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Heating effect on nutritional value from two morphotypes (palmate and semi-palmate leaves) of *Hibiscus sabdariffa*

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ABSTRACT

Leafy vegetables play an important role by contributing to most nutrients intake for health and human well-being. Different varieties or morphotypes of *Hibiscus sabdariffa* leaves are cultivated for medicine and food. H. Sabdariffa leaves are cooked before consumption. However, studies on the variation of nutritional value in different varieties or morphotypes and the effect of heating are relatively limited. This research aimed to assess the variation in different morphotypes (palmate and semi-palmate leaves) and the effect of heating on nutritional value of *H. sabdariffa* leaves. To do that, fresh leaves were collected, air dried and divided into raw and cooked. The raw and cooked samples were analyzed to determine the proximate and phytochemical properties (pH, ash, sugars, polyphenols, tannins and proteins) and minerals (Nitrogen). There was variability in nutritional content among the morphotypes. Sugars, proteins and Nitrogen were present at significantly different levels among the morphotypes. The most abundant proteins (3.26 ± 0.08%) and Nitrogen (0.52 ± 0.01%) was found in semi-palmate leaves and sugars (4751.64 ± 992.60 mg/100g) in palmate leaves. The heating effect on these compounds was not significant. However, the heating decreased ash, sugars, polyphenols and tannins from 2 to 46% and increased pH, N and proteins from 2 to 10%. *H. sabdariffa* leaves were an important source of nutritional value that could contribute to improve health and well-being.

1. Introduction

Leafy vegetables leaves play an important role in human well-being. In many parts of the world, leaves are consumed as green vegetables (Mahadevan and Kamboj, 2009). Among the leafy vegetables, there is Hibiscus sabdariffa leaves which are used as food (Sáyago-Ayerdi et al., 2007; Ochani and D'Mello, 2009). *Hibiscus sadariffa* is known as "Bissap" in Senegal. *H. sabdariffa* leaves are used as a vegetable in soup and salad mainly in Africa, but are disregarded as a food source in many countries (Falusi et al., 2014; Wang et al., 2016). The young leaves and tender stem of *H. Sabdariffa* are eaten raw in salads and chutney (Mohd-Esa et al., 2010). The leaves are rich in phytochemical content and flavonoids (Kwon et al., 2018; Ryu et al., 2019; Zhen et al., 2016) and have a variety of biological activities (Chen et al., 2013; Guardiola and Mach, 2014).

Hibiscus sabdariffa is cultivated widely in Africa, Asia and America for leaf, seed, fleshy calyx or fiber (Babatunde, 2003). Many varieties of H. Sabdariffa are widely cultivated in Africa, Asia, and America (Patel, 2014). *H. Sabdariffa* leaves from different varieties and morphotypes could have different chemical constituents, which may result in the improper food usage (food processing and preservation). Researches about *H. Sabdariffa* L. leaves do not specify the variety and the morphotype, making it difficult to make comparisons between the chemical profile and bioactivities of extracts obtained in different studies (Borrás-Linares et al., 2015). A strategy for clarifying the chemical variations of different varieties and morphotypes of *H. Sabdariffa* L. Consist of the qualitative and quantitative analysis of bioactive components (Jin et al., 2008) and chemical fingerprint (Kong et al., 2009).

However, information is lacking regarding nutritional content and effect of heating on the phytochemical and proximate characteristics in different local morphotypes of *H. Sabdariffa* leaves. This research aimed to assess the variation in different morphotypes (palmate and semi-palmate leaves) and the effect of heating on nutritional value of *H. sabdariffa* leaves.

2. Material and methods

❖ Vegetal material collection

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The Fresh leaves of *H. sabdariffa* were collected from Saint Maure market of Ziguinchor Province (Fig. 1). Within the species, two morphotypes (palmate and semi-palmate leaves) were considered (Fig. 2). Four samples of fresh leaves of each morphotype of *H. sabdariffa* were collected.

❖ Plant extract preparation

The samples were cleaned properly to remove all the waste particles and were air dried. The dried product was divided into two groups (raw and cooked). The dried leaves of *H. sabdariffa* were boiled once during 15 min (Fig. 3).The well cleaned and dried mortar and pestle were used to prepare the powder of the above dried specimen. The powder was sieved in 22 mm pore size sieve to get fine powder, which was stored in amber glass container and kept in dark

❖ Proximate and phytochemicals analysis

The different parts of leaf samples were analyzed at Laboratoire d'analyse et essai of Ecole Supérieure Polytechnique UCAD de Dakar. Proximate (pH, ash, sugars, proteins and Nitrogen) and phytochemical properties (Polyphenols and Tannins) were determined.

✓ Proximate

To determine pH, shredded leaves were mixed are with distilled water and the homogenized solution is measured directly with a pH meter. Samples were dried at 105 °C in an isothermal oven during 24h and the humidity was determined. To determine the ash, the samples were incinerated at 525 ± 25 °C for 4 h using a muffle furnace. Total sugars were evaluated by acid hydrolysis (HCl) in accordance with the LuffSchoorl method (Marrubini et al., 2017). Proteins and Nitrogen were determined using fluorimetry method. Nitrogen and proteins content is determined by the Kjeldahl method (Sáez-Plaza et al., 2013). The acidity is the content of organic and mineral acids determined by titration according to the volumetric method with Dichlorophenol Indophenol (DCPIP).

✓ Phytochemicals

Analytical methods were used to separate, identify and quantify phytochemical components. Polyphenols and Tannins were analyzed by a separation technique using Spectrophotometric method. The method consists in oxidizing the oxidizable groups of phenols in basic medium by the method of Folin-Ciocalteu developed by Georgé et al. (2005). Tannins were determined by the colorimetric method of Folin Denis, described by Joslyn (1970).

❖ Statistical analysis

Data collected were subjected to two-way analysis of variance (ANOVA)performed with R 4.1.3 (Team, 2015). When effects were significant, Tukey's test wasused for multiple mean comparisons to detect the significant differences between the morphotypes (palmate and semi-palmate) and status (Raw and Cooked). Statistical significance was fixed at 0.05. Considering the two status, all data are hence expressed as overall means ± SE.

3. Results

There were significant differences in sugars, Nitrogen and proteins content between morphotypes. Palmate leaves had higher sugars content (4751.64 ± 992.60 mg/100g) than semi-palmate (2251.97 ± 354.17 mg/100g). The highest Nitrogen (0.52 ± 0.01%) and proteins (3.26 ± 0.08%) was observed in semi-palmate leaves. The pH and ash values did not vary significantly. The pH varied between 3.23 ± 0.19

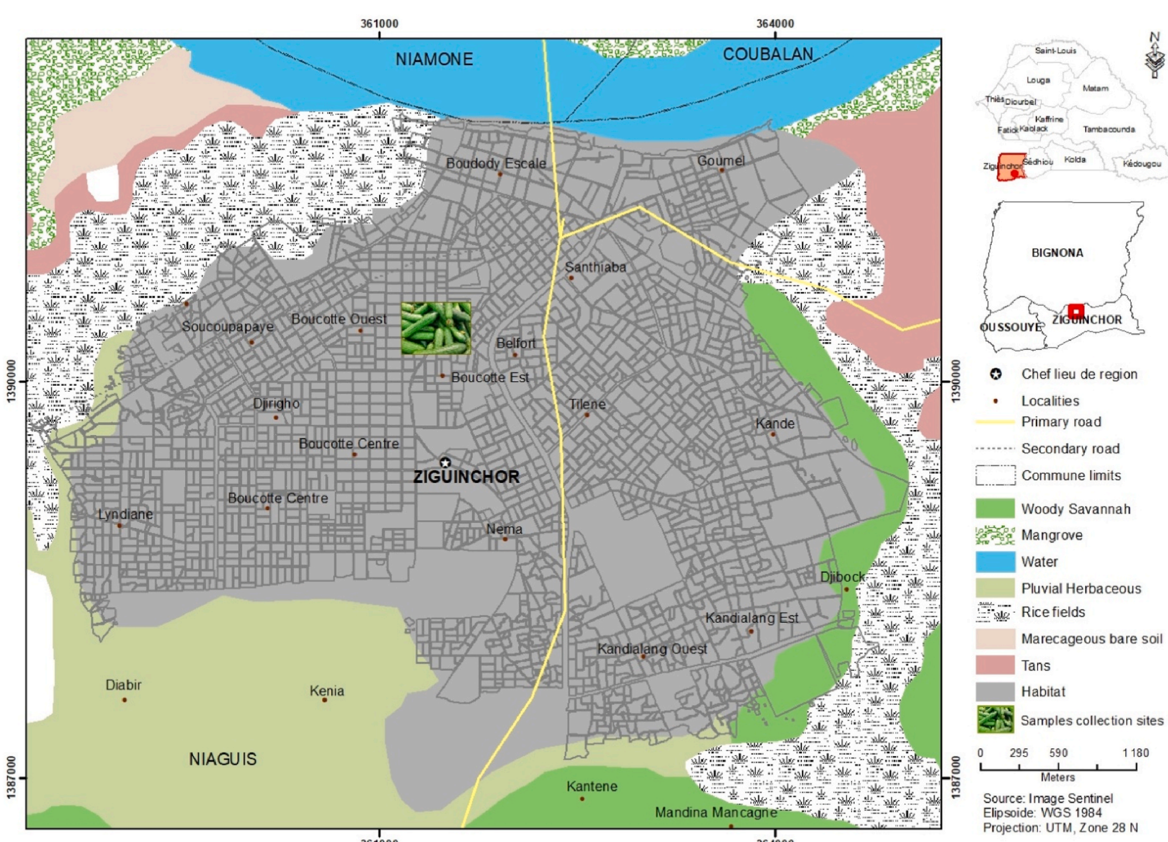

Fig. 1. Localization of collected samples.

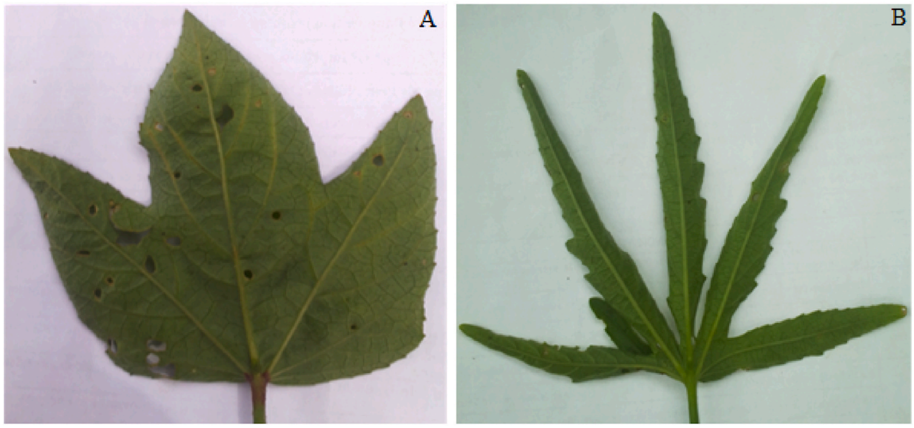

Fig. 2. Fresh leaves of *H. sabdariffa*; semi-palmate (A) and palmate (B).

Fig. 3. Dried leaves of *H. sabdariffa* (A) and boiling process (B).

and 3.47 ± 0.23 and ash between 11.37 ± 0.74 and 12.99 ± 0.94 g/100g.

Heating effect was not significant ($p > 0.05$) for the proximate content. However, the heating decreased ash and sugars from 4 to 46% and increased pH, N and proteins from 2 to 6% (Fig. 4). Sugars were reduced mostly by heating from 18 to 46%. Sugars content varied from 1574.40 ± 366.74 to 5237.54 ± 1869.29 mg/100g and the highest values were recorded in raw extracts of *H. sabdariffa* leaves.

There were no significant differences in polyphenol and tannin content between the two morphotypes. Polyphenols and tannins were recorded with important values varying from 175.111 ± 4.94 to 301.24 ± 17.55 mg/100g depending on the morphotypes. Palmate leaves recorded slightly higher polyphenols (301.24 ± 17.55 mg/100g) and tannins (180.09 ± 1.58 mg/100g) compared to semi-palmate (264.44 ± 23.97 and 175.11 ± 4.94 mg/100g). Phytochemical content did not vary significantly with different status. Raw *H. Sabdariffa* leaves had higher polyphenols (309.22 ± 14.04 mg/100g) and tannins (182.81 ± 3.51 mg/100g) than cooked *H. Sabdariffa* leaves (257.07 ± 17.84 and 172.39 ± 2.92 mg/100g respectively). Heating reduced polyphenols from 16 to 18% and tannins from 2 to 9% (Fig. 5).

4. Discussion

- Proximate and phytochemical content in *H. Sabdariffa* leaves

The analyses of *H. Sabdariffa* leaves revealed the presence of proximate (sugars, ash, Nitrogen and proteins) and phytochemicals (polyphenols and tannins). *H. Sabdariffa* leaves were good sources of proteins, sugars, ash and Nitrogen. *H. sabdariffa* leaves were rich in ash (6.5 ± 3%), protein (17.3 ± 2%) and total phenol (57.8 ± 16.9 mg/g) (Min et al., 2011). Other results revealed that phytochemicals were present quantitatively in high percentages with Tannins (17.0%) and phenols (1.1–23%) in *H. Sabdariffa* leaves (Nkumah, 2015; Mungole and Chaturvedi, 2011; Adegunloye et al., 1996). Some phytochemicals (polyphenols, tannins, flavonoids and ascorbic acid) have been reported in the leaves of H. Sabdariffa (Rodríguez-Medina et al., 2009; Wang et al., 2014).

The results showed that the nutritional content varied among different morphotypes of *H. Sabdariffa*. Mataa et al. (2020) demonstrated the variability in nutritional, anti-nutrient and vitamin C contents among local roselle genotypes. The nutritional content of *H. Sabdariffa* leaves varied from 10.5 to 54.9% according to accessions (Rodríguez-Medina et al., 2009). The phenol compounds varying between 18.75 and 46.51 mg/g were present at significantly different levels among the accessions (Lyu et al., 2020). Previous studies concluded that variations in phenol compound content depend on the origin, harvest time, and cultivation conditions (Wang et al., 2016; Ryu et al., 2016).

- Heating effect on nutritional values of *H. Sabdariffa* leaves

Heating affected the proximate and phytochemical content of *H. Sabdariffa* leaves by but decreasing ash, protein, sugar, Nitrogen, polyphenol and tannin content. No significant changes were found in protein and ash content after artificial drying (Gausman et al., 1952). Heat processing decreased ash, crude protein, crude fat and ascorbic acid content of all the edible leafy vegetables investigated (Onyeike et al., 2003). Microwave heating caused severe quality, nutritional and

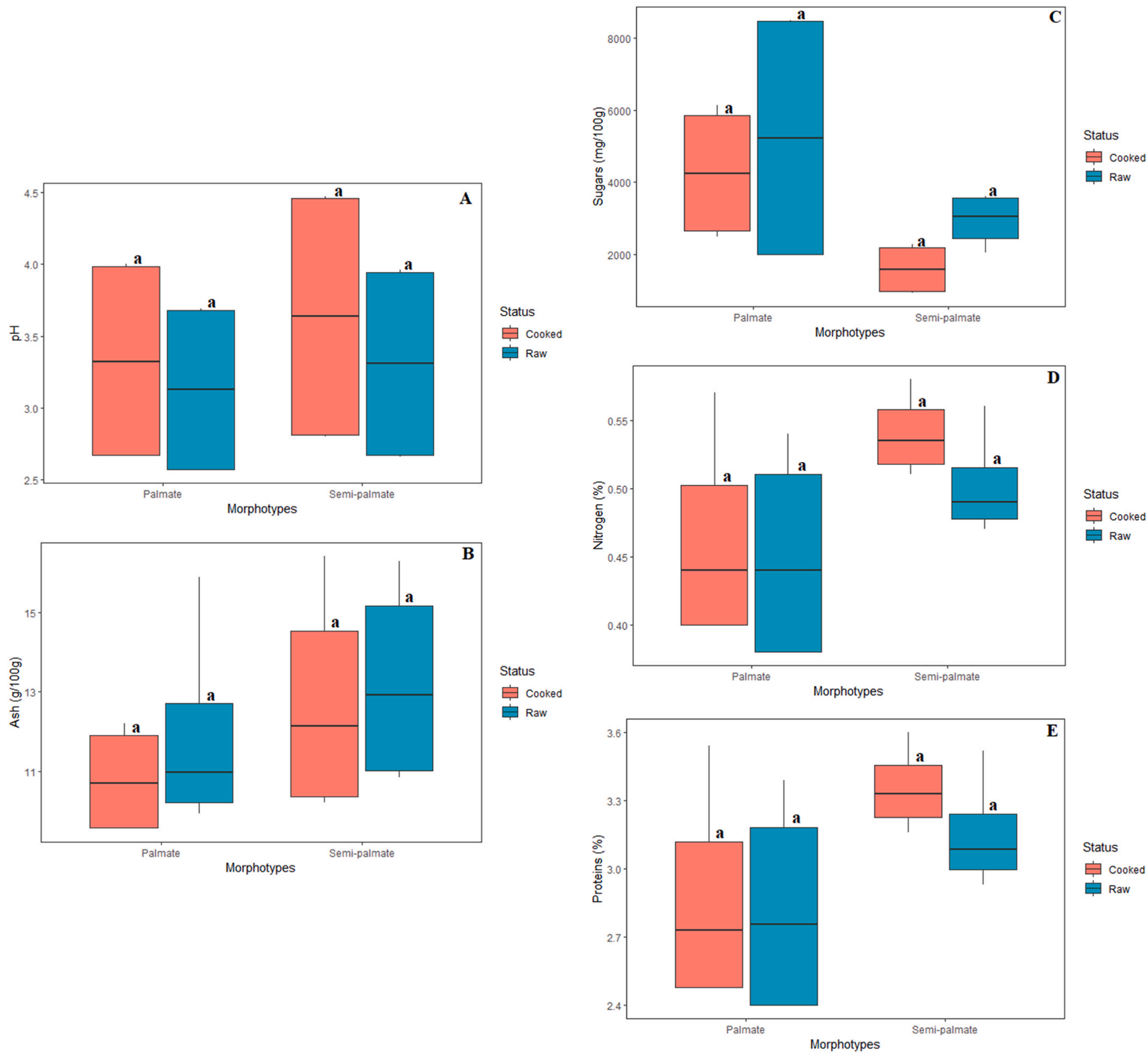

Fig. 4. Proximate content variation according to morphotypes and status; pH (A), ash (B), sugars (C), Nitrogen (D) and proteins (E).

compositional losses, mainly beyond 3 min of heating, with marked increase in peroxide value of olive leaves (Malheiro et al., 2013). The reduction on content of total polyphenols and tannins caused microwave cooking velvet bean is significant (87.5 and 69.9%) respectively (Gurumoorthi et al., 2013). Cooking vegetables affects the nutritional value and the effects depend on many conditions, such as the amount of heat, cooking pressure, moisture used, time of cooking and other factors will affect the end product (Seerley, 1966). Heating of oil also decreased the total polyphenols content in the oils, thereby decreasing their anti-oxidant nutritive values (Avni et al., 2016).

5. Conclusion

H. sabdariffa leaves were a good source of ash, sugars, protein, polyphenol and tannin. The nutritional values of H. Sabdariffa leaves depended on the morphotypes. Among the morphotypes, semi-palmate leaves had the highest Nitrogen, protein and ash content. While, palmate leaves recorded the highest sugar, polyphenol and tannin values. *H. sabdariffa* leaves were consumed as cooked. The heating during the cooking process reduced ash, sugar, polyphenol and tannin content and increased the pH, protein and Nitrogen values. In addition to their traditional usage in food, the leaves of *H. sabdariffa* may be considered as a potential source of nutrients for the population diets.

Author statement

The potential of leafy vegetables to increase and sustain food security in developing countries is increasingly recognized by the international research community. In many parts of the world, vegetables are being reduced in number and extension, implicating that contributions of these resources to nutrition are declining. However, studies assessing how heating affects the nutritional values of leafy vegetables are few, especially in the Sahel and Sudan zone. Consequently, the nutritional contribution of wild leafy vegetables to people's diets remains largely unknown.

The aim of this paper is to increase knowledge on the effect of

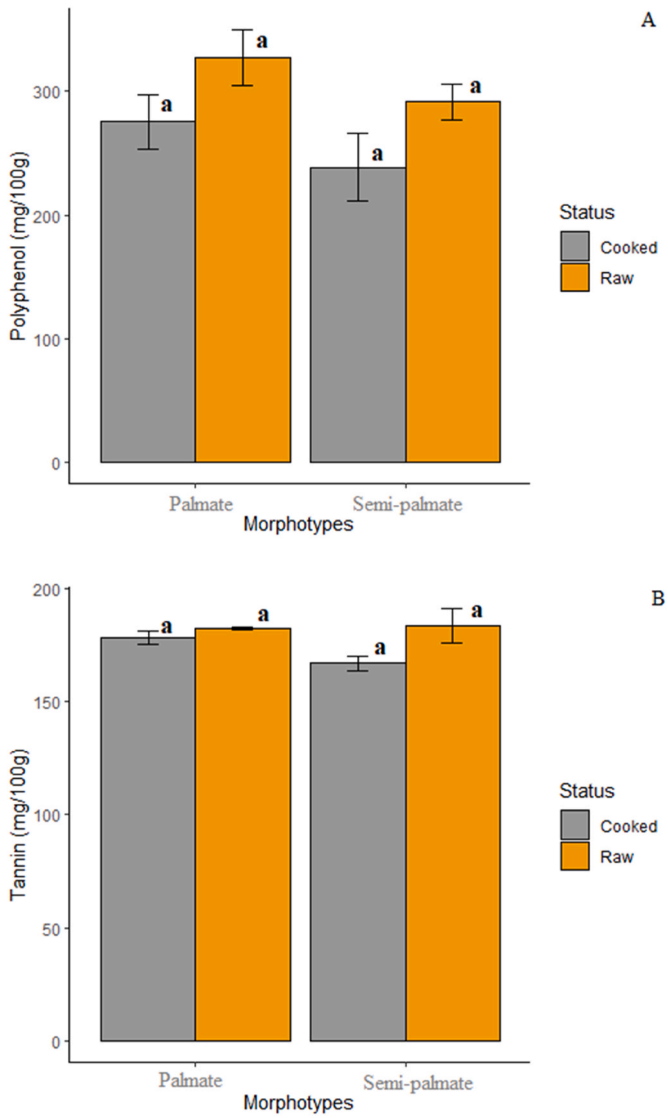

Fig. 5. Polyphenol (A) and tannin (B) content of *H. Sabdariffa* leaves according to morphotypes and status.

heating on nutritional values of *Hibiscus sabdariffa* leaves. The overall hypothesis of the research is that *H. sabdariffa* leaves play an important role for the nutrition of rural communities but the cooking process will reduce their nutritional value.

This study demonstrates that although heating reduce the nutritional content of *H. sabdariffa* leaves but they were an important source of nutritional value that could contribute to improve health and well-being.

Declaration of competing interest

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Data availability

No data was used for the research described in the article.

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