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RESEARCH ARTICLE

Chios mastic, a natural supplement for zinc to enhance male sexuality and prostate function

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Abstract

Mastic is a natural resin extracted from the stem of the evergreen tree *Pistacia lentiscus* var. Chia (Duham) (Anacardiaceae). For a long time, mastic has been esteemed for its aphrodisiac properties. To test this hypothesis, the trace element zinc was determined while the quantity released after a certain time of chewing was studied. For comparison, three commercial chewing-gums were analyzed as well. A portion of natural mastic or commercial gum was uniformly chewed for 1, 2, 3, and 4 h and the zinc content measured. The zinc content of mastic from *P. lentiscus* var. Chia was compared to that of other natural resins from the same genus (*Pistacia terebinthus* L.) or conifer [*Pinus halepensis* Mill. (Pinaceae)], having a different secretion mechanism and also used as an additive in human nutrition. Secreted resin and plant tissues from the above trees were sampled and the zinc content was determined. Zinc concentrations in the resin were lower than in the plant tissues. The Chios mastic showed a slightly greater zinc content compared to the other analyzed specimens. Among all gums studied, only the Chios mastic released a small amount of about 0.7 mg kg^{-1} zinc in the mouth and gastrointestinal system after 4 h chewing time. With commercial gums, the zinc content increased to a large degree (up to 2 mg kg^{-1}) after the same treatment, a fact which was attributed to the zinc uptake from salivary secretions, indicating zinc deprivation for the human organism.

Keywords: *Chios; mastic; prostate; sexuality; zinc*

Introduction

Mastic gum is a natural resin extracted from the stem of the evergreen shrubby tree *Pistacia lentiscus* var. Chia Duham (Anacardiaceae), growing in the southern part of the island of Chios (north-east Aegean Sea) (Figure 1a). Although *P. lentiscus* is a common species of Mediterranean evergreen with sclerophyllous formations normally producing resin, mastic is secreted only from trees on the southern part of Chios (Figure 1b), where large-scale mastic production takes place (Figure 1c and d). Many ancient writers, among them Dioscorides, referred to mastic gum, which was considered a panacea for many maladies.

In Mediterranean countries and the Middle East, *P. lentiscus* mastic has been used as a food additive or herbal remedy for a long time (Lev & Amar 2002, 2008). Today the benefits of this natural resin are being rediscovered, and several studies have already been published on mastic gum, gaining respect among the scientific and medical community. The mastic has antibacterial properties, particularly against *Helicobacter pylori*, which causes most gastric and duodenal ulcers (Al-Habal et al., 1984; Huwez & Al-Habbal, 1986).

As-Suyuti (1414) in his "Medicine of the Prophet" drawing from Islamic philosophy of life refers to the mastic, among other things, as promoting sexual desire and beautifying the complexion. The mastic is employed as flavoring in bread, which becomes tasty, easy to digest, and stimulant. According to Piacenza (1688):

> …the chief cook of Sultan was accustomed in preparing bread with some quantity of mastic in order to increase the Sultan's sexual performance. This practice turns on sexuality, having a mysterious

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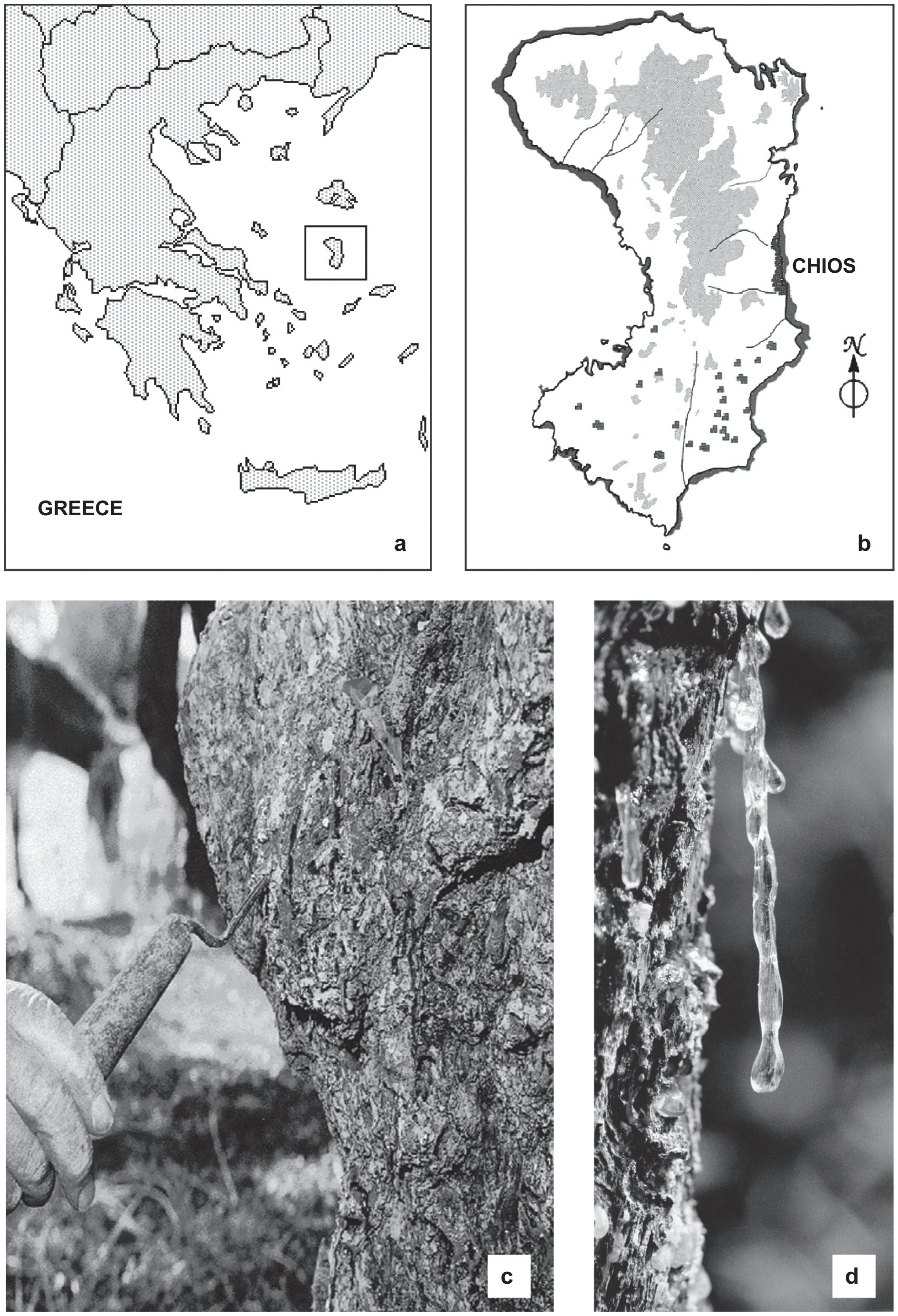

Figure 1. (a) Map of Greece indicating the island of Chios, where the mastic tree grows. (b) Chios island and the 24 villages in the southern region where mastic is produced. (c) Incisions (10–15 mm long and 4–5 mm deep) on the tree trunk made by special tools. (d) Hardened resin, which has flowed from the incisions, after 10–20 days. (See colour version of this figure online at www.informahealthcare.com/phb)

> merit and power, not only occasionally but also as a steady food supplement. Mastic acts as sexual awakening for sleepy or lethargic aphrodisiac desire, and nothing is more efficacious among the many known aromatics.

In some parts of Africa or Asia, especially Hong Kong, mastic has been esteemed for its aphrodisiac properties. In Saudi Arabia the mastic is offered as a nuptial present from the groom to the bride in order to keep away evil spirits and presumptive rivals.

Although mastic has been recorded as an important aphrodisiac material by many authors for hundreds of years, the scientific research in this direction has received little attention, if any at all. This fact prompted us to correlate its aphrodisiac properties referred to in the past with the presence of zinc, because this trace element is important to male sex organ function and reproductive fluids. It is found in high concentrations in the prostate gland, suggesting its function in this area. The prostate contains 10 times more zinc than any other part of the body, and there many studies on the importance of zinc in prostate metabolism. Low zinc levels have been correlated with low testosterone levels (Mason, 2000). On the other hand, prostate problems are more prevalent with zinc deficiency, and a course of zinc supplements may be helpful (Costello & Franklin, 1998).

Male teenagers with subtle zinc deficiencies have delayed or absent sexual development. Even in sexually developed males, low zinc levels have been correlated with a decrease in testosterone levels and a lower sperm count. Evidence of human zinc deficiency began to emerge in the 1960s, when cases of zinc-responsive delayed sexual maturation were first reported among Egyptian adolescents (Prasad, 2008). Zinc treatment was found to help these conditions by stimulating growth and sexual development. According to an analysis of data from the Food and Agricultural Organization, the prevalence of zinc deficiency might be as high as 40% worldwide (Brown et al., 2001; Arsenault & Brown, 2003).

Zinc absorption is highly dependent on the presence of other competitive minerals such as cadmium. Both elements compete for the amino acids available and the specific sites of absorption in the small intestine; thus, any excess of zinc over its competitor will increase its chances of absorption (Gerson & Shaikh, 1984). Cadmium is considered a potentially toxic heavy metal and an antimetabolite of zinc. The basis of cadmium toxicity is its negative influence on the enzymatic systems of cells, resulting from the substitution of zinc and other metallic ions in metalloenzymes (Stohs & Bagchi, 1995; Brzoska & Moniuszko-Jakoniuk, 2001). A low-zinc diet can markedly increase the cadmium content in various internal organs such as the liver, kidneys, and testes. Thus, some aspects of cadmium toxicity can be markedly increased by zinc deficiency (Tanaka et al., 1995), and now the protective effect of zinc in conditions of cadmium intoxication is well understood. Apart from cadmium, zinc is also antagonistic to mercury and lead and can play a role in heavy metal detoxification (Schauss, 1999).

The aim of this study was to determine the trace element zinc and its antagonist cadmium in the mastic gum from *P. lentiscus* var. Chia. We analyzed the quantity of both elements released after certain times of chewing. To demonstrate its uniqueness, mastic gum was also compared to other natural resins such as those from the same genus *P. terebinthus* L. or from conifer *Pinus halepensis* Mill. (Pinaceae). Both resins are used in human nutrition as a gum or as a wine additive, respectively. Among analogous commercial products, the mastic was compared with some popular chewing gums, namely Elma, Orbit Classic, and Trident (R) Fruit.

Material and methods

Sample preparation

Resin and related plant tissues (leaves and bark) were sampled directly from *P. lentiscus* var. Chia, *P. terebinthus*, and *P. halepensis* trees. In the laboratory, specimens were left to dry at room temperature. After drying and pulverizing, the samples were placed in polythene bags and stored at 4°C. A portion of about 4 g of natural mastic or commercial gum was uniformly chewed for 1, 2, 3, and 4 h by the same adult person. All care was taken to avoid any external contamination; thus, chewing started after thorough tooth cleaning. The practice was repeated twice more in order to have all samples in triplicate.

Analytical methods

The samples were taken by means of plastic spatulas for replicate analyses and dried at 40°C to constant weight. About 3 g of material of each kind of resin or mastic was placed in an open tube and moved into a cold muffle furnace, heated with gradually increasing temperature up to 450°C (4 h), and additionally heated at this temperature (4 h). Upon cooling, 1.5 mL of concentrated nitric acid (65%; Merck, *pro analysi*) was added drop by drop and the sample was heated slowly on a sand bath. This was repeated again with 2 mL nitric acid for complete dissolution. The filtrate, obtained through medium size pores (Filpap KA 2), was diluted with double distilled water (0.06 μS cm^{-1}) up to 10 mL.

About 2 g of leaf or bark material was treated with 15 mL nitric acid (9.67 M) overnight. The wet-ash procedure was continued with heating on a water bath, followed by the addition of 2 mL portions of hydrogen peroxide (30%). This treatment was repeated untill full digestion. The filtrate (through Filpap KA 2) was diluted with double distilled water (0.06 μS cm^{-1}) to 25 mL. All solutions were stored in plastic flasks. Duplicates of each sample were prepared independently. Zinc and cadmium were determined by atomic emission spectrometry with inductively coupled plasma (ICP-AES) using a Varian Vista-PRO instrument in a certified laboratory. The analytical wavelengths used were 213.857 nm for Zn and 226.502 nm for Cd. The detection limit of zinc and cadmium determined by ICP-AES was 0.004 mg L^{-1}.

The analytical precision was verified by replication (deviation between the duplicates was below 5% in all cases) and by use of blanks and stock standard solutions (1000 μg L^{-1}; Merck) for the preparation of working aqueous solutions. Quality control was checked using standard reference material (CRM 281) from the Community Bureau of Reference, Commission of the European Communities. The results of ICP-AES analysis were in good agreement with the certified values (RSD < 5%). The result for each sample is the average of three sub-samples and for separate samples is the mean of three analytical determinations. All concentrations are presented as mg kg^{-1} dry weight.

Results and discussion

The mean concentrations of zinc of the three resin-yielding Mediterranean trees are given in Table 1. The cadmium content in resin and tissues from all trees remained always under the level of 0.01 mg kg^{-1}. In all cases the leaf values were higher, followed by those of the bark. Zinc is an essential nutrient serving as a catalytic or structural cofactor for many different proteins found in the cytoplasm of active plant cells. Thus, cells efficiently accumulate this metal ion and distribute it within many cell organelles, across their plasma membranes, or as intracellular free zinc (Eide, 2006). In contrast, the outer layers of bark are composed mainly of dead cork cells, where the active organelles are scarce, if not completely absent (Prance et al., 1993).

Zinc concentrations in resin were lower than in the plant tissues. This is expected, since resin (being a secretion product) does not contain active membranes and organelles where zinc is mainly localized. However, among the investigated trees, *P. lentiscus* var. Chia had a zinc concentration in resin higher than that of *P. terebinthus* or *P. halepensis*. This fact is attributed to the different resin secretion mechanisms among the above studied trees. In *P. lentiscus* var. Chia, the epithelial cells of resin ducts decompose, releasing their content into the duct lumen. Thus, in secreted resin (mastic), large masses of disorganized cytoplasm with many zinc-rich vesicles, organelles, or membrane remnants from disintegrated cells can be found (Sawidis et al., 2000).

In contrast, in *P. halepensis* the resin, synthesized in the epithelial cells, is eliminated from their protoplasts in the form of droplets by endoplasmic reticulum (ER) elements without any cell disintegration (Fahn, 1979). On the other hand, in the other species, *P. terebinthus*, of the same genus as *P. lentiscus* var. Chia, no cell disintegration was observed during the secretion process (Sawidis et al., 2009, in press). Thus, the zinc content in the resin duct was lower than in *P. lentiscus* var. Chia and similar to that of *P. halepensis.* Nevertheless, both resins have similar and comparable physicochemical properties (Giner-Larza et al., 2000).

The zinc content in the natural resins together with that in commercial gums is shown in Figure 2. It is obvious that the Chios mastic gum shows a slightly greater zinc content when compared with the other specimens analyzed. Although the content of zinc in Chios mastic is not high, it could be useful in the case of marginal deficiencies. It is well known that zinc is an essential trace element for animals and humans, occurring mainly in meat and seafood. Its average daily intake from food has been estimated to be in the range of 5–22 mg (World Health Organization, 1996). Normal levels of zinc in most crops and pastures are in the range 1.2–73 mg/kg dry weight (Kabata-Pendias & Pendias, 1992). Dietary reference values for zinc vary according to the dietary pattern of the country, assumptions on the bioavailability of dietary zinc, age, sex, and physiological status (World Health Organnization, 2001).

Zinc content in chewing gum could be increased artificially by additive E 650, zinc acetate-dihydrate, which gives a bitter taste to the gum. According to the European Parliament and Council Directive No 95/2/EC (CONSLEG, 1995) on food additives other than colors and sweeteners, it has been considered that zinc should

Table 1. Mean zinc concentrations in resin and tissue samples from *Pistacia lentiscus* var. Chia, *Pistacia terebinthus*, and *Pinus halepensis*.

Tree species	Specimen	Zn (mg kg^{-1})	SD
Pistacia lentiscus var. Chia	Resin	1.419	± 0.14
	Leaves	12.401	± 0.25
	Bark	4.621	± 0.46
Pistacia terebinthus	Resin	0.649	± 0.15
	Leaves	14.14	± 0.28
	Bark	4.714	± 0.47
Pinus halepensis	Resin	0.764	± 0.18
	Leaves	17.281	± 0.35
	Bark	10.791	± 0.22

SD, standard deviation.

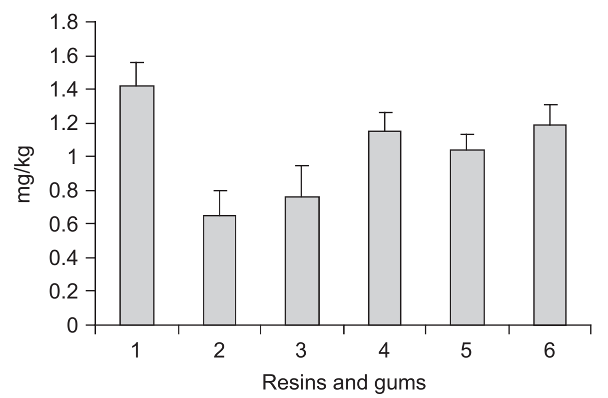

Figure 2. Zinc content in natural resins and commercial gums. 1, *Pistacia lentiscus* var. Chia (resin/gum); 2, *Pistacia terebinthus* (resin); 3, *Pinus halepensis* (resin); 4, Elma (gum base); 5, Orbit (gum); 6, Trident (gum).

be allowed as a flavor enhancer in chewing gum in concentrations of up to 1 mg. This content is equivalent to 0.3 mg zinc/ 1000 mg of chewing gum (which corresponds to 0.30 mg zinc/g), an acceptable level because of the non-toxicity of zinc at the expected exposure level. The above committee's assessment is that zinc is an essential trace element for humans, and the average daily intake of zinc from food is between 5 and 22 mg. Thus, an equivalent value of 0.3 mg of zinc in chewing gum would be an acceptable level.

Low dietary zinc is an important factor in increasing cadmium absorption from various external sources, and retention. In other words, persons deficient in zinc are especially vulnerable to cadmium uptake (Panemangalore, 1993; Brzoska & Moniuszko-Jakoniuk, 2001). In our case, the cadmium content was below 0.01 mg kg^{-1} in all mastic specimens, natural or commercial. The change in zinc content in all specimens used as gums after certain chewing times is shown in Figure 3. It is obvious that, among all gums studied, only the Chios mastic released a small amount in the stomatal cavity and gastrointestinal system.

After 4 h chewing time, about 0.7 mg kg^{-1} or 50% of the total zinc was adsorbed from the organism. In other gum samples the zinc content increased to a large degree (Figure 3), i.e., for Trident ~0.5 mg kg^{-1}, for Elma ~0.9 mg kg^{-1}, and for Orbit ~ 2 mg kg^{-1}. It is obvious that zinc adsorption in the gum base of the above commercial gums, after a certain chewing time, has a salivary origin, since chewing gum is a good mechanical and gustatory stimulant of saliva flow (Lingström & Moynihan, 2003). Salivary secretions contribute significant amounts of zinc to the mouth, as zinc is an important component of saliva (Etzel et al., 1997).

Assembling the total zinc amount after 4 h of chewing Chios mastic gum, we can account for: (i) ~0.7 mg kg^{-1} gained from the natural resin, (ii) an amount ~0.5–2.0 mg kg^{-1} from salivary secretions, which was found adsorbed in commercial gums, and (iii) an unknown amount from salivary secretions, the greatest percentage of which is reported to be associated with the metalloprotein gustin. Zinc deficiency decreases the salivary flow rate and therefore zinc is essential to maintenance of the integrity of the oral cavity environment (Bhagavan, 1992; Thatcher et al., 1998).

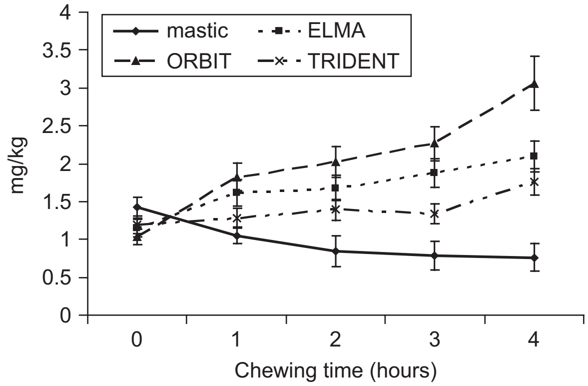

Figure 3. Zinc content in mastic and commercial gums after 1, 2, 3, and 4 h of chewing.

According to Markert (1994), zinc belongs to the essential elements for both plants and animals. It is estimated that 3000 of the hundreds of thousands of proteins in the human body contain zinc. Zinc is involved in more than 300 enzymatic biological processes in the human body (Murray & Pizzorno, 1998; Tapiero & Tew, 2003). Deficiency of zinc causes serious disorders, including oligospermia, growth retardation, and impaired neuropsychological functions, which are generally reversible by supplementation or food rich in this fundamental trace element. Preparations intended to increase zinc intake above that provided by the diet should not contain zinc levels that exceed dietary reference values. Taking more than 100 mg of zinc supplement a day doubles men's chances of developing advanced prostate cancer (Leitzmann et al., 2003).

Zinc is a key mineral in male sexual function, and zinc deficiency in males can lead to reduced sex drive. A primary or secondary deficiency of zinc has been linked with sexual function. Small amounts of zinc act as an aphrodisiac and help in hormonal balance (Tasman-Jones, 1980; Mason, 2000; Pelton et al., 2001). Zinc is the most critical trace mineral for male sexual function: it promotes healthy prostate function and is important for proper maintenance of the male reproductive system. It also supports the synthesis of testosterone and other male hormones (Buck, 1996). Chios mastic not only contains high concentrations of zinc but also enforces the salivary glands to produce more, which is slowly released in the stomatal cavity through the flow of saliva.

The prostate contains a higher concentration of zinc than any other tissue in the body, whereas semen contains the highest concentration of zinc of all body secretions (Costello & Franklin, 1998). Chia et al. (2000) examined the relationship between semen zinc concentration and sperm quality in fertile and infertile men. The geometric mean seminal zinc level was significantly lower in the infertile group compared with the fertile group (183.6 mg L^{-1} vs. 274.6 mg L^{-1}). Xu et al. (1993) showed that the concentrations of elements in seminal plasma were in the following descending order: Zn > Se > Pb > Cd. Interestingly, analogous order was observed in the elemental concentrations of natural Chios mastic, the mean values of which were: Zn 1.4 > Se 0.09 > Pb 0.08 > Cd 0.01 (for selenium and lead: Sawidis & Yurukova, 2009, in press).

Most effective is the use of Chios mastic as an additive in food such as bread, cakes, confectionery, or drinks. This is the reason why the "Sultan" preferred to have the mastic as an additive in his daily bread, contrary to the women of his harem who preferred to chew it (Piacenza, 1668). Analysis of the zinc content in Chios mastic under successive stomach conditions (mastic suspended in acid solution comparable to that of the stomach) showed that all trace elements were released from mastic, and thus available for absorption (Georgarakis et al., 1992).

It is also worth noting that chewing mastic gum, with a unique pleasant flavor, can help people relax and recover from both physical and mental work. Furthermore, the mastic acts as breath freshener and improves the flow of saliva, which is required for the appreciation of taste and in general for improvement of stomatal hygiene (Lingström & Moynihan, 2003). The mastic influence on sexual desire, for which stomatal contact is obligatory, is highly related to endorphin mobilization for psychological euphoria and sentimental reflexion (Bancroft, 1999; Hartmann, 2007).

In conclusion, our observations indicate that Chios mastic could be a natural source of zinc and could be used to provide it to humans in the case of minor deficiency of this trace element. The slow release of the trace element (during the long chewing time) follows the biological rates of intake and metabolism by the human organism. This product has advantages over others commercially available, e.g., pills, because Chios mastic is a natural product with long history of usage. After centuries of extensive use in Mediterranean and Middle Eastern countries, as both a dietary supplement and a herbal remedy, no undesirable side effects have ever been attributed to the mastic.

***Declaration of interest*:** The authors report no conflicts of interest.

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