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COMPARATIVE CHARACTERISTICS OF DIFFERENT GRILLED BEEF CUTS AND APPLICATION OF TORCH GINGER (*ETLINGERA ELATIOR*) FLOWER IN SEASONING

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Keywords: *beef cuts, dipping sauce, grilled beef, marinade, torch ginger flower*

Abstract

Grilled beef processed with high temperature has the potential to form toxic compounds that are mutagenic and carcinogenic. This can be prevented by using beef cuts with low-fat content and antioxidant-rich spices, such as torch ginger (Etlingera elatior) flower. This study is aimed to analyze the physicochemical characteristics and antioxidant activity of grilled beef using different beef cuts and application of torch ginger flower in seasoning. Tenderloin and brisket cuts were chosen to represent the low fat and high fat content of the meat. The beef was seasoned with torch ginger flower as one of ingredients for marinade and for dipping sauce, and cooked using grilling method. This study was designed using randomized block design (CRD) with 2 × 6 factorial pattern, consisting of two beef cuts and six seasoning methods with three blocks of the samples manufacturing periods. The differences in beef cuts used to cook grilled beef were related to pH value, water, protein, fat, and malondialdehyde (MDA) content. The use of tenderloin cuts featured lower MDA levels ($p \leq 0,05$) than brisket cuts. Tenderloin cuts MDA content was 3,76 mg/kg while brisket cuts had MDA content of 1,67 mg/kg. The application of torch ginger flower in seasoning can increase water content and antioxidant activity while also reduce MDA levels in grilled beef. Soaking of beef in seasoning marinade without torch ginger flower and dipping sauce with the addition of torch ginger flower has resulted to the highest ($p \leq 0,05$) antioxidant capacity (135,19 mg EVC g^{-1}), which is more effective compared to other seasoning modes.

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Introduction

Beef is one of the animal products relied upon to meet the nutritional needs of the Indonesian people due to its high protein content with a balanced amino acid composition [1]. The interest to beef consumption is influenced by the rapid development of the food processing industry, certain lifestyles and people's consumption patterns [2]. It is also relied upon in fulfilling the consumers' diets as a great source of proteins, zinc, iron, selenium, phosphorus, also vitamins of A- and B-complex [3]. Processed meat products favored by Indonesian people generally involve heating through grilling, one of which product is grilled beef [4]. Food processed with roasting can form toxic compounds which are mutagenic and carcinogenic to the body if consumed for a long period of time [5]. High-temperature heating processes have the potential to produce free radical compounds affected by the lipids naturally present in meat, resulting in lipid oxidation reactions [6]. The fat content in processed meat is one of the factors that influences the risk level of carcinogenic compounds formation when cooked [7,8,9]. One of the by-products of lipid oxidation reactions is malonaldehyde (MDA), which is a known carcinogen that can provide a negative impact on human health [10]. The formation of carcinogenic compounds can be prevented if the fat content in meat is reduced. One of the methods is selecting meat cuts that have low-fat content [4]. Beef cuts that are often used to make grilled beef include brisket and tenderloin cuts [11]. Brisket cuts tend to have higher fat content than other cuts [12], including tenderloin cuts, thus the two cuts were used to represent different uses of beef cuts with different fat content.

The formation of toxic substances due to roasting can also be prevented by using food ingredients that are rich in antioxidants, such as torch ginger. *Etlingera elatior*, commonly known as torch ginger, is a source of natural antioxidants that are widely cultivated throughout Southeast Asia [13]. The flower of torch ginger, which is rich in active substances such as saponins, flavonoids and polyphenols, is frequently utilized for medical purposes and serves as a seasoning in many dishes in Indonesia, such as urab, pecel, chili sauce, and many others [14]. Moreover, flavonoids and phenolics in torch ginger flowers are known to reduce free radical levels in the human body [15]. Torch ginger flower can be used as an ingredient in grilled beef seasoning, one method that can be used is by marinating. Marinades have been increasingly used for processing meat products over the years among the many types of natural preservatives [16]. Adding compounds that have antioxidant properties to the meat marinating process can reduce the possibility of toxic compounds formation during the cooking process.

However, there are assumptions that high heating temperatures may reduce the antioxidant activity of natural ingredients due to its instability [17,18], including antioxidant compound in torch ginger flower [19]. Apart from marinating, seasoning a food can also be done after the cooking process, such as using dipping sauce. Dipping sauce as a condiment can be used as a means of applying torch ginger to grilled beef [14].

There have been many studies related to the physicochemical characteristics and antioxidant activity of processed meat products treated with torch ginger through marination [19,20,21]. However, there is no research related to the comparison of physicochemical characteristics and antioxidant activity of torch ginger before and after the cooking process of processed meat products, as well as the relevance of selecting low-fat beef cuts to inhibit the formation of carcinogenic compounds in grilled beef. The use of torch ginger as a natural antioxidant used in grilled beef seasoning and attention to the use of meat cuts in beef is expected to reduce the level of consumption of toxic substances contained in grilled beef. This study is aimed to analyze the physicochemical characteristics and antioxidant activity of grilled beef on the examples of different beef cuts and application of torch ginger flower in seasoning.

Materials and methods

Materials

Meat in this study was obtained from brisket and tenderloin of Brahman cross-breed cattle and were bought from meat supplier in Bogor, West Java. The ingredient used for production of marinade and dipping sauce were bought from local market in Indonesia.

Marinade preparing

The marinade formula used was the result of trial and error method on the pre-research stage using the limited number of the panelists; each ingredient was weighed in ratio based on the weight of beef used. The marinade ingredients include garlic (27.5%), chili (10.5%), onion (7%), ginger (2.5%), honey (36.5%), sesame oil (8%), vinegar (2.5%), salt (3.5%), and pepper (2%) were weighed, then pureed with a blender (Miyako BL-152, Kencana Gemilang, Indonesia) so that the marinade without the addition of torch ginger flower was obtained. The marinade without the addition of torch ginger flower then was supplemented with torch ginger flower (10%) and pureed with a blender to obtain the marinade with the addition of torch ginger flower. The marinade was weighed in a ratio of 2:1 as per the meat to each marinade.

Production of dipping sauce

The dipping sauce formula used was the result of trial and error method on the pre-research stage using the limited number of the panelists; each ingredient was weighed in ratio based on the weight of beef used. The dipping sauce was made by stir-frying garlic (15%) and onion (13%) that had been pureed using a blender (Miyako BL-152, Kencana Gemilang, Indonesia) for 3 minutes, then put in a pot along with brown sugar (14%), soy sauce (19%), sesame oil (9%), soy sauce (13%), and honey (17%), and heated until boiling (100 °C) for 5 minutes. The flame of the stove was turned off and the sauce was set aside until the temperature decreased up to room temperature (± 27 °C), resulting to obtaining the dipping sauce without the addition of torch ginger flower. The dipping sauce without the addition of torch ginger flower then was supplemented with torch ginger flower (10%) and pureed with a blender to obtain the dipping sauce with the addition of torch ginger flower. The dipping sauce was weighed in a ratio of 2:1 as per the meat to each sauce.

Production of grilled beef

Beef brisket and tenderloin was thinly sliced using a meat slicer (MSC-HS10, Astro Pandu Perkasa, Indonesia) with a thickness of 3.5 mm. The sliced beef were grouped into 5 parts according to the treatment of torch ginger flower application in the marinade. The sliced meat was marinated using immersion technique in a closed container at refrigerator temperature, which was about 4 °C for 1 hour, then grilled evenly using a grill pan on a stove (Rinnai, Rinnai Corporation, Japan) at 150–180 °C for 5 minutes with flipping the meat every 1 minute. After the grilling process, the meat was dipped in the dipping sauce according to the predetermined treatment for 10 seconds and prepped for later analysis.

Analysis of physicochemical characteristics

The physicochemical analysis of grilled beef samples covered the measurement of pH [22], water content [22], fat content [22], protein content [22], and browning intensity [23].

Analysis of antioxidant activity and capacity

Compounds from 1 g of the sample were extracted using 2.5 mL of 100% methanol at room temperature for 24 hours. After filtration, the filtrate was collected into a separate tube, and another 2.5 mL of methanol was added to the remaining retentate. The first filtrate was stored in a capped tube at –25 °C for 24 hours. The second filtrate was separated and combined with the first filtrate in a 10 mL volumetric flask, with methanol added until the total volume reached 10 mL. 0.15 mL of filtrate was taken and reacted with 0.9 mL of 0.1 mM DPPH solution in a vial tube. The solution was incubated in a waterbath (Memmert, Memmert GmbH, Germany) at 37 °C for 20 minutes. The absorbance was measured with a spectrophotometer (UV–Vis Agilent 8453, Agilent, USA) ($\lambda = 517$ nm). Antioxidant activity was assessed by measuring the percentage of DPPH radical scavenging activity, while antioxidant capacity was evaluated based on the inhibition of vitamin C impact at various concentrations on the DPPH radical. Antioxidant capacity was expressed as mg of vitamin C equivalent (VCE) per 100 g of the sample [24].

Analysis of malondialdehyde (MDA)

Analysis of malondialdehyde in grilled beef was carried out using analysis of thiobarbituric acid reactive substances (TBARS) content. A total of 10 g of sample was put into an Erlenmeyer flask and extracted with 97.5 mL distilled solution containing 0.1% propyl gallate (PG) and 0.1% ethylenediamine tetra acetate (EDTA). The sample was then supplemented 2.5 mL of 4 N HCl solution with a ratio of HCl and distilled water of 1:2 and 0.5 mL of antifoam drops. The mixture was then distilled until 50 mL of distillate was obtained from each sample. A total of 5 mL of distillate sample was supplemented with 5 mL of 0.02 M TBA solution. The samples were then incubated on waterbath at 100 °C for 40 minutes. Afterward, the samples were removed and cooled under running water. Determination of malondialdehyde levels was carried out using spectrophotometry (UV–Vis Agilent 8453, Agilent, USA) with a wavelength of 532 nm [25].

Experimental design and data analysis

The study was designed using randomized block design (CRD) with 2×6 factorial pattern consisting of two beef cuts and six methods of grilled beef seasoning with three blocks of samples manufacturing periods. The beef cuts included brisket and tenderloin cuts, while the grilled beef seasoning method consists of as follow:

- B0: control sample, without marinade and dipping sauce;
- B1: marinade with torch ginger flower;
- B2: dipping sauce with torch ginger flower;
- B3: marinade and dipping sauce without torch ginger flower;
- B4: marinade with torch ginger flower and dipping sauce without torch ginger flower;
- B5: marinade without torch ginger flower and dipping sauce with torch ginger flower.

The data were analyzed using analysis of variance to determine the effect of each mode, and the difference of means were analyzed using Tukey test.

Results and discussion

The mode of seasoning application by marination and/or dipping sauce and the use of different beef parts provided a significant effect ($p \leq 0.05$) on the pH value, but there was no significant interaction between the two modes, as shown in Table 1. The pH value of grilled beef processed with marinade and/or dipping sauce was significantly lower ($p \leq 0.05$) compared to grilled beef cooked without marinade or dipping sauce. This decrease in pH value may occur due to the influence of the acid content found in the ingredients added to the marinade. The use of seasonings for soaking meat can reduce the pH value of the processed meat final product [26,27].

Muhammad et al. [28] stated the torch ginger flower can reduce the acidity of meat because it has a low pH, which ranges from 4.18 to 4.92. This opinion differs from the results of the study which showed that the addition of torch ginger flower to the marinade and dipping sauce did not result to pH values in grilled beef which were statistically different from the seasoning without torch ginger flower, possibly due to the small amount of addition of torch ginger flower in the seasoning formula. Grilled beef from tenderloin cuts featured a higher pH value and water content ($p \leq 0.05$) compared to brisket cuts (Table 1). This is presumably related to the higher protein content in the tenderloin which can cause the pH value to be higher due to the protein's ability to bind water and maintain a more alkaline environment. Protein has a higher isoelectric point so it can absorb water more effectively and cause the muscle fibers to become tighter and the pH to be higher [29]. The moisture content of grilled beef processed with marinade without torch ginger flower and dipping sauce with torch ginger flower was higher ($p \leq 0.05$) compared to the control sample of the grilled beef. Moisture absorption from seasoning applied to beef contributed to the increase of grilled beef moisture content [30,31]. The addition of marinade and/or dipping sauce provided a significant effect ($p \leq 0.05$) on the absorbance value of the browning intensity of grilled beef (Table 1). The browning that occurs during cooking process

Table 1. pH value, water content, and browning intensity of grilled beef

Treatment	Beef cuts		Means
	Brisket	Tenderloin	
pH value			
B0	5.74 ± 0.47	5.83 ± 0.54	5.79 ± 0.06^{b}
B1	5.11 ± 0.17	5.30 ± 0.17	5.19 ± 0.16^{a}
B2	5.15 ± 0.14	5.33 ± 0.26	5.24 ± 0.07^{a}
B3	5.13 ± 0.23	5.33 ± 0.16	5.23 ± 0.14^{a}
B4	5.08 ± 0.10	5.21 ± 0.14	5.14 ± 0.11^{a}
B5	5.12 ± 0.17	5.22 ± 0.16	5.17 ± 0.07^{a}
Means	5.21 ± 0.26^{a}	5.37 ± 0.23^{b}	
Water content (%)			
B0	30.58 ± 2.78	34.19 ± 5.44	32.38 ± 2.55^{a}
B1	35.51 ± 4.33	39.58 ± 6.96	37.55 ± 2.87^{ab}
B2	31.38 ± 3.47	35.76 ± 7.18	33.57 ± 3.10^{ab}
B3	36.27 ± 5.16	42.91 ± 5.08	39.59 ± 4.70^{ab}
B4	34.98 ± 4.01	42.00 ± 4.16	38.49 ± 4.96^{ab}
B5	35.89 ± 3.57	45.85 ± 1.61	40.87 ± 7.04^{b}
Means	34.10 ± 2.47^{a}	40.05 ± 4.44^{b}	
Browning intensity			
B0	0.13 ± 0.03	0.12 ± 0.02	0.13 ± 0.005^{a}
B1	0.19 ± 0.08	0.18 ± 0.05	0.18 ± 0.01^{ab}
B2	0.20 ± 0.06	0.17 ± 0.03	0.19 ± 0.03^{ab}
B3	0.22 ± 0.06	0.20 ± 0.03	0.21 ± 0.01^{b}
B4	0.21 ± 0.04	0.19 ± 0.04	0.20 ± 0.02^{b}
B5	0.24 ± 0.04	0.22 ± 0.03	0.23 ± 0.01^{b}
Means	0.20 ± 0.04	0.18 ± 0.03	

Note: Different letters in the same row and column indicates significant differences (P < 0.05), B0: control sample, without marinade and dipping sauce; B1: marinade with torch ginger flower; B2: dipping sauce with torch ginger flower; B3: marinade and dipping sauce without torch ginger flower; B4: marinade with torch ginger flower and dipping sauce without torch ginger flower; B5: marinade without torch ginger flower and dipping sauce with torch ginger flower.

contributes significantly to the flavor, aroma, and appearance of the cooked meat [32,33,34]. Heating can cause non-enzymatic browning as indicated by Maillard reaction, due to reducing sugars or aldehyde groups from other sources reacting with amino groups obtained from amino acids, peptides and proteins [35,36]. The sugar contained in honey in the marinade may contributes to the Maillard reaction [37] when the beef is being cooked, thus increasing the browning process of the grilled beef.

Table 2 shows that protein and fat content of grilled beef were significantly ($p \leq 0.05$) affected by the interaction of applying the seasoning and the use of different beef cuts. The protein content of grilled beef on the example of tenderloin cuts and seasoning application was lower ($p \leq 0.05$) compared to the processing mode without applying the seasoning. This indicates that the seasoning application can reduce the protein content of grilled beef. Rahman et al. [31] explained that marinating the meat can cause protein-rich sarcoplasmic fluid to escape from the meat tissue. This dilution effect can cause reductions in meat protein content. The results of this study are also in line with Kumar et al. [38] which states that lemon-marinated and ginger-marinated chicken tikkas featured lower protein levels compared to the control mode. There was a decrease in fat content in grilled beef brisket pieces with applying the seasoning compared to the control sample ($p \leq 0.05$) (Table 2). This is likely due to the properties of fat that contradict with the moisture of food products, whereas the fat content in processed meat products can be significantly reduced when the water content increases [39]. Meanwhile, the addition of torch ginger flower to the seasoning did not resulted to a significant difference in protein content or fat content of grilled beef. This condition is in line with Fitri et al. [40] which stated that the addition of torch ginger extract had no significant effect on the protein and fat content of beef sausage.

Table 2. Protein content and fat content of grilled beef

Treatment		Protein content (%)	Fat content (%)
Beef cuts	Seasoning		
Brisket	B0	22.87 ± 2.16^{abc}	39.52 ± 1.76^{d}
	B1	23.18 ± 0.16^{abc}	23.79 ± 5.34^{bc}
	B2	22.57 ± 1.28^{abc}	24.29 ± 4.77^{c}
	B3	18.49 ± 4.27^{ab}	15.82 ± 4.77^{b}
	B4	20.52 ± 1.67^{ab}	18.81 ± 2.74^{bc}
	B5	16.66 ± 2.05^{a}	20.58 ± 1.01^{bc}
Tenderloin	B0	37.66 ± 2.66^{d}	3.10 ± 0.39^{a}
	B1	28.31 ± 1.94^{c}	5.05 ± 1.19^{a}
	B2	28.72 ± 2.03^{c}	3.76 ± 0.83^{a}
	B3	23.31 ± 3.32^{abc}	4.82 ± 0.91^{a}
	B4	29.29 ± 2.66^{c}	4.55 ± 0.70^{a}
	B5	24.99 ± 1.27^{bc}	4.83 ± 0.30^{a}

Note: Different letters in the same row and column indicates significant differences ($P < 0.05$), B0: control sample, without marinade and dipping sauce; B1: marinade with torch ginger flower; B2: dipping sauce with torch ginger flower; B3: marinade and dipping sauce without torch ginger flower; B4: marinade with torch ginger flower and dipping sauce without torch ginger flower; B5: marinade without torch ginger flower and dipping sauce with torch ginger flower.

Table 3 shows the results of DPPH inhibitory activity and antioxidant capacity, which results presented that there were significant differences ($p \leq 0.05$) between control sample of grilled beef and grilled beef processed with marinade and/or dipping sauce, as well as the using torch ginger flower in the seasoning. The grilled beef soaked with seasoning generally featured higher antioxidant activity ($p \leq 0.05$) than control sample griled beef. Various antioxidant compounds obtained from natural ingredients used for seasoning applications such as saponins, flavonoids and polyphenols from torch ginger flower [14], allicin and diallyl sulfides from garlic [41,42], quercetin from onion [43], gingerol from ginger [44,45], also flavonoids and phenolic acids from honey [46] has contributed to increasing the antioxidant activity of grilled beef. Zhang et al. [47] stated that antioxidants from natural food ingredients can counteract free radicals by replacing hydrogen from phenolic groups and are able to produce stable products. These natural antioxidants demonstrate a variety of biological activities, such as anti-inflammatory, antibacterial, anti-aging, and anticancer properties [48,49]. Moreover, grilled beef processed with adding marinade without torch ginger flower and dipping sauce with torch ginger flower (B5) had significantly higher antioxidant activity value ($p \leq 0.05$) than grilled beef processed with adding marinade with torch ginger flower and dipping sauce without torch ginger flower (B4). This suggests that exposure to high temperature heat during grilling process on the beef may affect the antioxidant activity of torch ginger flower applied in marinade, which is in line with previous study [19]. Heat treatment, as one of step in manufacturing certain products for human consumption, may lead to degradation which is attributed to

Table 3. Antioxidant activity and capacity of grilled beef

Treatment	Beef cuts		Means
	Brisket	Tenderloin	
DPPH radical scavenging activity (%)			
B0	25.76 ± 7.91	27.51 ± 5.05	26.64 ± 1.23^{a}
B1	48.88 ± 3.05	53.94 ± 13.90	51.41 ± 3.57^{bc}
B2	54.12 ± 7.25	59.68 ± 9.99	56.90 ± 3.93^{c}
B3	40.49 ± 2.30	47.50 ± 8.87	43.99 ± 4.95^{b}
B4	62.14 ± 8.37	58.99 ± 5.97	60.56 ± 2.23^{cd}
B5	74.79 ± 3.70	71.14 ± 5.77	72.96 ± 2.58^{d}
Means	51.03 ± 17.04	53.13 ± 14.76	
Antioxidant capacity (m g EVC g^{-1})			
B0	43.55 ± 14.66	47.39 ± 9.75	45.47 ± 2.71^{a}
B1	87.66 ± 5.05	97.14 ± 27.30	92.40 ± 6.71^{bc}
B2	99.55 ± 14.19	110.20 ± 18.88	104.88 ± 7.53^{c}
B3	71.57 ± 4.55	85.74 ± 17.04	78.65 ± 10.02^{b}
B4	112.20 ± 14.95	105.94 ± 10.04	109.07 ± 4.42^{c}
B5	138.53 ± 5.70	131.85 ± 10.34	135.19 ± 4.73^{d}
Means	92.18 ± 32.90	96.38 ± 28.48	

Note: Different letters in the same column indicate significant differences ($P < 0.05$), B0: control sample, without marinade and dipping sauce; B1: marinade with torch ginger flower; B2: dipping sauce with torch ginger flower; B3: marinade and dipping sauce without torch ginger flower; B4: marinade with torch ginger flower and dipping sauce without torch ginger flower; B5: marinade without torch ginger flower and dipping sauce with torch ginger flower.

the breakdown of the flavonoid structure, and can lead to a reduction in their bioactivity [18,50,51].

The results of malondialdehyde (MDA) content of grilled beef are shown in Table 4. The MDA level of grilled beef was significantly affected ($p \leq 0.05$) by the use of different beef cuts and seasoning treatment. Grilled beef samples using the brisket cuts had higher MDA levels ($p \leq 0.05$) than grilled beef with tenderloin cuts. According to Utrera et al. [52], fat content is one of the factors that can cause the formation of MDA. The higher fat content in meat leads to a higher MDA levels.

Grilled beef processed with marinade without torch ginger flower and dipping sauce with torch ginger flower (B5) and grilled beef processed with marinade with torch ginger flower and dipping sauce without torch ginger flower (B4) featured significantly lower MDA value ($p \leq 0.05$) than control sample of grilled beef. Natural ingredients that have antioxidant components, including kecombrang flowers, are able to inhibit oxidation reactions, thus resulting to lower MDA levels. The decrease in MDA levels can occur through inhibition of oxidation reactions that take place in case of increase in antioxidant activity [53]. According to Campo et al. [54], the limit of malondialdehyde value of meat products that are considered not rancid by the trained panelists is 2.28 mg/kg. Based on this limit, the grilled beef processed with both marinade and dipping sauce for the seasoning mode has a value of rancidity lower than the perceptable threshold limit.

Tabel 4. Malondialdehyde (MDA) formation intensity of grilled beef

Treatment	Beef cuts		Means
	Brisket	Tenderloin	
B0	5.04 ± 1.67	2.54 ± 0.46	3.79 ± 1.86^{b}
B1	3.81 ± 0.64	1.36 ± 0.44	2.58 ± 1.43^{ab}
B2	4.33 ± 0.92	1.16 ± 0.31	2.74 ± 1.84^{ab}
B3	3.65 ± 1.10	1.86 ± 0.31	2.76 ± 1.22^{ab}
B4	2.87 ± 0.59	1.51 ± 0.37	2.19 ± 0.87^{a}
B5	2.84 ± 1.01	1.58 ± 0.25	2.21 ± 0.95^{a}
Means	3.76 ± 1.21^{b}	1.67 ± 0.62^{a}	

Note: Different letters in the same column indicate significant differences ($P < 0.05$), B0: control sample, without marinade and dipping sauce; B1: marinade with torch ginger flower; B2: dipping sauce with torch ginger flower; B3: marinade and dipping sauce without torch ginger flower; B4: marinade with torch ginger flower and dipping sauce without torch ginger flower; B5: marinade without torch ginger flower and dipping sauce with torch ginger flower.

Conclusion

The use of beef tenderloin and brisket cuts resulted in differences in pH value, water content, protein content, fat content, and MDA levels of grilled beef. Tenderloin cuts featured lower MDA levels than brisket cuts. The application of torch ginger flower in seasoning can increase water content and antioxidant activity, and can reduce MDA levels in grilled beef. Based on the decrease in antioxidant activity of torch ginger flower due to its exposure to high temperature caused by grilling the beef, the application of torch ginger flower is reasonable and effective to use after the grilling process via its addition to the dipping sauce.

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