The effect of pre-drying treatments on the quality of dehydrated ground beef

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Abstract. Dehydrated ground meat is widely used as an ingredient in various instant products. This study was aimed to investigate the effect of pre-drying treatments on the physicochemical properties of dehydrated ground beef. The experimental design used a completely randomized design of 3 x 3 factorial, with 3 grinding times (1, 3, and 5 minutes) and 3 cooking methods (steaming, pressure cooking/presto, and roasting). The beef was sliced, milled and cooked according to the treatments, frozen for 24 h, then dried by using an oven drier at a constant temperature of 60°C for 3 h, and finally powdered. The physicochemical properties of dried ground beef were determined including the yield, particle size distribution, rehydration ratio, hygroscopicity, color, moisture content, and fat content. Results showed that the presto method produced the highest moisture content of the cooked beef. Longer grinding time increased the particle passed mesh-6, rehydration ratio, and color, but decreased the final moisture content and fat content. Grinding time of 5 minutes with pressure cooking was selected as the best treatment to prepare dried ground meat. This treatment had a yield of 22.26%, moisture content of 3.38%, rehydration ratio of 3.25, the hygroscopicity of 6.13%, lightness of 53.62, value ‘a’ of 5.52, value ‘b’ of 10.21, and fat of 6.36%.

1. Introduction
Meat is food as a source of essential amino acids, B-complex vitamins, and minerals [1]. Microorganisms grow easily on fresh meat due to high-water activity which limits the shelf life of the meat [2]. The drying process can remove the water content of meat therefore, the shelf life of dried meat can be extended [3]. Dehydrated meat, either cut or ground meat, is widely used as an ingredient in various instant product formulas, such as pasta, noodles, porridge, and soup. The presence of dried meat ingredients in instant food products increases the nutrition and sensory value of these products [4, 5].

The drying process should be designed properly so that the dried product satisfied the product standards. Generally, the drying process must consider nutritional and sensory aspects, traceability, and food safety [6]. The drying process results in significant changes in the physicochemical properties and structure of foods [1]. Some changes on the product due to meat drying are nutritive value [2]; color, rehydration, texture, and muscular structure [4].

Pre-treatments before the drying process such as mincing, heating, cooking, freezing, and thawing can enhance in reducing the internal resistance to mass transfer [1]. Fitriani et al. [7] reported that the longer grinding time resulted in the finer particle obtained during meat grinding, which due to friction induces breaking big particles into smaller particles. The cooking process is the main factor that impacts
the quality of meat products due to a series of chemical and physical reactions [8]. Moreover, Choi et al. [9] reported that the particle size of ground dried-pork meat products is influenced by the binding properties of meat. Laopoolkit and Suwannaporn [4] obtained that higher pressure-cooking and lower freezing treatment followed by atmospheric pressure drying produced fine dried pork products. However, the study on the effect of pre-treatment, prior drying process, on the quality of dehydrated ground beef was limited. Therefore, this study was aimed to evaluate the effect of grinding time and cooking techniques on the quality of dehydrated ground beef.

2. Materials and method

2.1. Materials
The fresh sample of beef was purchased from a local market in Subang, Indonesia. All intramuscular fat was removed from the muscle [9].

2.2. Experimental set-up
The experimental design used was a completely randomized design of 3 x 3 factorial, with 3 grinding times (T) (1, 3, and 5 min) and 3 cooking methods (steaming for 45 min (K), pressure cooking/presto for 10 min (P), and roasting for 10 min (S)). The treatment details could be seen in Table 1. Each treatment was repeated 3 times.

| Code | Treatment                          |
|------|-----------------------------------|
| T1K  | steaming + 1 min of grinding time |
| T3K  | steaming + 3 min of grinding time |
| T5K  | steaming + 5 min of grinding time |
| T1P  | presto + 1 min of grinding time   |
| T3P  | presto + 3 min of grinding time   |
| T5P  | presto + 5 min of grinding time   |
| T1S  | roasting + 1 min of grinding time |
| T3S  | roasting + 3 min of grinding time |
| T5S  | roasting + 5 min of grinding time |

The beef was sliced and thoroughly washed. About 1 kg of beef was milled and cooked according to the treatments. The ground beef was frozen for 24 h and then dried using an oven drier at a constant temperature of 60°C for 3 h [2]. Subsequently, the dried beef was powdered by a pulverizer (Phillips Inc) and sieved by the 6 and 12-mesh screen so that, we obtained 3 particle size (i.e unpass 6-mesh, pass 6-mesh but unpass 12-mesh, and pass 12-mesh).

2.3. Product analysis
The moisture content of cooked meat was analyzed as initial moisture content. The characteristic of dried meat was examined including moisture and fat content, product yield, particle size distribution, rehydration ratio, hygroscopicity, and color.

Product yield (%) was calculated by dividing the weight of dried meat and fresh ground meat [10]. The size distribution was calculated based on the comparison between the particles that were sieved with the 6 and 12-mesh screen and dried meat. Moisture and fat content of samples were determined following procedures which are described in the AOAC [11] using a hot air oven and Soxhlet apparatus.

The rehydration ratio of the sample was evaluated using the method described by Laopoolkit and Suwannaporn [4]. Meat samples (about 5g) were rehydrated in boiled water (30 mL) for 3 min. The rehydrated meat was drained for 30 min by filter paper that had been known the weight and then was weighed immediately. The rehydration ratio was calculated as the ratio of the rehydration meat weight to the dry sample weight.
The hygroscopicity of the sample was determined using the method described by Ayanwale et al. [2]. About 5 g of sample was exposed to ambient conditions (temperature of 27°C and humidity of 75%). Hygroscopicity was then expressed as the ratio of weight gained by the sample after 48 h of exposure.

The color of samples was measured by a chromameter (3NH, China) according to Mishra et al. [12]. The color parameters of samples including lightness (L), red-green (a), and blue-yellow (b) were recorded in this study.

2.4. Statistical analysis
An analysis of variance (ANOVA) and Duncan test (confidence level, α= 0.05) were performed on the obtained results in order to establish significant differences using SPSS ver. 13.0 software. Means and standard deviations were computed and reported for each parameter. The best treatment was determined by using an effective index method. All parameters (i.e. yield, rehydration ratio, moisture content, color, and fat content) were used to evaluate the effect of grinding time and cooking techniques using the effective index method, namely selection based on the highest total result value (Nh). The highest rating is determined from the highest score (Nh) [13].

3. Results

3.1. Yield and size distribution
The drying yield and size distribution of dehydrated ground beef are shown in Table 2. Based on Table 2, the results of drying yield indicated that there was no significant difference between all treatments. Every 1000g of fresh ground beef produced about 220 – 255g of dehydrated ground beef. This means that more than half of the material lost during meat processing, mainly water due to evaporation during the cooking and drying process.

| Treatments | Yield, %  | < 6 mesh | 6-12 mesh | > 12 mesh |
|------------|-----------|----------|-----------|-----------|
| T1K        | 23.47 ± 0.70a | 64.57 ± 4.88b | 21.22 ± 4.14a | 14.22 ± 0.75ab |
| T3K        | 23.67 ± 1.04a | 47.77 ± 0.41ab | 34.03 ± 1.31bc | 18.12 ± 0.81ab |
| T5K        | 22.07 ± 3.24a | 32.84 ± 1.13a | 41.96 ± 3.33bc | 25.19 ± 2.34b  |
| T1P        | 22.06 ± 1.70a | 59.83 ± 2.26b | 28.90 ± 1.30ab | 11.10 ± 3.46a  |
| T3P        | 22.25 ± 0.83a | 49.52 ± 1.95ab | 35.28 ± 1.76bc | 15.33 ± 3.58ab |
| T5P        | 22.26 ± 1.65a | 38.35 ± 1.85a | 40.37 ± 4.37c  | 21.25 ± 2.56ab |
| T1S        | 25.46 ± 1.52a | 59.56 ± 9.00b | 29.02 ± 6.40a  | 11.41 ± 2.53a  |
| T3S        | 25.33 ± 1.72a | 48.05 ± 2.12ab | 34.35 ± 5.81bc | 17.66 ± 6.13ab |
| T5S        | 24.56 ± 0.78a | 38.04 ± 2.75a | 38.54 ± 7.04bc | 23.41 ± 4.27ab |

Values followed by the same letter(s) are not statistically different (p>0.05) in column direction for each parameter

The size distribution shows that more ground beef was unpassed mesh 6 than that of passed mesh 6 and passed mesh 12. Table 2 shows that different cooking methods revealed no significant difference in size distribution. The grinding time of 5 minutes resulted in a lower percentage of sample unpassed mesh 6 than that produced by grinding time of 1 minute. The increase in grinding time allowed the knife to chop the meat longer, thus resulting in a smaller size of the ground beef. Furthermore, Fitriani et al. [7] noticed that the longer grinding time produced in the finer particle during meat grinding, which due to friction induces breaking big particles into smaller particles.

3.2. Moisture content
Fresh beef had a moisture content of 77.75%. The cooking process decreased the moisture content of ground beef, as presented in Table 3. Initial moisture content shows the moisture content of ground beef
after cooking, while final moisture content is the moisture content of ground beef after the drying process. The initial moisture content of the presto treatment was significantly higher than the steaming treatment, but no significant difference with the roasting treatment. The grinding time did not give a significant difference in the initial moisture content of the ground beef.

### Table 3. The average and standard deviation of moisture content of dehydrated ground beef.

| Treatments | Initial moisture content, % | Final moisture content, % |
|------------|-----------------------------|--------------------------|
| T1K        | 65.05 ± 2.80^a              | 3.22 ± 0.03^b            |
| T3K        | 64.32 ± 0.68^a              | 2.45 ± 0.42^ab           |
| T5K        | 65.16 ± 1.73^a              | 2.19 ± 0.24^a            |
| T1P        | 70.09 ± 2.42^b              | 5.34 ± 1.48^c            |
| T3P        | 71.29 ± 1.40^b              | 3.55 ± 1.14^ab           |
| T5P        | 69.51 ± 4.24^b              | 3.38 ± 0.51^ab           |
| T1S        | 67.09 ± 1.33^ab             | 5.42 ± 2.09^c            |
| T3S        | 67.51 ± 1.74^ab             | 4.23 ± 0.56^bc           |
| T5S        | 69.51 ± 2.26^ab             | 3.35 ± 0.92^ab           |

Values followed by the same letter(s) are not statistically different (p>0.05) in column direction for each parameter.

The difference in the initial moisture content of samples could be caused by the differences in cooking time and cooking temperature. During cooking, water may escape from the meat due to evaporation. The cooking time of steaming treatment was 45 min, while presto and roasting treatment was 10 min. The temperature of hot water in the presto treatment ranges from 115-116°C [14] and the steam temperature in the steaming treatment ranges from 85-90 °C [15], while the temperature process of roasting treatment ranges from 98-102°C. The presto treatment produced the highest initial moisture content due to the meat being contacted directly with hot water during the cooking process. Cheng et al. [8] reported that the water content of meat cooked in boiling water is steady since no water escapes from the meat during the cooking process. The steaming technique had the lowest water content compared to other treatments. This is possibly due to it takes longer time than other treatments, so that more water evaporates. Moreover, the enthalpy value of steam is higher, and more energy can be transferred to the meat than dry air and water [8]. The roasting technique allowed direct contact between the meat and heat by the conduction process of the cookware [16]. Its cooking time was shorter than the steaming technique resulted in the meat with higher water content. It is in line with various cooking methods of pork ham conducted by Cheng et al. [8] in which the water cooking method resulted in the highest moisture content compared with wet air cooking (steaming) and dry air cooking.

Table 2 shows that there were no significant differences observed according to final moisture content with different cooking methods. The grinding time of 5 minutes resulted in significantly lower final moisture content than that of the grinding time of 1 minute. The increase in grinding time allowed the ground beef to be smaller in size and promoted a larger surface area in contact with the heating media. It resulted in more water evaporation for the same drying time. Achaglinkame et al. [17] reported similar results on drying three-size of snails. Fitriani et al. [7] also revealed grinding time of 5 minutes produced the lowest moisture content of meat roulade among the other grinding time.

### 3.3. Rehydration ratio and hygroscopicity

The rehydration ratio and hygroscopicity of dehydrated ground beef are presented in Figure 1. No significant difference in rehydration ratio was observed among cooking treatments. The rehydration ratio of the sample with a grinding time of 1 minute was significantly lower than the product produced with other grinding times, except for roasting treatment. It is possibly related to the sample size and it is in agreement with the results of Achaglinkame et al. [17].
Mishra et al. [1] explained that the rehydration ratio of dehydrated meat is obtained by developing porosity in the meat products. The higher the porosity in meat structure, the higher the rehydration ratio in the dehydrated meat sample [18]. Furthermore, Laopoolkit and Suwannaporn [4] explained rehydration ratio depended on the water absorption capacity, water holding capacity of muscle fibers, and the formation of spaces within muscle fibers.

Hygroscopicity indicates the ability of meat to absorb moisture under certain conditions. Figure 1 showed that there were no significant differences in hygroscopicity among grinding time and cooking method treatments. Rostami et al. [19] reported that the major changes in hygroscopicity of meat powders happened when the fourth day of the absorption/desorption of moisture. Hygroscopicity measurements in this study were carried out on the second day, which possibly allowed the sample not to be exposed to more water vapor. Ayanwale et al. [2] reported that the oven-dried meat samples had a hygroscopic value higher than the sun-dried samples due to the higher exposure of the sun-dried samples to the atmosphere.

3.4. Color
Color is an important parameter of food due to it can be directly assessed by consumers. The color of dehydrated ground meat is presented in table 4 including lightness (L), redness (a), and yellowness (b) values. Meat prepared with 1-minute grinding time had a significantly lower value in lightness and ‘b’ value than grinding times of 5 minutes. Cooking treatments did not give significantly different results in color parameters.
Table 4. The average and standard deviation of color of dehydrated ground beef.

| Treatments | Lightness (L) | Red-Blue (a) | Green-Yellow (b) |
|------------|---------------|--------------|------------------|
| T1K        | 50.90 ± 3.32<sup>abc</sup> | 5.40 ± 0.33<sup>ab</sup> | 9.03 ± 0.46<sup>ab</sup> |
| T3K        | 52.35 ± 3.02<sup>abcd</sup> | 6.07 ± 0.29<sup>d</sup> | 9.45 ± 0.13<sup>ab</sup> |
| T5K        | 54.67 ± 2.87<sup>d</sup> | 6.16 ± 0.27<sup>d</sup> | 11.34 ± 0.77<sup>d</sup> |
| T1P        | 48.93 ± 1.90<sup>ab</sup> | 5.36 ± 0.18<sup>a</sup> | 8.11 ± 0.96<sup>a</sup> |
| T3P        | 50.77 ± 1.89<sup>abcd</sup> | 5.30 ± 0.15<sup>a</sup> | 9.12 ± 0.73<sup>ab</sup> |
| T5P        | 53.62 ± 2.20<sup>d</sup> | 5.52 ± 0.51<sup>abc</sup> | 10.21 ± 0.98<sup>bc</sup> |
| T1S        | 48.50 ± 0.59<sup>a</sup> | 5.41 ± 0.17<sup>ab</sup> | 8.35 ± 0.29<sup>a</sup> |
| T3S        | 49.52 ± 1.67<sup>abc</sup> | 5.43 ± 0.34<sup>ab</sup> | 8.90 ± 0.01<sup>bc</sup> |
| T5S        | 53.15 ± 2.27<sup>abcd</sup> | 5.99 ± 0.44<sup>bcd</sup> | 10.62 ± 0.98<sup>cd</sup> |

Values followed by same letter(s) are not statistically different (p>0.05) in column direction for each parameter.

Results in Table 4 show that cooking treatments did not give significantly different results in color parameters. Meat prepared with 5-minute grinding time had a significantly highest value in lightness (L), redness (a) and yellowness (b). Grinding is important to the food industries as it helps to improve the surface area, thereby creating a larger surface for chemical and biochemical reactions [20]. The longer time of grinding, the greater the surface area of the exposed meat to a high-temperature environment during the cooking and drying process. It results in more browning of sugar-amine, which is the result of the reaction between amine groups of muscle proteins and available reducing sugars in the connective tissue of meat [21].

3.5. Fat content

Figure 2 presents the fat content of dehydrated ground beef. There were no significant differences in the fat value among treatments. Fresh beef has a fat content of 1.60% (wet weight basis) or 7.21% (dry weight basis). The heating process (cooking and drying) decreased the fat content of dried meat ranged 6.36-7.03% (dry weight basis) as reported by Ayanwale et al. [2] which fat content is higher in fresh meat than that of the dried meat. It could be explained that the heating process (cooking) results in lipid oxidation, leaching and increased solubility of some micronutrients of fresh meat [2]. Cheng et al. [8] revealed that the decrease in fat content of meat could be attributed to the higher cooking loss during the cooking process. In our study, the ground meat was cooked directly at high temperature, with no cooking bag packaged. It implicated weight loss and reduced nutrition value (fat) caused by water evaporation.
Figure 2. Average value of fat content of dehydrated ground beef. Values followed by the same letter(s) are not statistically different (p>0.05), vertical error bars represent standard deviation.

Based on the result of all parameters (i.e yield, rehydration ratio, moisture content, color, and fat content), the best treatment was determined using the effective index method [13]. All parameters were fixed in this calculation. The result showed that grinding time of 5 minutes and pressurized cooking (presto) (sample T5P) had the first grade. It suggested that this treatment was the chosen method to prepare dehydrated ground beef.

4. Conclusions

The study revealed that as the grinding time increased, the particle passed 6-mesh, rehydration ratio, and color of dried meat increased while its moisture content and fat content reduced. Grinding time of 5 minutes produced dried meat with better physicochemical properties than those produced by grinding time of 1 and 3 minutes. The cooking method gave a significant effect on the moisture content of cooked meat. Presto method produced cooked meat with the highest moisture content compared to the other cooking methods. The grinding time of 5 minutes with the presto method was the best treatment to prepare dried meat.

References

[1] Mishra B, Mishra J, Pati P K and Rath P K 2017 Dehydrated meat products: A review Int. J. Livest. Res. 7 10–22
[2] Ayanwale B A, Ocheme O B and Oloyede O O 2007 The effect of sun-drying and oven-drying on the nutritive value of meat pieces in hot humid environment Pakistan J. Nutr. 6 370–4
[3] Modi V K, Sachindra N M, Nagegowda P, Mahendrakar N S and Rao D N 2007 Quality changes during the storage of dehydrated chicken kebab mix Int. J. Food Sci. Technol. 42 827–35
[4] Laopoolkit P and Suwannaporn P 2011 Effect of pretreatments and vacuum drying on instant dried pork process optimization Meat Sci. 88 553–8
[5] Aykın E and Erbaş M 2016 Quality properties and adsorption behavior of freeze-dried beef meat from the Biceps femoris and Semimembranosus muscles Meat Sci. 121 272–7
[6] Bonazzi C and Dumoulin E 2011 Quality changes in food materials as influenced by drying processes Mod. Drying. Technol. 3 1–20
[7] Fitriani L N, Hanotoro D R A and Widayak K 2013 Pengaruh lama penggilingan daging kelinci terhadap keempukan, kadar air, dan kesukaan rolade [The effect of grinding time on the softness, moisture content and sensory acceptance of roulade made from rabbit meat] J. Ilm. Peternak. 1 572–6 [In Indonesian]
[8] Cheng Q, Sun D W and Scannell A G M 2005 Feasibility of water cooking for pork ham processing as compared with traditional dry and wet air cooking methods J. Food Eng. 67 427–33

[9] Choi Y S, Ku S K, Park J D, Kim H J, Jang A and Kim Y B 2015 Effects of drying condition and binding agent on the quality characteristics of ground dried-pork meat products Korean J. Food Sci. Anim. Resour. 35 597–603

[10] Chmiel M, Adamczak L, Wronska K, Pietrzak D and Florowski T 2017 The effect of drying parameters on the quality of pork and poultry-pork kabanosy produced according to the traditional specialties guaranteed recipe J. Food Qual. Article ID 1–7

[11] AOAC 1990 Official Methods of Analysis vol 1 (Arlington, Virginia USA: Association of Official Analytical Chemists, Inc.)

[12] Mishra B P, Chauhan G, Mendiratta S K, Sharma B D, Desai B A and Rath P K 2015 Development and quality evaluation of dehydrated chicken meat rings using spent hen meat and different extenders J. Food Sci. Technol. 52 2121–9

[13] DeGarmo E P, Canada J R and Sullivan W G 1984 Engineering Economy (New York: MacMillan Publishing Company)

[14] Saparudin, Wulandani D and Purwanti N 2016 Validasi simulasi tekanan dan suhu air serta suhu daging sapi selama pemasakan dalam pressure cooker [Validation of simulation of pressure and temperature of water and beef for cooking in pressure cooker] J. Teknol. Ind. Pertan. 26 343–51

[15] Sholichah E, Kumalasari R, Afifah N, Indrianti N, Nurintan F, Rahayuningtyas A and Budiati T 2020 Pengaruh proses pemasakan dan penambahan bahan pengawet terhadap karakteristik lemang selama masa penyimpanan [The effect of cooking method and preservative on storage time of Lemang (Rice Bamboo)] J. Pangan 29 149–60 [In Indonesian]

[16] Bastin S 2011 Heat in Cooking Univ. Kentucky, Coll. Agric. 1–3

[17] Achaglinkame M A, Owusu-Mensah E, Boakye A A and Oduro I 2020 Effect of size and drying time on the rehydration and sensory properties of freeze-dried snails (Achatina achatina) Int. J. Food Sci. Article ID 1–5

[18] Rahman M S, Salman Z, Kadim I T, Mothershaw A, Al-Riziqi M H, Guizani N, Mahgoub O and Ali A 2005 Microbial and physicochemical characteristics of dried meat processed by different methods Int. J. Food Eng. 1 1–14

[19] Rostami H, Dehdad D, Jafari S M and Tavakoli H R 2017 Evaluation of physical, rheological, microbial, and organoleptic properties of meat powder produced by refractance window drying Dry. Technol. 36 1076–85

[20] Oyinloye T M and Yoon W B 2020 Effect of freeze-drying on quality and grading process of food produce: A review Processes 8 1–23

[21] Nathakaranakule A, Kriawanichkul W and Saponronnarit S 2007 Comparative study of different combined superheated-steam drying techniques for chicken meat J. Food Eng. 80 1023–30