (Suryati, Astawan, Lioe, & Wresdiyati, 2012). These spices were reported to have an antioxidant activity (Tangkanakul et al., 2009). It is known that one of garlic component, S-oxodiallyl disulfide, has an ability to inhibit *N*-nitrosodimethylamine formation and to scavenge nitrite reactivity (Choi, Chung, Lee, Shin, & Sung, 2007). Therefore the use of spices in dendeng processing was considered to be able to reduce nitrite residue and malonaldehyde (MDA) level. The presence of nitrite residue in commercial dendeng (Bintoro, Morit, Mikawa, & Yasui, 1987) could be due to the curing agent used in dendeng industry. Curing with sodium or potassium nitrate, well known as saltpeter, is applied in industrial dendeng processing (Suryati et al., 2012) to obtain a stable red color and to extend its shelf life.

Besides sodium nitrate, sodium nitrite could also be used as a curing agent at lower concentration than sodium nitrate (Directive, 2006) because of the high reactivity of sodium nitrite (Honikel, 2008; Sebranek & Bacus, 2007). Nitrate or nitrite salt could form an intermediate nitrosating agent, $N_2O_3$, and then formed other nitrosating agents, NO and $NO_2$ (Honikel, 2008; Rostkowska, Zwierz, Rozanski, Moniuszko-Jakoniuk, & Roszczenko, 1998; Skibsted, 2011). Reactive NO could be reacted with myoglobin to yield nitrosylmyoglobin that yield the characteristic red color of cured meat, and its denatured pink form, nitrosylhemochromogen pigment, contributed to cooked cured meat color (Skibsted, 2011). NO group could react with secondary and tertiary amines to form carcinogenic compounds, nitrosamines (Rostkowska et al., 1998; Skibsted, 2011). But the reactivity of NO could be prevented through the stabilization of $N_2O_3$ by a role of antioxidants, such as ascorbic acid (Skibsted, 2011). Antioxidant activity of dendeng spices could be considered to stabilize $N_2O_3$ and prevent the reactivity of NO.

In addition to the potent hazard due to nitrite residue excess, MDA is another potent hazard that could be formed in dendeng as a result of lipid oxidation in meat. MDA is a secondary product of lipid oxidation that had contribution to the off-quality of meat product (Fernandez, Perez-Alvarez, & Fernandez-Lopez, 1997). MDA can also be reacted with DNA to form DNA adducts which are mutagenic (Marnett, 2000). Therefore it is needed to control MDA formation. The use of

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antioxidant-rich spices has been reported to be able to reduce MDA in meat products, such as hamburger (Li et al., 2010). Thus, the use of spices and curing, besides the benefit to give color and flavor, is expected to effectively reduce MDA content.

Dendeng is usually prepared by soaking in water for a moment to rehydrate it before frying, so that it does not result burnt flavor during frying that could decrease its palatability. In addition to that, soaking before frying is done to produce tender fried dendeng. There is no standard of duration of soaking before frying of dendeng. However whether the precooking preparation has a further effect on the reduction of nitrite residue and MDA content is not known. This research was conducted to evaluate the use of spices at different concentrations, and the application of different curing technique and precooking preparation to reduce the nitrite residue and MDA level in fried dendeng.

## 2. Materials and methods

### 2.1. Materials

Meat in this study was obtained from the round of Brahman cross cattle 1.5 yr. The spices i.e. galangal, coriander, garlic, tamarind, pepper were bought from local market, Indonesia. Analyses were conducted by using chemicals of analytical grade: absolute methanol, Folin–Ciocalteu, gallic acid, vitamin C, thiobarbituric acid (TBA) from Merck (Merck KGaA, Germany), and 1,1-diphenyl-2-picrylhydrazil (DPPH), propylgallate (PG), ethylenediaminetetraacetic acid (EDTA), 1,1,3,3-tetraethoxypropane (TEP), 1-(N)-naphthylethylenediamine dihydrochloride and sulfanilamide from Sigma (Sigma Aldrich Co., USA).

### 2.2. Dendeng production and sample preparations

Dendeng was produced using two different formulas of spices, formula I and II, as presented in Table 1. Spice formula II contained garlic and coriander at 2-fold the level of formula I. Garlic and coriander are the main spices in dendeng that have played a role factor on reduction of nitrite reactivity and antioxidant activity, and the use of them in commercial dendeng is of various levels, 1%–15% for garlic and 1%–4% for coriander (Suryati et al., 2012). Therefore, in this study garlic and coriander were used at low and medium levels, garlic was used 5% (formula I) and 10% (formula II), and coriander was used 1% (formula I) and 2% (formula II). The frozen beef was thawed and trimmed and then sliced about 5 mm thickness. For wet curing treatments, meat slices (1 kg) were soaked in sodium nitrite solution (150 mg/L potable water) for 12 h at room temperature. Then the nitrite cured meat was mixed with other ingredients as appropriate for spices treatments I and II (Table 1), and held for 12 h, this gave the total time for wet curing process of 24 h. The cured and spiced meats were finally dried using oven at 60 °C for 3 h, and it was reversed in such a way that the bottom side is in up position, and the drying was continued at 70 °C for 5 h.

In dendeng with dry curing, sodium nitrite (150 mg/kg) was added to meat slices by mixing the nitrite salt with other ingredients prior to the application on meat, then these were applied to the meat by manual stirring for 30 min. The marination process lasted for 12 h at room temperature. In addition to spiced dendeng, non-spiced dendeng was made as a control treatment. The process of uncured dendeng (without sodium nitrite curing) was similar to that of dry curing, given that the meat slices were mixed readily with ingredients mix but without soaking in sodium nitrite solution at first.

After drying and before frying, dendeng was stored at room temperature for 24 h then kept at refrigerator until frying process was conducted (about a week). Fried dendeng were prepared with and without soaking in potable water for 5 min and were drained and left for 15 min before frying. Frying was done by using vegetable oil at 150 °C for 1.5 min. Oil was not repeatedly used for frying. Two litres of palm oil was used for frying 300 g dendeng. Fried dendeng samples were ground and homogenized by using a blender, then it were packed and stored at −25 °C prior to analysis.

**Table 1**
Ingredient composition of dendeng.

| Materials | Formula | | | |
|---|---|---|---|---|
| | I | | II | |
| | (%)[a] | Weight (g) | (%)[a] | Weight (g) |
| Beef | | 1000 | | 1000 |
| Salt | 2.5 | 25 | 2.5 | 25 |
| Galangal | 8.5 | 85 | 8.5 | 85 |
| Coriander [b] | 1.0 | 10 | 2.0 | 20 |
| Garlic [b] | 5.0 | 50 | 10.0 | 100 |
| Brown sugar | 16.5 | 165 | 16.5 | 165 |
| Sugar | 16.5 | 165 | 16.5 | 165 |
| Tamarind | 0.3 | 3 | 0.3 | 3 |
| Pepper | 0.3 | 3 | 0.3 | 3 |
| $NaNO_2$ (150 mg/kg)[c] | 0.03 | 0.3 | 0.03 | 0.3 |

[a] Based on meat weight.
[b] Formula II had 2-fold higher coriander and garlic, compared to formula I.
[c] $NaNO_2$ added to curing treatment; $NaNO_2$ was not added to uncured treatments.

### 2.3. Moisture and pH determination

Moisture and pH on fried dendeng were measured as additional variables to explain the condition in dendeng system (nitrite residue forming and oxidation reaction). Moisture was determined by oven-drying at 105 °C according to AOAC (2005). pH was measured by a pH meter Hanna HI 99163 (Romania, Europe).

### 2.4. Total phenolics, antioxidant activity and capacity

The determination of total phenolics, antioxidant activity and capacity was carried out on fried dendeng by following procedure as described by Tangkanakul et al. (2009) with modification in extraction procedure. Compounds in 1 g of sample were extracted with 2.5 mL of 100% methanol at room temperature for 24 h. After filtration, the filtrate was separated in other tube and 2.5 mL of methanol was added into retentate. The first filtrate was stored for 24 h in −25 °C in a capped tube. After 24 h, the filtrate from the second filtration was separated and mixed with the filtrate of the day before in 10 mL volumetric flask, and methanol was added into these until the volume reached 10 mL. Extracts were stored in −25 °C prior to analysis of total phenolics and antioxidant activities. Total phenolics were expressed as mg gallic acid equivalent (GAE) per 100 g dry matter (DM) of dendeng. Antioxidant activity was determined by the percentage of scavenging activity on radical DPPH, and antioxidant capacity was determined based on the inhibition of vitamin C at some concentrations (in a linear calibration) on radical DPPH. Antioxidant capacity was expressed by mg vitamin C equivalent (VCE) per 100 g DM of dendeng.

### 2.5. Nitrite residual analysis

Residual nitrite in fried dendeng was analysed according to the method described by AOAC (2005). Nitrite residual was expressed as mg nitrite per kg DM of dendeng.

### 2.6. Malonaldehyde (MDA) analysis

Malonaldehyde analysis for fried dendeng was carried out using analysis of thiobarbituric acid reactive substances (TBARS) according to the method as described by Sørensen and Jørgensen (1996) with a little modification. The modification was the homogenization of sample before the addition of PG and EDTA solution. TBARS analysis by spectrophotometer (GeneQuant 1300, Sweden) was done after 5 mL of sample distillate was reacted with 5 mL TBA 0.02 M and then incubated at

100 °C for 40 min. Absorbance at λ 532 nm was measured using two replications for each sample. TBARS was expressed as mg of malonaldehyde (MDA) per kg DM of dendeng using TEP as a standard.

### 2.7. Proximate analysis

Proximate analysis was conducted according to AOAC (2005) and represented by cured and non-cured fried dendeng processed with spice formula II and prepared by soaking before frying.

### 2.8. Statistical analysis

The study was conducted in a split-plot design by three replicates. Treatment combination of ingredient (without spices, with spices formula I or II) and curing method (without curing, with wet curing or dry curing technique) was the main-plot, and precooking preparation technique (with or without soaking in the water for 5 min) was the subplot. The data were analyzed using analysis of variance, and the differences of means were analyzed using Tukey test. Analyses of all data were conducted using program Statistix 8.

## 3. Results and discussion

### 3.1. Moisture content and pH

The application of spices and curing technique affected the moisture content of fried dendeng, but their effect didn't show the consistent pattern of moisture content on the product as presented in Table 2. Wet cured dendeng with high spices formula II contained higher moisture than control treatment. However dry cured dendeng had moisture content similar to the non-cured control treatment. This indicated that the seasoning in wet cured dendeng could retain the moisture, even after frying. The hygroscopic effect of palm sugar seems to play a role to increase moisture retention of wet cured dendeng. Dendeng with soaking treatment before frying had higher moisture ($p < 0.05$) than without soaking (Table 2). This indicated that the absorbed water in soaking treatment was not removed totally from product during frying because of short frying time.

The pH value of fried spiced dendeng ranged from 5.18 to 5.59, which was lower than control (non-spiced) dendeng, which had a pH range of 5.66 to 6.27 (Table 3). This pH value was not widely different with that of fried commercial (5.19–5.90) reported by Suryati et al. (2012). The treatment of soaking before frying did not affect on dendeng pH. The increasing of dendeng moisture was not followed by the decreasing of its pH. The decreasing of dendeng pH was merely caused by seasoning usage on the dendeng process, not by the increasing of moisture.

**Table 2**
Moisture (%) of fried dendeng processed by different spices formula, curing and precooking preparation techniques.*

| Treatment [a] | Precooking preparation | | Means [b] |
|---|---|---|---|
| | Without soaking | Soaking | |
| Without curing | | | |
| Non-spices | 11.94 ± 1.63 | 23.61 ± 4.45 | 17.78 ± 7.06[ab] |
| Spices formula I | 13.15 ± 1.63 | 27.17 ± 0.94 | 20.16 ± 7.77[a] |
| Spices formula II | 15.53 ± 0.47 | 24.36 ± 2.25 | 19.95 ± 5.05[ab] |
| Wet curing | | | |
| Non-spices | 8.93 ± 1.37 | 19.22 ± 3.24 | 14.08 ± 6.06[b] |
| Spices formula I | 15.09 ± 3.03 | 24.11 ± 1.25 | 19.60 ± 5.36[ab] |
| Spices formula II | 12.34 ± 2.43 | 27.66 ± 4.37 | 20.00 ± 8.96[a] |
| Dry curing | | | |
| Non-spices | 12.63 ± 4.13 | 21.59 ± 4.27 | 17.11 ± 6.18[ab] |
| Spices formula I | 14.96 ± 0,16 | 24.40 ± 1.13 | 19.68 ± 5.22[ab] |
| Spices formula II | 13.31 ± 1.24 | 23.60 ± 1.24 | 18.45 ± 5.75[ab] |
| Means [c] | 13.10 ± 2.64[b] | 23.97 ± 3.47[a] | |

* Means ± SD.
[a] Treatment interactions were not significant.
[b] Means in the same column with different superscript letters are different ($p < 0.05$).
[c] Means in the same row with different superscript letters are different ($p < 0.05$).

**Table 3**
pH of fried dendeng processed by different spices formula, curing techniques and precooking preparation.*

| Treatment[a] | Precooking preparation | | Means[b] |
|---|---|---|---|
| | Without soaking | Soaking | |
| Without curing | | | |
| Non-spices | 5.83 ± 0.34 | 6.27 ± 0.38 | 6.05 ± 0.40[a] |
| Spices formula I | 5.41 ± 0.18 | 5.59 ± 0.27 | 5.50 ± 0.23[bc] |
| Spices formula II | 5.48 ± 0.07 | 5.48 ± 0.08 | 5.48 ± 0.07[bc] |
| Wet curing | | | |
| Non-spices | 5.66 ± 0.12 | 6.13 ± 0.13 | 5.90 ± 0.28[ab] |
| Spices formula I | 5.44 ± 0.15 | 5.35 ± 0.09 | 5.40 ± 0.12[c] |
| Spices formula II | 5.38 ± 0.03 | 5.18 ± 0.14 | 5.28 ± 0.14[c] |
| Dry curing | | | |
| Non-spices | 6.02 ± 0.54 | 5.97 ± 0.17 | 5.99 ± 0.36[a] |
| Spices formula I | 5.31 ± 0.23 | 5.34 ± 0.03 | 5.32 ± 0.15[c] |
| Spices formula II | 5.22 ± 0.23 | 5.42 ± 0.13 | 5.32 ± 0.20[c] |
| Means | 5.53 ± 0.33 | 5.64 ± 0.41 | |

* Means ± SD.
[a] Treatment interactions were not significant.
[b] Means in the same column with different superscript letters are different ($p < 0.05$).

The pH value and moisture could affect the reactions occurred in food system, such as Maillard reaction (Lertittikul, Benjakul, & Tanaka, 2007; Martins & Van Boekel, 2005; Matiacevich, Santagapita, & Buera, 2010), oxidation (McClements & Decker, 2000), and nitrite residue formation (Honikel, 2008; Sebranek & Bacus, 2007; Skibsted, 2011). The intensive Maillard reaction resulted in browning product, besides antioxidant compound (Alfawaz, Smith, & Jeon, 1994; Dong et al., 2012; Gu et al., 2010; Miranda, Rakovski, & Were, 2012; Sun, Zhao, Chui, Zhao, & Yang, 2010; Yilmaz & Toledo, 2005; Zhuang & Sun, 2011). These components could exist in dendeng, but in dendeng system malonaldehyde and nitrite residue might be inhibited, as a result of antioxidant activity of dendeng. Moreover, the oxidation reaction could produce free radical compounds and secondary products such as malonaldehyde that contributed to the off-quality of products (Campo et al., 2006; Fernandez et al., 1997).

### 3.2. Total phenolics, antioxidant activity and capacity

Dendeng processed by using both of spices formula I or II resulted in higher total phenolic contents ($p < 0.05$) than control. Total phenolics content of dendeng was not different between treatments prepared with spice formula I or II. Thus, use of twofold higher garlic and coriander concentrations (formula II) resulted in a similar total phenolics content as formula I. However, addition of spices at either level (I or II) increased total phenolics content of dendeng ($p < 0.05$), compared to control treatments without spices (Table 4). The soaking before frying also had no effect on total phenolic contents of fried dendeng (Table 4). It is known that total phenolic contents were correlated to antioxidant activity. Some research results showed high correlation between total phenolic contents and antioxidant activity (Kim, Yang, Lee, & Kang, 2011; Leelarungrayub, Rattanapanone, Chanarat, & Gebicki, 2006; Mahae & Chaiseri, 2009; Tangkanakul, Trakoontivakorn, Auttaviboonkul, Niyomvit, & Wongkrajang, 2006; Tangkanakul et al., 2009), but others showed low or no correlation (Chan et al., 2008; Kaur & Kapoor, 2002; Othman, Ismail, Abdul Ghani, & Adenan, 2007).

In this study, total phenolics was not in line with DPPH scavenging activity and antioxidant capacity. Total phenolics were affected by spices only (Table 4), but DPPH scavenging activity and antioxidant capacity were affected by the interaction between spices and curing combination with soaking before frying (Table 5). As shown in Table 5 antioxidant capacity of dendeng soaked before frying was similar to that without soaking treatment.

**Table 4**
Total phenolics (mg GAE 100 $g^{-1}$ DM) fried dendeng processed by different spices formula, curing techniques and precooking preparation.*

| Treatment[a] | Precooking preparation | | Means[b] |
|---|---|---|---|
| | Without soaking | Soaking | |
| Without curing | | | |
| Non-spices | 41.98 ± 4.44 | 48.66 ± 2.27 | 45.32 ± 4.83[b] |
| Spices formula I | 104.71 ± 9.70 | 97.17 ± 10.16 | 101.50 ± 9.06[a] |
| Spices formula II | 106.24 ± 6.43 | 100.31 ± 9.63 | 104.03 ± 7.58[a] |
| Wet curing | | | |
| Non-spices | 38.88 ± 2.35 | 43.57 ± 3.79 | 41.25 ± 3.48[b] |
| Spices formula I | 94.31 ± 5.33 | 95.52 ± 8.02 | 95.70 ± 5.97[a] |
| Spices formula II | 105.40 ± 6.16 | 108.90 ± 9.86 | 107.81 ± 7.16[a] |
| Dry curing | | | |
| Non-spices | 44.41 ± 5.88 | 50.03 ± 12.33 | 45.97 ± 9.00[b] |
| Spices formula I | 103.24 ± 4.45 | 110.33 ± 15.60 | 105.68 ± 10.43[a] |
| Spices formula II | 99.62 ± 13.77 | 95.38 ± 13.64 | 97.97 ± 11.46[a] |
| Means | 82.09 ± 29.91 | 83.32 ± 27.78 | |

* Means ± SD; GAE = gallic acid equivalents; DM = dry matter.
[a] Treatment interactions were not significant.
[b] Means in the same column with different superscript letters are different ($p < 0.05$).

DPPH scavenging activity and antioxidant capacity were both significantly increased ($p < 0.05$) by addition of spices to dendeng, compared to non-spice controls (Table 5.). DPPH scavenging activity was not different between spice levels I and II. However, antioxidant capacity was significantly higher ($p < 0.05$) for spice treatment II, compared to spice treatment I without soaking before frying (Table 5). This indicated that antioxidant activity of dendeng was not affected by total phenolic contents only. This was similar with the research result of commercial dendeng (Suryati et al., 2012). Based on this result, the antioxidant activity on dendeng was not only affected by total phenolics, but perhaps also by other compounds such as Maillard reaction products, because non enzymatic browning as a result of Maillard reaction was occurred on dendeng (Buckle & Purnomo, 1986). Protein and sugar contained in dendeng undergo a browning reaction to form Maillard products. It is known that Maillard reaction product, such as melanoidin, also had antioxidant activity (Dong et al., 2012; Gu et al., 2010; Miranda et al., 2012; Sun et al., 2010; Yilmaz & Toledo, 2005; Zhuang & Sun, 2011). Antioxidant activity that resulted from this Maillard reaction was considered to affect DPPH scavenging activity and antioxidant capacity of dendeng.

### 3.3. Nitrite residue content

Nitrite residue content was affected by the interaction between spices formulation and curing technique combined with precooking preparation treatment. Fried dendeng processed without curing, either soaking or without soaking before frying, as expected did not contain detected nitrite residue (Table 6). Except on samples of wet cured dendeng combined with spices formula I prepared by soaking before frying, spices treatment could decrease nitrite residue significantly ($p < 0.05$) either with wet curing or dry curing. Wet cured dendeng with spices formula II, either prepared by soaking or without soaking, had no detected nitrite residue. However, nitrite residue of dry cured dendeng was about 2-fold higher than wet cured dendeng prepared without spices (3.57 and 7.88 ppm residual nitrite respectively for without soaking, and 7.12 and 14.90 ppm residual nitrite respectively for with soaking before frying treatment; Table 6). This was due to some of sodium nitrite from solution was not absorbed into meat in wet curing. In contrast, in dry curing process all of sodium nitrite added were allowed to be contained in meat, therefore nitrite residue in dry cured dendeng was higher than wet cured dendeng.

Except on wet cured dendeng with spices formula II, soaking before frying treatment resulted in higher nitrite residue ($p < 0.05$) than that of without soaking. No explanation is apparent for the observation that residual nitrite levels increased after soaking. Wet cured dendeng with spices formula II curing process might not produce nitrite excess because probably almost all of nitrite reacted with myoglobin, or even if there was a nitrite excess, the nitrosating agent was stabilized by antioxidants of spices. Thus nitrite as residue in cured dendeng with spices formula II, either soaked or not, was not detected.

Reducing nitrite as a result of spices used in dendeng gave value added, besides an increasing palatability caused by a nice flavor and aroma of dendeng. It is noted that nitrite residue of dendeng in this study was still under maximum level (100 mg/kg) for meat product (Directive, 2006). Limitation of nitrite consumption is necessary to prevent the risk of a carcinogenic compound, nitrosamine. Thus, the reduction of nitrite residue of cured dendeng to the undetected limit in this study gives the benefit aspect to decrease the risk of nitrosamine forming.

### 3.4. Malonaldehyde content

Malonaldehyde was determined by TBARS value expressed as mg MDA per kg DM of dendeng. MDA was produced in fried dendeng due to lipid oxidation that occurred during processing, especially during drying and frying process that involved heating. High fat and low moisture content of dendeng was represented by the composition of fried dendeng prepared by spice formula II with soaking before frying (Table 7). This result indicated that the intensive lipid oxidation potentially occurred in dendeng.

**Table 5**
DPPH scavenging activity and antioxidant capacity of fried dendeng processed by different spices formula, curing techniques and precooking preparation.*

| Treatment | DPPH scavenging activity (%)[1,2] | | Antioxidant capacity (mg VCE/100 g DM of dendeng)[1,2] | |
|---|---|---|---|---|
| | Without soaking | Soaking | Without soaking | Soaking |
| Without curing | | | | |
| Non-spices | 28.89 ± 3.54[e] | 21.06 ± 0.64[e] | 53.68 ± 5.60[d] | 59.53 ± 3.58[d] |
| Spices formula I | 86.22 ± 3.10[a] | 61.33 ± 4.71[cd] | 162.60 ± 8.11[bc] | 177.91 ± 15.46[abc] |
| Spices formula II | 81.65 ± 5.11[a] | 61.47 ± 7.92[cd] | 204.11 ± 12.68[a] | 171.26 ± 18.06[abc] |
| Wet curing | | | | |
| Non-spices | 27.61 ± 6.51[e] | 26.82 ± 5.96[e] | 49.76 ± 12.16[d] | 68.01 ± 10.79[d] |
| Spices formula I | 77.45 ± 5.94[abc] | 56.56 ± 2.68[d] | 150.45 ± 10.08[c] | 157.20 ± 6.11[bc] |
| Spices formula II | 79.69 ± 3.66[ab] | 62.91 ± 3.84[bcd] | 191.77 ± 9.89[ab] | 183.66 ± 10.07[abc] |
| Dry curing | | | | |
| Non-spices | 37.40 ± 5.82[e] | 33.72 ± 4.88[e] | 74.25 ± 4.82[d] | 92.41 ± 9.04[d] |
| Spices formula I | 84.38 ± 1.97[a] | 62.42 ± 9.12[bcd] | 162.33 ± 4.15[bc] | 174.41 ± 24.94[abc] |
| Spices formula II | 79.73 ± 7.70[ab] | 60.04 ± 7.89[d] | 194.00 ± 16.12[ab] | 165.76 ± 19.19[abc] |

* Means ± SD.
[1] Treatment interactions were significant ($p < 0.01$).
[2] Within measurements (DPPH Scavenging, or Antioxidant Capacity), means with different superscript letters are different ($p < 0.05$). DPPH = 1,1 diphenyl-2-picrylhydrazil; VCE = vitamin C equivalents; DM = dry matter.

**Table 6**
Nitrite residue and TBARS content of fried dendeng processed by different spices formula, curing techniques and precooking preparation.*

| Treatment | Nitrite residue (mg/kg of DM) [1,2] | | TBARS (mg MDA/kg of DM) [1,2] | |
|---|---|---|---|---|
| | Without soaking | Soaking | Without soaking | Soaking |
| Without curing | | | | |
| Non-spices | ND | ND | 15.42 ± 1.19[b] | 10.93 ± 1.34[bc] |
| Spices formula I | ND | ND | 2.12 ± 0.47[d] | 1.33 ± 0.44[d] |
| Spices formula II | ND | ND | 3.88 ± 1.20[d] | 2.15 ± 0.47[d] |
| Wet curing | | | | |
| Non-spices | 3.57 ± 1.13[d] | 7.12 ± 1.08[bc] | 36.02 ± 5.65[a] | 11.37 ± 3.31[b] |
| Spices formula I | ND | 4.54 ± 1.08[bcd] | 4.26 ± 1.42[cd] | 1.37 ± 0.10[d] |
| Spices formula II | ND | ND | 2.36 ± 1.13[d] | 1.72 ± 0.13[d] |
| Dry curing | | | | |
| Non-spices | 7.88 ± 2.46[b] | 14.90 ± 1.78[a] | 13.33 ± 5.01[b] | 3.11 ± 0.73[d] |
| Spices formula I | 4.03 ± 0.06[cd] | 5.49 ± 1.16[bcd] | 2.40 ± 1.16[d] | 1.16 ± 0.21[d] |
| Spices formula II | ND | 4.28 ± 0.62[cd] | 2.76 ± 1.21[d] | 1.78 ± 0.42[d] |

* Means ± SD.
[1] Treatment interactions were significant ($p < 0.01$).
[2] Within measurements (Nitrite Residue, or TBARS) means with different superscript letters are different ($p < 0.05$). TBARS = thiobarbituric acid reactive substances; MDA = malonaldehyde; DM = dry matter; ND = not detectable.

Spices used in dendeng, either from formula I or II, significantly decreased TBARS values ($p < 0.05$) compared to control without spices (Table 6). This indicated that the spices used in dendeng contributed antioxidant compounds that played a role on inhibiting of lipid oxidation. Dendeng control (without seasoning) with soaking before frying, had lower TBARS values than without soaking ($p < 0.05$). It means that soaking before frying resulted in lower TBARS ($p < 0.05$) compared to other treatments, possibly due to an extraction of water soluble TBA reactive substances into the water phase, and subsequent loss during the 15 min draining period. Statistically, TBARS values of samples with soaking before frying treatment for cured or non-cured spiced dendeng were not different with those of without soaking treatment. But all of dendeng with spices formula I or II and soaked before frying had TBARS values lower than 2.28 mg/kg at which the limit of TBARS value could give a rancid flavor in meat (Campo et al., 2006).

Based on TBARS values, it is known that soaking before frying as dendeng precooking preparation had a benefit to reduce MDA content. Decreasing of MDA in this case was caused by the decreasing of oxidation reaction intensity during frying and the reduction of MDA formed during drying due to water soluble TBARS dissolved in soaking process. Generally, wet cured dendeng combined with spices formula II and preparation by soaking before frying was effective to produce dendeng with undetected nitrite residue and low MDA content, compared to non cured dendeng with spices formula I or II prepared by soaking before frying.

## 4. Conclusions

Spices used in dendeng contained phenolic compounds that had antioxidant activities which could reduce nitrite residue and malonaldehyde levels. Brief soaking before frying, lowered MDA of non-spices dendeng, but no effect of soaking was observed in spiced samples.

**Table 7**
Proximate composition of fried dendeng with the application of spices formula II and prepared by soaking before frying.

| Composition (%) | Uncured dendeng | Wet cured dendeng |
|---|---|---|
| Moisture | 22.41 | 21.70 |
| Proteins | 24.93 | 23.98 |
| Fat | 7.08 | 6.98 |
| Ash | 3.75 | 3.64 |
| Crude fiber | 2.70 | 2.63 |
| Carbohydrate | 41.14 | 44.27 |

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