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Effects of freezing-thawing on sensory descriptive profiles of cooked poultry breast meat*

ZHUANG Hong, BOWKER Brian

(USDA, Agricultural Research Service, Russell Research Center, Athens, Georgia 30605, USA)

Abstract: Freezing is a common method used by consumers to extend meat shelf life and by researchers to allow for subsequent meat quality assessments and processing. However, the effects of freezing on the sensory quality of cooked poultry breast meat are not well documented. The objective of this study was to compare sensory quality profiles of fresh and frozen/thawed chicken breast fillets (pectoralis major). Breast fillets were removed from carcasses within 24 h postmortem and either cooked from a fresh state or placed in a -20℃ freezer. Frozen samples were thawed by three different methods: thawing during cooking directly from a frozen state (0 h), thawing in 20℃ water for 2 h prior to cooking (2 h), or thawing at 4℃ for 24 h prior to cooking (24 h). A control treatment with fillets cooked directly from a fresh state was used. Fillets were cooked to an endpoint temperature of 78℃ and sensory quality was evaluated by trained descriptive panelists using 0 ~ 15 universal intensity scales. Results show that there were not treatment differences ($P > 0.05$) in the average intensity scores for any of the descriptive flavor attributes or for 5 of the descriptive texture attributes (cohesiveness, hardness, juiciness, wad size, and wetness of wad). However, the intensity scores for cohesiveness of mass, rate of breakdown, and chewiness were significantly different among the treatments ($P < 0.05$). Cohesiveness of mass intensity scores for 0h and 24 h fillets were significantly higher than 2 h samples. Fillets cooked directly from a frozen state (0 h) had significantly higher intensity scores for rate of breakdown and chewiness than fresh controls and 2 h samples, respectively. These results indicate that freezing-thawing does not affect sensory flavor quality; however, it may change the texture attributes of cooked chicken breast meat products. The effects on meat texture depend on thawing methods prior to cooking.

Key words: chicken breast; sensory; flavor; texture; freezing-thawing

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1 Introduction

The practice of freezing and storing fresh meat in a -20℃ freezer for later use has been widely adopted for shelf life extension by consumers [1] and for sample preparation by researchers [2]. Previous studies have

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Corresponding author: ZHUANG Hong, USDA, Agricultural Research Service, Russell Research Center, 950 College Station Road, Athens, Georgia 30605, E-mail: hong.zhuang@ars.usda.gov

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shown that freezing and thawing can cause significant changes in muscle [1,3]. During freezing, ice crystals form between and within the muscle fibers and physically disrupt the ultra-structure of the meat. During thawing, de-crystalization leads to excessive moisture loss from the meat tissue [4-6]. It has been hypothesized that thawing may have a greater impact on meat quality than freezing. Thawing generally occurs much slower than freezing and can cause chemical and physical changes and subsequent tissue damage [7].

For red meat products, it has been demonstrated that thawing methods can affect sensory quality. Lee, et al. [8] investigated the effects of different thawing methods on the sensory quality of pre-rigor beef muscle and found that meat thawed at 18℃ had lower sensory scores than those samples thawed at −2 and 2℃. In this study the samples thawed at −2℃ had significantly higher sensory scores for tenderness and juiciness than those thawed at 18 or 2℃ and showed no significant difference from fresh meat controls. Vail et al. [9] and James and Rhodes [10] reported that beef thawed during cooking was less tender than beef thawed prior to cooking. Lowe et al. [11], however, found that red meat thawed prior to cooking was less juicy than meat thawed during cooking.

Compared to red meat, there is very limited information about how freezing-thawing affects the quality and sensory attributes of boneless skinless poultry breast meat. Yu et al. [12] found that thawing frozen hot-boned chicken breast meat at high temperatures (18℃ for 2 h) resulted in increased thaw drip loss (more than 3 times) and shear force (about 2 times) compared to thawing samples at 0℃ for 24 h. Kim et al. [13] showed that microwave thawing of frozen hot-boned chicken fillets resulted in significantly reduced thawing loss and shear force compared with 4℃ refrigerator thawing. In early-deboned boneless skinless chicken breast meat, Zhuang and Savage [14] reported that thawing during cooking resulted in higher shear force than thawing prior to cooking. Based on indirect measures of meat quality, findings from these studies suggest that freezing and thawing poultry breast meat may result in significantly different sensory characteristics. Further research is needed, however, to provide consumers and researchers with more detailed and direct information on the potential effects of freezing and thawing on the eating quality of poultry breast meat. Therefore, the objective of the present study was to investigate the effects of freezing and thawing on the sensory quality of cooked boneless skinless chicken breast meat. For this study, frozen fillets were thawed using three different methods: thawing during cooking, thawing with water (23℃) prior to cooking, and thawing at a refrigerated temperature (4℃) prior to cooking. Fresh, never frozen fillets were used as controls.

2 Materials and methods

2.1 Broiler breast fillets

Commercially processed broiler carcasses were obtained from a local processing plant (Athens, GA). Carcasses (a total of 90) were transported to the laboratory within 20 min, where breast fillets (pectoralis major) were removed from carcasses within 24 h. Breast fillets were individually weighed and vacuum packaged in cooking bags (Seal-a-Meal bag, The Holmes Group, El Paso, TX). Breast fillets were then either placed in a 4℃ refrigerator (True Refrigerator, True Manufacturing Co., St. Louis, MO) prior to cooking or frozen in a −20℃ freezer (True Freezer, True Manufacturing Co., St. Louis, MO) prior to thawing and cooking.

2.2 Treatments, sample preparation, and sensory evaluation

A total of four treatments were evaluated in the present study:

1. Cooked directly from a fresh state (Control).
2. Cooked directly from a frozen state (0 h).
3. Cooked after samples were thawed in ambient (23℃) tap water for 2 h (2 h).
4. Cooked after samples were thawed in a refrigerator at 4℃ for 24 h (24 h).

All fillets were cooked in bags with a Henny Penny MCS-6 combi oven (Henny Penny Corp. Eaton, OH 45320) with internal dimensions of 65 cm × 51 cm × 57 cm set at 85℃ and tender steam to an endpoint temperature of 80℃. The internal temperatures were checked in the thickest part of each fillet using a handheld digital thermometer fitted with a hypodermic needle probe (Doric Digital Thermometer, Model 450-ET, Doric Scientific, San Diego, CA). Cooked breast fillets were allowed to cool at room temperature for 3 - 5 min and then removed from their bags. The cooked fillets were then sliced for sampling one at a time following the sampling scheme outlined by Lyon and Lyon [15]. One 1.9 cm wide strip was removed from the breast by cutting next to a template aligned parallel to the muscle fibers and adjacent to the cranial end. The strip was then cut into 2 subsections (1.9 cm high × 1.9 cm wide) and used for sensory evaluation. Each panelist received 2 subsections from a single breast piece in capped 4 ounce Styrofoam cups labeled with 3-digit blind codes (Fig. 1). Sensory profiles included eight texture and nine flavor attributes (Table 1).

Table 1 Sensory attributes and definitions used by descriptive analysis panel to evaluate test samples

ATTRIBUTE		DEFINITION
Texture Phase 1. First few bites:	1. Cohesiveness	Distance you can bite into the sample before it breaks, cracks, crumbles-first bite.
	2. Hardness	Force to compress the sample with the molars during first 2 bites
	3. juiciness/dryness	Amount of moisture coming from the sample during the first 5 chews
Texture Phase 2. Chew Sample to bolus-evaluate:	4. Cohesiveness of mass	Degree the Chewed sample holds together in a wad
	5. Bolus size	Change in sample size with formation of bolus or wad
	6. Wetness of wad	Amount of moisture in the bolus.
	7. Rate of break-down	Rate the sample breaks down, fast to slow
Texture Phase 3. Evaluate at time of swallow:	8. Chewiness	Amount of work to chew the sample to the point of swallow (or spit out)
Flavor Phase 1. Aromatics:		Aromatic taste sensation associated with:
	1. Chickeny	Cooked white or dark chicken muscle
	2. Brothy	Meat stock
	3. Cardboardy	Cardboard, wet paper
	4. Barnyard/Wet Feathers	A chicken coop; combination of manure, moldy hay, feed and poultry odors including wet poultry feathers
	5. Bloody/Serumy/Metallic	Raw or ´rare´ lean meat, blood, serum or metal/iron
Flavor Phase 2. Basic tastes:	6. Sweet	Sugars and high potency sweeteners
	7. Salty	Sodium salts, especially sodium chloride (table salt)
	8. Sour	Acids
	9. bitter	Caffeine or quinine

Samples were evaluated by an 8-member, trained descriptive panel with a minimum of 100-h training (Fig. 2) in flavor and texture profiling and with extensive experience in descriptive analysis using a Spectrum-like method. Data were collected using Compusense Five, version 4.8 software (Compusense, Inc, Guelph, Ontario, Canada) as described in our previous publication [16].

Figure 1 Serving area with coded samples prepared for a descriptive profile test

Figure 2 The trainning room for training a 8-member trained descriptive panel

2.3 Statistical Analysis

Sensory data were analyzed using the General Linear Models (GLM) procedures of SAS (SAS version 9.1,SAS Institute Inc.,2004,Cary,NC). Means were separated with the Tukey option at a significance level of 0.05. Principal Component Analysis (PCA) for sensory profile mapping was carried out using XLSTAT software (Versions 2007.5,Addinsoft Co.,Paris,France) under the Multivariate Analysis selection.

3 Results

Table 2 shows average intensity scores for 8 texture and 9 flavor sensory attributes of breast fillets prepared with different methods. There were not significant differences ($P > 0.05$) in the average intensity scores between the four different sample preparation methods for any of the 9 flavor attributes or five of the texture attributes (cohesiveness,hardness,juiciness,bolus/wad size,and wetness of wad). However,significant differences were found with texture attributes of cohesiveness of mass,rate of breakdown,and chewiness among the four treatments. For cohesiveness of mass,the intensities scores of 0 h and 24 h fillets,which were not significantly different from each other,were significantly higher than that of 2 h samples. Cohesiveness of mass was not different between controls and frozen-thawed fillets. For rate of breakdown,the average intensity score of cooked 0 h fillets was significantly higher than that of the controls. However,there were no differences ($P > 0.05$) between the three frozen-thawed treatments for rate of breakdown. For chewiness,the average intensity score of 0 h samples was significantly higher than that of 2 h samples; however,no differences ($P > 0.05$) were observed between the controls and frozen-thawed samples.

Table 2　Sensory intensity mean scores (0 – 15 scale) of descriptive attributes of cooked boneless skinless chicken breast meat (pectoralis major) prepared with different methods prior to cooking (mean ± stderr)[1]

SENSORY ATTRIBUTE		SAMPLE PREPARATION METHOD			
		Cook from Fresh State (control)	Cook from Frozen State (0 h)	Cook after Thawing for 2 h in ambient tap Water (2h)	Cook after thawing in a refrigerator for 24 h (24 h)
Texture	1. Cohesiveness	$5.1^{a} \pm 0.2$	$6.0^{a} \pm 0.2$	$5.2^{a} \pm 0.2$	$5.2^{a} \pm 0.2$
	2. Hardness	$5.1^{a} \pm 0.2$	$5.9^{a} \pm 0.2$	$5.0^{a} \pm 0.2$	$5.2^{a} \pm 0.2$
	3. Juiciness/dryness	$5.1^{a} \pm 0.2$	$5.4^{a} \pm 0.1$	$5.3^{a} \pm 0.2$	$5.0^{a} \pm 0.2$
	4. Cohesiveness of mass	$5.9^{ab} \pm 0.2$	$6.2^{a} \pm 0.2$	$5.4^{B} \pm 0.2$	$6.0^{a} \pm 0.2$
	5. Bolus/wad size	$4.2^{a} \pm 0.2$	$5.6^{a} \pm 0.2$	$4.8^{a} \pm 0.2$	$4.7^{a} \pm 0.2$
	6. Wetness of wad	$5.9^{a} \pm 0.1$	$6.0^{a} \pm 0.1$	$6.1^{a} \pm 0.1$	$5.9^{a} \pm 0.1$
	7. Rate of breakdown	$5.7^{B} \pm 0.2$	$6.8^{a} \pm 0.2$	$5.9^{ab} \pm 0.2$	$6.0^{ab} \pm 0.2$
	8. Chewiness	$5.1^{ab} \pm 0.2$	$6.2^{a} \pm 0.2$	$5.1^{B} \pm 0.1$	$5.4^{ab} \pm 0.2$
Flavor	1. Chickeny	$4.7^{a} \pm 0.2$	$4.6^{a} \pm 0.1$	$4.8^{a} \pm 0.2$	$4.8^{a} \pm 0.1$
	2. Brothy	$3.8^{a} \pm 0.2$	$3.8^{a} \pm 0.1$	$4.1^{a} \pm 0.2$	$4.1^{a} \pm 0.2$
	3. Cardboardy	$2.5^{a} \pm 0.1$	$2.0^{a} \pm 0.1$	$1.8^{a} \pm 0.1$	$2.3^{a} \pm 0.1$
	4. Barnyard/Wet feathers	$2.8^{a} \pm 0.1$	$2.2^{a} \pm 0.1$	$2.1^{a} \pm 0.2$	$2.4^{a} \pm 0.1$
	5. Bloody/serumy/Metallic	$3.2^{a} \pm 0.1$	$3.0^{a} \pm 0.1$	$2.7^{a} \pm 0.2$	$3.0^{a} \pm 0.2$
	6. Sweet	$2.8^{a} \pm 0.2$	$2.4^{a} \pm 0.1$	$2.4^{a} \pm 0.2$	$2.6^{a} \pm 0.2$
	7. Salt	$2.6^{a} \pm 0.1$	$2.4^{a} \pm 0.1$	$2.4^{a} \pm 0.1$	$2.4^{a} \pm 0.1$
	8. Sour	$2.6^{a} \pm 0.1$	$2.2^{a} \pm 0.2$	$2.3^{a} \pm 0.2$	$2.2^{a} \pm 0.1$
	9. Bitter	$1.6^{a} \pm 0.1$	$1.3^{a} \pm 0.1$	$1.2^{a} \pm 0.1$	$1.1^{a} \pm 0.1$

[ab] Mean values with no common superscript in the same row are significantly different from each other ($P < 0.05$).

[1] Intensities with a higher number are stronger.

The Principal Component Analysis (PCA) of the sensory attributes and samples are shown in Figure 3 and Figure 4.

More than 75% of the variation was explained by two principal components (PC1 and PC2) . PC1 or the main principal component explained more than 52% of the variation and was more positively correlated with all of the texture attributes and five of the flavor attributes (sour, salty, barnyard, bloody, and bitter) . The PC2 explained 23% of the variation and was mainly correlated with five of the flavor attributes (chickeny, brothy, bitter, sweet, and carboardy) and two of the texture attributes (bolus size and rate of breakdown) . Chickeny, brothy, bolus size, and rate of breakdown were correlated to PC2 on the positive side, and cardboardy, bitter, and sweet on the negative side. All sensory variables plotted relatively close to the center (0 ± 1) of the biplot, while thawing treatments (Fig. 4) were significantly further away from the center (0 ± 6 for PC1 and 0 ± 4 for PC2) . These observations indicate that the sensory characteristics have much smaller contributions to the sample positions in the plots compared to the treatments [17] .

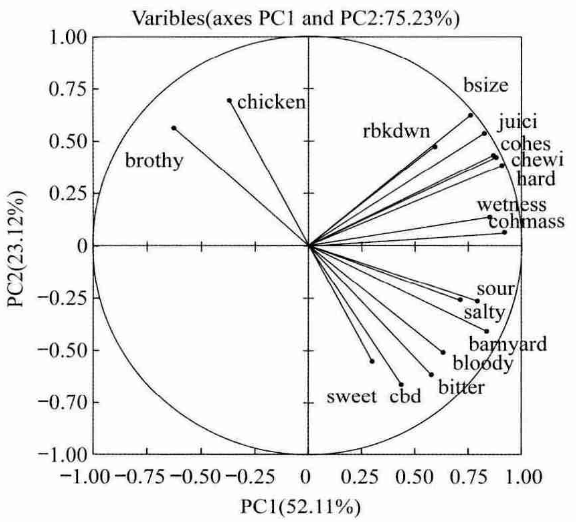

Figure 3 PCA correlation loadings plot for PC1 versus PC2

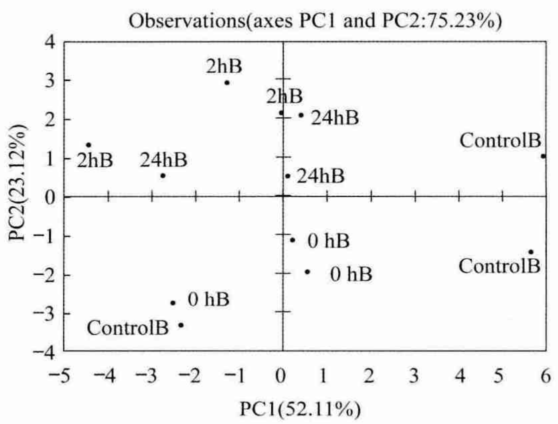

Figure 4 PCA scores plot for PC1 Versus PC2

Regardless of thawing method, all samples that were frozen prior to cooking were located close together near the center or to the left side of PC1 (Fig. 4) , which was far from all of the texture attributes and the majority of the flavor attributes (Fig. 3) . Samples that were thawed prior to cooking (2 h and 24 h) tended to locate on the positive side of PC2 (upper left corner) and were closely associated with brothy and chicken flavor attributes. However, the samples cooked directly from a frozen state tended to locate on the negative side of PC2. The samples cooked from a fresh state (controls) were located far from each other among the three replications (Fig. 4) . Two of the controls were located on the far positive side of PC1, closely associated with all of the texture attributes and the majority of the flavor attributes, and one of the controls was located in the lower left corner (negative sides of both PC1 and PC2) , close to those samples cooked directly from a frozen state.

These results indicate that even though statistically there were no significant differences for the majority of the sensory attributes among the four freezing-thawing treatments, overall perception of frozen chicken breast meat was not well associated with any texture attribute evaluated in this study. Regardless of the conditions used for thawing, frozen fillets that were thawed prior to cooking (2 h and 24 h) were distinguishable from samples that were thawed during cooking (0 h) or never frozen (controls) by the sensory panel. Fillets thawed prior to cooking tended to have more brothy and chickeny flavors than the fillets that were thawed during cooking. Cooked fresh fillets showed more variations in the intensities of the texture properties and some of them were perceived as harder more cohesive, and more chewy than the other. Freezing-thawing tended to reduce the variations in the intensity of sensory descriptive attributes.

4 Discussion

In the present study, we demonstrate that freezing-thawing does not affect the sensory flavor profiles of cooked chicken breast meat. However, freezing-thawing can significantly influence sensory texture profiles of cooked chicken breast meat and the effects are dependent upon how the frozen meat is thawed prior to cooking. These results are in line with published findings on frozen red meat. With 100% beef patties, Bigner-George and Berry [18] found that thawing prior to cooking consistently increased firmness and rate of breakdown texture attributes compared with thawing during cooking but did not see the same relationship for sensory beef flavor attributes. Moody et al. [19] studied the effects of thawing methods on the sensory characteristics of beef steaks and found that samples that were thawed prior to cooking were tenderer than samples cooked from a frozen state but that there were no difference in juiciness and flavor between the treatments.

In frozen-thawed meat, texture properties are thought to be influenced by the combination of the loss of structural integrity caused by ice crystal formation and the loss of fluid during thawing [1]. The formation of large, extracellular ice crystals disrupts the physical structure by breaking muscle fiber, resulting in tenderization [1,5]. Fluid loss during thawing results in less water being available to hydrate the muscle fibres which can increase number of fibers per surface area and the toughness as perceived by sensory panelists [1,20].

The finding that no differences were observed in the flavor profiles of cooked chicken breast meat among the four treatments agrees with previous red meat studies [21-23] and is consistent with our previously published results [16,24]. In a quality survey of breast meat products found in US retail markets [24] and a study on the effects of broiler carcass chilling method on breast meat [16], we did not observe differences in the sensory profiles of chicken breast fillets between different treatments. This provided evidence that few factors during processing and post-processing handling can affect poultry meat flavor. The present study provides evidence that, regardless of thawing method, the effects of freezing-thawing on the flavor of cooked chicken breast meat are minimal and below the threshold of detection for even a trained sensory panel. Similarly, Shrestha et al. [25] reported that sensory panelists could not distinguish a flavor difference between chicken breast meat that was thawed in hot-water or in a refrigerator prior to grilling.

Our PCA analysis shows that chicken fillets that are thawed prior to cooking (2h and 24h) are grouped together and can be easily separated from fillets that are cooked fresh or fillets that are thawed during cooking. The differences in sensory quality profiles between cooking directly from a frozen state and cooking after thawing have been similarly observed in red meat. Jones et al. [26] found that frozen pork loins cooked from a frozen state were more juicy and acceptable, and contained more moisture than frozen samples that were thawed before cooking. Beef patties cooked after thawing were more tender and juicier than those cooked from a frozen state [18]. Moody et al. [19] reported that thawed samples were scored higher than the frozen samples for juiciness and flavor in beef roasts. For chicken breast meat, several studies found that samples cooked directly from a frozen state have higher shear force values and cook loss than samples cooked after thawing [14,24]. Zhuang and Savage [27] also reported that the texture, as indicated by shear force, of chicken breast meat cooked directly from a frozen state was more similar to that of cooked fresh meat (never frozen) than meat that was thawed prior to cooking. These PCA results suggest that refrigerated thawing and tap water thawing result in similar sensory perceptions of cooked frozen chicken breast meat. Thawing during cooking, however, results in sensory characteristics in breast meat that cannot always be separated from those of meat that is cooked fresh.

In summary, results from the current study demonstrate that freezing-thawing can significantly impact sensory texture profiles of cooked chicken fillets and that the effects depend upon how the meat is thawed during meat preparation. Texture of cooked frozen fillets tends to be less intense than cooked fresh fillets and freezing-thawing reduces the intensities of sensory attributes. Frozen fillets that are thawed prior to cooking tend to be perceived differently from those that are cooked from either a fresh state or a frozen state by a sensory panel. The sensory properties of the cooked fresh fillets vary largely compared with cooked frozen fillets. Furthermore, fillets cooked from either a fresh state or directly from a frozen state cannot always be distinguished from each other based on the sensory attributes evaluated in the present study.

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冷冻-解冻对烹饪后鸡胸肉的感官描述剖面的影响

ZHUANG Hong，BOWKER Brian

（美国农业部 农业研究服务 Russell 研究中心，雅典，乔治亚州 30605）

摘　要：冷冻是消费者用于延长肉类储藏期的一种常用方法，也是研究人员常用于肉类品质评估和加工的前道工序. 目前尚无完善记录表明，冷冻对烹饪后的禽胸肉质的感官品质会产生影响. 本研究的目的是比较新鲜与冷冻-解冻鸡胸肉的感官质量剖面属性. 鸡胸肉块在宰后 24 h 内从胴体上分割，分别以新鲜状态直接烹饪或置于 －20℃ 冷冻. 冷冻样品采用三种不同解冻方式：冷冻后直接取出烹饪解冻（0 h）；在 20℃ 水中预解冻 2 h 后烹饪（2 h）；或在 4℃ 预解冻 24 h 后烹饪（24 h）. 对照组则为新鲜鸡胸肉直接烹饪. 肉块加热到 78℃ 时用于评价感官质量属性. 该实验由经过训练的描述型品评员采用 0～15 强度标度法进行评价. 结果显示：不同的处理方式并没有引起任何风味特征和 5 种质构特征（内聚力、硬度、多汁、肉块大小、肉块湿度）上的差异（$P>0.05$）. 然而，不同处理方式引起了团块内聚性、分解率和咀嚼性上的显著差异（$P<0.05$）：冻后直接烹饪（0 h）和解冻 24 h 烹饪（24 h）的鸡肉块的团块内聚性评价要明显高于预解冻 2 h 的样品. 冻后直接烹饪样品（0 h）的分解率和咀嚼性显著高于新鲜对照组和预解冻 2 h 的样品. 本研究结果表明，冷冻-解冻对鸡胸肉的感官风味品质无影响，但可能改变烹饪后鸡胸肉的质构特征. 因此，冷冻-解冻对肉类质构的影响取决于烹饪前的解冻方法.

关键词：鸡胸肉；感官；风味；质地；冷冻-解冻

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