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# Handling Practices and Quality Attributes Along the Supply Chain of *gboma* (*Solanum macrocarpon*): A Leafy Vegetable in Southern Benin

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## Abstract

*Gboma* is a leafy vegetable commonly consumed in Benin, which plays an important role in food security. This study assessed the handling and preservation practices as well as quality attributes of *gboma* along the supply chain in Southern Benin. A survey among 785 people (285 producers, 180 wholesalers/retailers, and 326 consumers) living in four Departments of Benin was conducted to evaluate the consumption frequency, the transportation mode, the preservation methods and quality attributes of *gboma* during purchasing. The survey revealed that, in general, *gboma* sauce is consumed twice to three times a month in all the departments covered. Different practices, including humidification, were used to preserve the leaves during selling. Traditional baskets or old clothes were used for the transportation and storage of *gboma*. Important quality attributes mostly used by actors during purchasing were freshness and color followed by physical damage and, to a lesser extent, weight and leaf surface at different degrees. *gboma* is currently sold in informal markets; however, improving handling and selling practices could preserve the freshness of this leafy vegetable that could then be placed in conventional supermarkets. Thereby, the selling and consequently the production level will increase, with positive impact on the income of producers.

**Keywords:** *Solanum macrocarpon*; leafy vegetables; quality criteria; transportation materials; frequency of consumption

## 1 Introduction

Vegetables are annual or perennial horticultural crops with certain parts such as roots, stalks, flowers, fruits, leaves, are consumed by humans. They are important for human nutrition and health because of their content in bioactive

nutrients such as vitamins, minerals, phytochemical compounds and dietary fiber (Ilodibia et al., 2016). Adequate vegetable consumption can be protective against some chronic diseases (diabetes, obesity, metabolic syndrome, ...), and reduce risk factors related to these diseases (Grubben et al., 2014; Oyenuga & Fetuga,

1975). Leafy vegetables, especially dark leafy green vegetables, are important sources of minerals (iron and calcium), vitamins (A, C, and riboflavin) and fiber sources (Ülger et al., 2018). Young fresh leaves contain more vitamin C than mature plants, while thinner and greener leaves are most nutritious and usually have lower calories (Ülger et al., 2018).

In Africa where the daily diet is dominated by starchy staples, indigenous leafy vegetables are generally used to balance the nutrition value of such diet. They are reported to play an important role in income generation and subsistence (Schippers, 2002). Leafy vegetables are crucial commodities for poor households because they are readily available everywhere and their prices are relatively affordable when compared to other food items. Besides, they provide essential sources of employment for those people outside the formal sector in peri-urban areas since this activity is generally short labour-intensive, with low levels of investment and a high yield (Schippers, 2002).

Among leafy vegetables produced in Benin, *Solanum macrocarpon* L. (Solanales: Solanaceae), commonly called *gboma* (Figure 1), is widely consumed in the form of *gboma* sauce that is well appreciated by the people (Baco, 2019; Dougnon et al., 2012). It is mainly produced in urban and peri-urban zones by both men and women. After production, *gboma* is purchased in the production sites by wholesalers, and sold in different local markets (Achigan-Dako et al., 2010; MAEP, 2016). Most studies have focused on the production system, the nutritional value as well as the consumption level of this leafy vegetable in West Africa (Baco, 2019; Chinedu et al., 2011; Dougnon et al., 2012; Hounou et al., 2020; Kwenin et al., 2011). For instance, apart from its richness in macronutrients, *gboma* also contains calcium (391 mg/100 g) and phosphorus (49 mg/100 g); and its composition is comparable to that of other dark green leafy vegetables (Chinedu et al., 2011).

However, there is a lack of information on some aspects related to the handling practices of *gboma*, from the production sites to consumers' houses; this could help develop relevant practices to extend its shelf life as well as its quality

attributes. Additionally, such information is important to improve the preservation of the integrity of *gboma* during transportation and selling. The present study fills this gap by assessing the handling practices and preservation conditions of *gboma* along the supply chain in southern Benin. It also evaluated the quality criteria that guide buyers and consumers during *gboma* purchasing.

## 2 Materials and Methods

### 2.1 Study area and sampling of respondents

A survey was conducted from July to September 2018 in some production locations of *gboma* identified in four Departments of Southern Benin, namely Atlantique (Abomey-Calavi, Alada and Ouidah), Littoral (Cotonou), Mono (Bopa, Grand-Popo, and Lokossa), and Ouémé (Avrankou, Porto-Novo, and Sèmè-Podji) (Figure 2). Three groups of actors involved in the *gboma* value chain were targeted in this study: producers, wholesalers/retailers, and consumers. Adequate sampling size for respondents was determined by using the equation N. 1

$$N_i = \frac{4pi(1 - pi)}{d^2} \quad (1)$$

where  $N_i$  is the total number of actors surveyed in department  $I$ ;  $pi$  is the proportion of actors implied in the value chain of *gboma* (producers, wholesalers and consumers), to the total number of populations  $i$ ; and  $d$  is the expected error margin in the conclusion, which was fixed at 0.05 (Dagnelie, 1998). The number of persons interviewed in each group of actors in each Department was proportional to its number in the total population (case of consumers) or in the total agricultural population (for other groups of stakeholders).

Based on this formula, 178 people were selected in Atlantique Department, 200 people in the Littoral, 140 in the Mono, and 267 in the Oueme, giving a total of 785 respondents among which 279 producers, 180 wholesalers/retailers and 326 consumers.

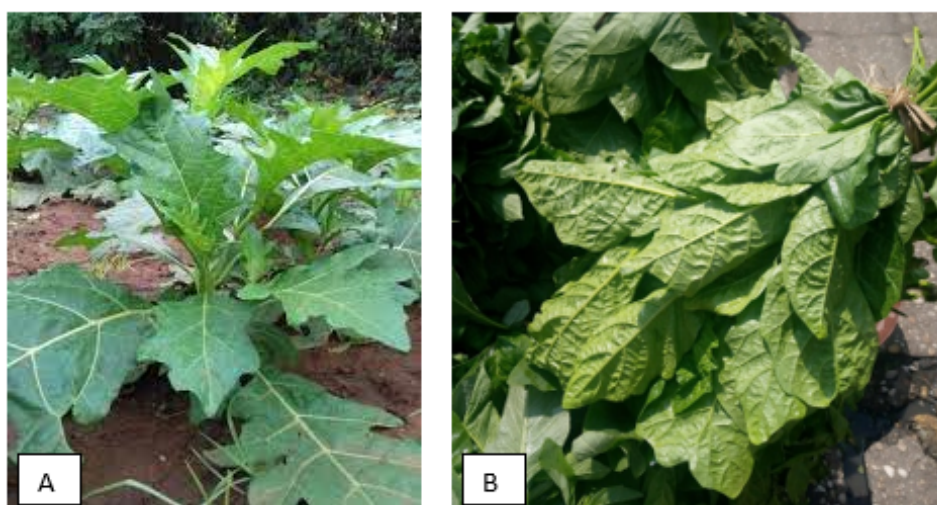


Figure 1: A: *Gboma* (*Solanum macrocarpon*) plant; B: *Gboma* tuft sold in market

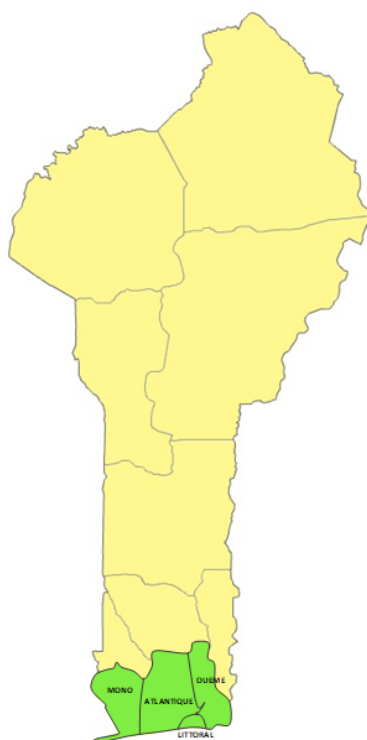


Figure 2: Map of Benin showing in color the study departments

## 2.2 Questionnaire content and data collection

Specific questionnaires were developed for each type of actor. They were tested and adjusted if needed before the survey. In each location, respondents were randomly selected and face-to-face interviews were conducted in the language or dialect that was best understood by the respondents, with translation when necessary. The questionnaires developed for the different stakeholders covered the following aspects:

**For the producers' level** questions were related to their socio-demographic characteristics, production and handling practices (sites and period of production in a year, selling sites, packaging materials used by buyers for handling), criteria to determine *gboma* price, and characteristics of good quality of *gboma*.

**For the wholesalers/retailers' level** questions were linked to their socio-demographic characteristics, purchasing practices including the quality attributes considered during purchasing (places of purchase and sale, periods of high and low

availability, quality criteria retained during purchasing, criteria to determine the price, quality perception of the purchased *gboma*, packaging materials used for handling and selling, transportation conditions).

**For the consumers' level** questions addressed the following aspects: socio-demographic characteristics, purchasing practices including the quality attributes considered during purchasing (places of purchase, quality criteria during purchasing, quality perception of the purchased *gboma*) and consumption frequency.

### 2.3 Data Analysis

The raw data was saved in the Sphinx software (5.1.0.4). Descriptive statistics were processed using SPSS IBM 2020. Quality criteria identified were ranked and ordered according to actors.

## 3 Results and Discussion

Socio-demographic characteristics of actors indicated that all wholesalers/retailers interviewed and more than 97 % of consumers were females (Table 1). Women are less involved in *gboma* production than men: 68 % of producers were male. Respondents had various ages and diverse educational backgrounds. Most of them were between 40 and 60 years old. The majority of wholesalers (67.6 %) had no formal education and 28 % of producers had finished primary school. In addition, more than 40 % of producers and wholesalers had less than 10 years of experience in *gboma* production and selling activities.

### 3.1 Production and frequency of *gboma* consumption

*gboma* is produced all the year in the four Departments surveyed with noticeable differences in the production levels. In most locations of the Departments of Atlantique, Littoral and Mono, *gboma* production is a regular activity undertaken throughout the year. However, in some

locations in the Oueme Department, this activity is seasonal and it is done during the rainy season. In addition, the production period also depends on the customers' request. This figure was also observed by Achigan-Dako et al. (2010) who reported that *gboma* production is generally a full-time activity for most producers in Benin. The frequency of *gboma* consumption differed significantly among stakeholders. Globally, more than half of the interviewed persons consumed *gboma* at least 2 to 3 times a month, while around 4 % of consumers declared to rarely consume this product (less than once a month) (Table 2). High consumption level was observed in the Littoral Department in which 44 % of respondents consumed *gboma* sauce at least once a week, followed by Mono and Atlantique Departments. These observations could be explained by the fact that the Department of Littoral is represented by the city of Cotonou which is the largest urban city of Benin. Moreover, most of the inhabitants of Cotonou, not only know the importance of fruit and vegetable consumption on the health, but are also willing to pay for these products regardless of the price and the season. In fact, vegetables and specifically leafy vegetables are rich in micronutrients and health-promoting phytochemicals, and the increase in their consumption is critical to alleviate worldwide incidence of nutritional deficiencies (Yang et al., 2006). In contrast, low level of consumption frequency was noticed in Oueme Department where this situation could be attributed to the seasonal production of *gboma* in certain locations of the Department. The consequence is that the product is sometimes unavailable and also the resulting high cost during these periods of the year reduce its consumption. Similar patterns of *gboma* consumption frequencies were also found in other *gboma* producing countries in the West-African sub-region such as Ghana, Nigeria, and Togo (Bonsu et al., 2002; Schippers, 2002). Comparison among locations indicated that high frequencies consumptions (at least once a week) were observed in Allada (45 %) in Atlantique Department, Cotonou (44 %) in Littoral Department, Grand-Popo (41 %) and Lokossa (41 %) in Mono Department (Table 2). These observations could be explained by several factors such as: food habits, production levels of vegetables in general, and the purchasing power.

Table 1: Socio-demographic characteristics of respondents by actors

	Producers (N=279)	Wholesalers/retailers (N=180)	Consumers (N=326)
<b>Gender</b>			
Male	68.0	0.0	2.8
Female	32.0	100.0	97.2
<b>Age (year)</b>			
<25	2.9	2.2	11.0
25–29	11.8	5.6	9.5
30–39	26.8	14.5	25.8
40–60	49.3	62.6	46.0
> 60	9.2	15.1	7.7
<b>Education level</b>			
No formal education	39.9	67.6	42.5
Primary school	28.0	20.7	23.7
Secondary school (1st cycle)	18.8	8.4	15.4
Secondary school (2nd cycle)	8.9	2.8	8.0
University	4.4	0.6	10.5
<b>Experience in the activity (year)</b>			
0–10	42.3	41.1	
11–20	34.9	31.7	
21–30	13.6	18.3	
31–40	6.6	6.7	
More than 40	2.6	2.2	

“Values presented correspond to % of respondents”

In fact, in most of these municipalities, leafy vegetables are included in their food habit for a long time, and this practice is perpetuated from generation to generation regardless of their evolution of the living cost. Next to that, the production of leafy vegetables in these locations is done throughout the year, irrespective of the season; thereby encouraging people to consume *gboma* regularly. However, due to the health benefit from the consumption of fruits and vegetables, and to promote the consumption of vegetables, the World Health Organization recommends the consumption of at least three different vegetables species per day (WHO, 2003).

### 3.2 Quality attributes of *gboma* by actors of the supply chain

Quality criteria identified by different stakeholders in the *gboma* value chain are presented in

table 3. Among the six criteria identified, freshness and color were the major selection criteria used by wholesalers and consumers during purchasing. These two criteria were also the main factors mentioned by producers for *gboma* quality characterization. Freshness represents an important criterion for leafy vegetables that is measured by the shininess or brightness, and the vigor of the leaves (Bonsu et al., 2002; Kwenin et al., 2011; Schippers, 2002). Consumers usually purchase fresh products driven by their visual appearance, while additional other components of quality such as texture and aroma make them to claim for the same product whenever they are in the need (Kader, 2001).

Color is generally the most important attribute used by consumers to evaluate the quality of the vegetable, and plays, therefore, a decisive role in the acceptability of such products. Color change is the first visible symptom of senescence in many

Table 2: Consumption frequency of *gboma* among respondents by locations and departments

Municipalities	2 - 3 times/week	Once / week	2 - 3 times / month	Once month	Less than once/month
<b>Atlantique department</b>					
Abomey-Calavi (N=66)	13.6	25.8	24.2	31.8	4.6
Allada (N=11)	18.2	27.3	18.2	36.4	0.0
Ouidah (N=10)	0.0	20.0	20.0	60.0	0.0
Total in Atlantique (N=87)	12.6	25.3	23.0	35.6	3.4
<b>Littoral department</b>					
Cotonou (N=106)	16.0	28.3	24.5	26.4	4.7
<b>Mono department</b>					
Bopa (N=08)	12.5	25.0	12.5	50.0	12.5
Grand-Popo (N=22)	9.1	31.8	13.6	27.3	18.2
Lokossa (N=17)	17.6	23.5	29.4	23.5	5.9
Total in Mono (N=47)	12.8	27.7	19.1	29.8	10.6
<b>Oueme department</b>					
Avrankou (N=15)	0.0	13.3	33.3	53.4	0.0
Porto-Novo (N=50)	10.0	10.0	36.0	40.0	04.0
Seme-Kpodji (N=21)	0.0	23.8	28.6	47.6	0.0
Total in Oueme (N=86)	5.8	14.0	33.7	44.2	2.3
Total (N=326)	12.0	23.6	25.8	34.0	04.6

“Values presented correspond to % of respondents”

horticultural crops and may compromise their economic value. Additionally, the dark green color of the leaves is the color criterion preferred by all actors (Figure 2). Color may be considered as an index for estimating the antioxidant properties of the leafy vegetables (Ali et al., 2009; Tijsskens et al., 2001). Indeed, the green coloration of leafy vegetables is generally associated with the presence of chlorophyll which indicates the presence of antioxidant activities (Ali et al., 2009; Limantara et al., 2015).

Apart from these two criteria, leaf width or area and appearance were other important parameters that all actors used to appreciate the quality of *gboma*, but at different degrees. Appearance is referred to the integrity of the leaves. Wholesalers and consumers preferred *gboma* with a wide surface without any physical damage (Figure 3). Physical damage of the leaves is generally associated with insect and pests’ infestation or inappropriate use of synthetic pesticides during the cultivation (James et al., 2007). In contrast, odor and texture of the leaves of *gboma* are not the

main concerns for all actors.

In summary, all the actors investigated believed that *gboma* must be fresh (shiny and firm) with a large area without any physical damage.

### 3.3 Handling practices and preservation

Generally, producers sell their products to wholesalers or retailers; but sometimes, they are in direct contact with consumers who come to their garden for purchasing. Wholesalers directly bought plots of *gboma* which they harvested by themselves. After harvesting, different materials were used to handle the leaves from the production sites to markets or selling places (Table 4). Apart from baskets and bowls, respondents also used other materials for transportation because of their ease of transport on motorcycles. So, many old clothes or recycled rice bags are sewed together to get a large surface capable of carrying a large amount of *gboma* leaves. These materials (clothes and recycled rice bags) are widely used

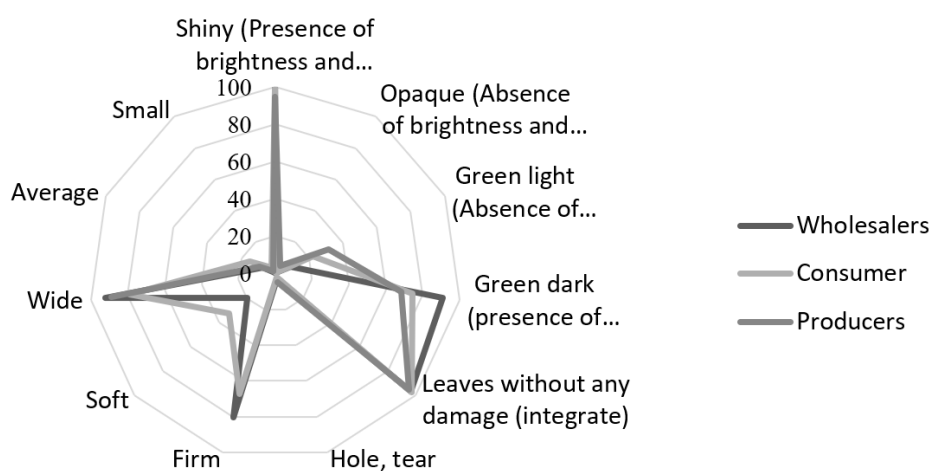


Figure 3: Rank of quality attributes among actors.

Table 3: Quality attributes of *gboma* among actors

Actors	Freshness	Color	Appearance	Texture	Odor	Leaves width
Producers (N=279)	23.6	23.7	19.8	13.1	0.4	19.3
Wholesaler (N=180)	26.6	22.9	19.3	9.9	0.1	21.2
Consumers (N=326)	25.5	22.7	22.3	10.5	0.5	18.5

“Values presented correspond to % of respondents”

Table 4: Materials used by wholesalers and retailers for *gboma* transportation

	Old clothes	Recycled rice bags	Baskets	Plastic bags	Leaves <sup>1</sup>	Large bowls
Wholesalers/retailers (N=180)	92.0 <sup>2</sup>	88.4	36.0	18.2	12.6	09.8

“Values presented correspond to % of respondents”; <sup>1</sup>*Tectona grandis* leaves wrapped with palms of *Elaeis guineensis* leaves; <sup>2</sup>Sum > 100 because several answers were possible

Table 5: Preservation methods of *gboma* among actors

Actors	Method 1*	Method 2	Method 3	Method 4	Method 5
Wholesalers/retailers (N=180)	79.5	12.2	8.2	0.0	0.0
Consumers (N=326)	15.7	51.4	12.9	18.6	1.4

“Values presented correspond to % of respondents”; \*: Method 1: water preservation (soaking in water, water spray); Method 2: dew preservation (dew exposition); Method 3: aeration preservation (shade and air exposition); Method 4: cold preservation (refrigeration and deep freezing). Method 5: parboiling preservation

Table 6: Producers and wholesalers/retailers reactions when *gboma* do not satisfy consumers' requirements

Actors	Purchase price reduction	Rejection of the whole lot	Sorting and rejection of spoiled leaves
Producers (N=279)	51.7	5.9	42.4
Wholesalers/retailers (N=180)	72.6	6.7	20.7

“Values presented correspond to % of respondents”

by wholesalers due to their affordability and also because they are easy to carry on while traveling. However, some of these packaging materials (baskets and clothes) often lead to physical deterioration of the *gboma* leaves which, according to Salunkhe and Desai (1988), thereby causing severe loss in the nutritional quality of fresh vegetables during subsequent handling operations such as distribution, storage, and marketing. Thus, proper packaging system and appropriate handling materials should be designed for an easy handling of the post-harvest *gboma* to prevent physical damage prior to selling.

Moreover, to optimize the quality and to prolong the shelf life of *gboma* after harvesting, it is important to maintain optimal temperature and relative humidity by avoiding solar exposure during the transport and selling period. Proceeding as such could help reduce the degenerative processes that occur during the post-harvest stages, thereby increasing the shelf life of the products (Yang & Tsou, 2006).

After packaging, the leaves of *gboma* are transported either on motorcycles (92 % of wholesalers interviewed) or by car (4 % of wholesalers) to the markets or selling sites. Few wholesalers (5 %) used pirogues for *gboma* transportation, a practice that is common in swampy locations in the Oueme department during the rainy season. Elsewhere, *gboma* is generally sold unpacked in markets and consumers who kept their stuff in plastic bags on their way home.

Different methods were used by actors in the markets or selling places to preserve the freshness and color of the *gboma* (Table 5). It appeared that more than 79 % of wholesalers/retailers soaked the leaves in water or regularly sprayed them with water; some of them (12.2 %) left the leaves to the dew for their humidification during

the night. When *gboma* is planned to be processed the day after purchasing, consumers left them to the dew (51.4 %) or in the fridge (18.6 %) to preserve their freshness. All these preservation's methods mentioned above have also been reported by Achigan-Dako et al. (2010) and Baco (2019) in Benin. These techniques are generally used to preserve the freshness of leafy vegetables (Vorster et al., 2003). However, some consumers also preserve the quality of the *gboma* using cooling systems (i.e. refrigeration or freezing), but this technique is more common in urban areas where electric power is available, and it is often consumers wealthy who choose this option.

In spite of all measures taken, the loss of quality of freshly harvested *gboma* leaves occurs in all groups of stakeholders. Wholesalers/retailers, sometimes, are confronted to quality deterioration (freshness, color, physical damage) that constraints them to sell their commodity at lower prices or to poor sales following rejection by the purchasers. Sometimes, *gboma* leaves are discarded when the supply exceeds the demand; this happens generally during rainy season. Several authors have investigated the causes of post-harvest losses of leafy vegetables and reported many causes including the use of local or auto-propagated seeds, excessive use of fertilizers, inadequate irrigation system, poor harvesting practices, inadequate handling conditions (poor transport and storage), attacks of insects and fungi (Able et al., 2003; Ahvenainen, 1996; Jacxsens et al., 2002). In addition, Salunkhe and Desai (1988) stated that significant changes in color, flavor, texture and nutritional quality of vegetables also occur during storage, as influenced by storage temperature and environment and could affect the quality of the vegetables, hence, their marketable value. With this as-

sumption, wholesalers and retailers need to preserve *gboma* during sales and storage to avoid losing the overall quality of their product.

When, unfortunately, some parts of the *gboma* production or stocks were rejected by the final consumers for one reason or another, producers and wholesalers are forced to adopt one of the strategies presented in Table 6. In that respect, most of the respondents (51.7 % of producers and 72.6 % of wholesalers) either reduce the quantity for sale or lowered the purchasing price. Some of them (42.4 % of producers and 20.7 % of wholesalers) sort and drop the spoiled leaves. In certain cases, producers sell to street food vendors or keep the spoiled products in the field, for them to rot into organic fertilizers.

#### 4 Conclusions

This study showed that *gboma* is consumed at least two to three times a month by the majority (>60% of respondents) of the population in the Southern part of Benin. Freshness (brightness and vigor) and color (dark green) followed by appearance (leaves without any damage) and, to a lesser extent, leaf surfaces were important quality criteria mentioned by respondents. Practices used by stakeholders to preserve the freshness of *gboma* leaves during selling, include humidification and nightly exposure to dew. Post-harvest handling practices and preservation conditions during selling may significantly impair the quality of the vegetable product. Research is advocated to improve or develop appropriate materials for packaging and transportation to improve the shelf life of *gboma* thereby increasing the income of the different actors.

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