



(RESEARCH ARTICLE)



THE CONCEPT OF FUNCTIONAL CHOCOLATE PRODUCT INNOVATION COMBINING CARTHAMUS TINCTORIUS LINN FOR COCOA PROCESSING SMES: A SYSTEMATIC LITERATURE REVIEW BASED ON PRISMA 2020

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ABSTRACT

Cocoa-processing SMEs need product differentiation, while the functional-food trend opens opportunities for herbal ingredients. *Carthamus tinctorius* Linn (safflower) is rich in phenolics and flavonoids but has not been explored in chocolate. This study formulates a functional chocolate product-innovation concept combining safflower for cocoa SMEs through a PRISMA 2020 systematic review. Six databases yielded 1,745 records; 29 studies were synthesised thematically and complemented by a semi-structured interview with one cocoa SME owner in Makassar. No study examined safflower–chocolate combinations directly, so conclusions rest on analogical inference. Plant-based enrichment consistently raised antioxidant activity in chocolate but altered viscosity, colour and moisture; safflower showed a biphasic effect, and hot-water extracts performed better on several functional endpoints. The proposed concept is a premium botanical functional chocolate with a local narrative, developed in stages (petal powder, dried aqueous extract, encapsulation) with claims limited to antioxidant content.

Keywords: Chocolate; *Carthamus tinctorius*; Safflower; Innovation; cocoa SMEs; PRISMA 2020

1 INTRODUCTION

Indonesia is one of the world's largest cocoa producers, but most commodities are still marketed as raw materials so domestic added value is relatively low. Cocoa processing SMEs play a strategic role in downstreaming, but face limitations in capital, technology, laboratory access, and research and development (R&D) capacity. As a result, products tend to be uniform and compete on price, while branded imported products have more established marketing networks (Purba et al., 2018).

On the demand side, consumer preferences are shifting toward functional foods, natural ingredients, and clean-label products. Chocolate is an attractive matrix because it naturally contains flavanols and phenolic compounds and has been linked to a reduced risk of cardiovascular disease (Singh et al., 2022). Several studies have enriched chocolate with plant extracts to enhance its functional value (Okstaviyani et al., 2024; Tuigunov et al., 2025).

Carthamus tinctorius Linn (safflower; known in Sulawesi as kasumba turate) has long been used as a traditional medicine, natural dye, and source of vegetable oil. Its flowers contain chalcone-quinoid flavonoids such as hydroxysafflor yellow A (HSYA) and the pigment karthamin (Adamska & Biernacka, 2021). However, a recent bibliometric review noted that the bioactives of oil-producing plants remain underexplored in functional chocolate research (Asmediana et al., 2026).

Relevant evidence is scattered across sparsely connected fields: cocoa technology, safflower phytochemistry, sensory and consumer science, and SME innovation. Without synthesis, product development by SMEs risks being a trial-and-error process that is difficult to justify scientifically and regulatoryly. This study aims to (1) identify and synthesize evidence on ingredient potential, formulation and processing approaches, consumer acceptance, and feasibility of application to SMEs; and (2) formulate a concept for safflower-combined chocolate product innovation and its research gaps as a basis for further experimental research.

2 MATERIAL AND METHODS

2.1 Research Design

This study employed a qualitative approach with a Systematic Literature Review (SLR) reported according to PRISMA 2020 (Page et al., 2021) and the principles of Kitchenham and Charters (2007). Semi-structured interviews served as supporting data to triangulate practitioner perspectives. The study did not include laboratory tests, experimental formulations, or consumer surveys.

2.2 Search Strategy

The search was conducted in Scopus, Web of Science, ProQuest, Taylor & Francis, EBSCO, PubMed, and Google Scholar. Keywords were composed of five concepts using Boolean operators: ("chocolate" or "cocoa product") and ("functional food" or "functional chocolate") and ("*Carthamus tinctorius*" or "safflower") and ("product innovation" or "new product development") and ("SMEs" or "small and medium enterprises"). Search limitations: peer-reviewed journal articles in English or Indonesian, with full text available, from 2015–2026.

2.3 Inclusion and exclusion criteria

Inclusion criteria: (a) peer-reviewed journal articles; (b) discussing chocolate, cocoa, functional foods, or herbal-based foods; (c) discussing product innovation, new product development, diversification, or added value; and (d) having empirical data or a clear conceptual framework. Exclusion criteria: non-scientific publications (blogs, opinion pieces, editorials, news), full text unavailable, duplicates, and irrelevant to the topic.

2.4 Selection, Quality Assessment, and Data Extraction

The selection process followed the stages of identification, screening (title and abstract), eligibility (full text), and inclusion. Article quality was assessed based on clarity of objectives, appropriateness of methods, data validity, journal reputation, and topic relevance. Data were extracted into a form containing the author(s) and year, country, objectives, methods, product type, functional ingredients, results, and implications for product innovation.

2.5 Thematic Synthesis

Data were analyzed using thematic synthesis (Thomas & Harden, 2008) through three stages: open coding, axial coding, and theme development. Themes were then integrated into a conceptual framework: functional chocolate trends, safflower potential, SME innovation needs, and product added value.

2.6 Supporting Interviews

Semi-structured interviews were conducted with an informant, a cocoa processing industry owner and operator in Makassar. Topics included views on safflower as a herbal ingredient, potential combinations with chocolate, ingredient availability, and opportunities for product positioning. Informants were selected purposively based on their understanding of the chocolate-making process and safflower farming. Their responses were summarized thematically and compared with the SLR results.

3 RESULTS

3.1 Results of literature selection

The search yielded 1,745 records (Scopus 879; Web of Science 317; ProQuest 198; Taylor & Francis 127; EBSCO 110; PubMed 99, and Google Scholar 15). After title and abstract screening, 159 studies were evaluated in more detail, 65 studies were reviewed at the full text stage, and 36 were excluded due to duplication, year of publication, or insufficient data, resulting in 29 studies being included in the synthesis (Scopus 21; Web of Science 3; PubMed; ProQuest, Taylor & Francis, EBSCO, and Google Scholar 1 each) as shown in Figure 1.

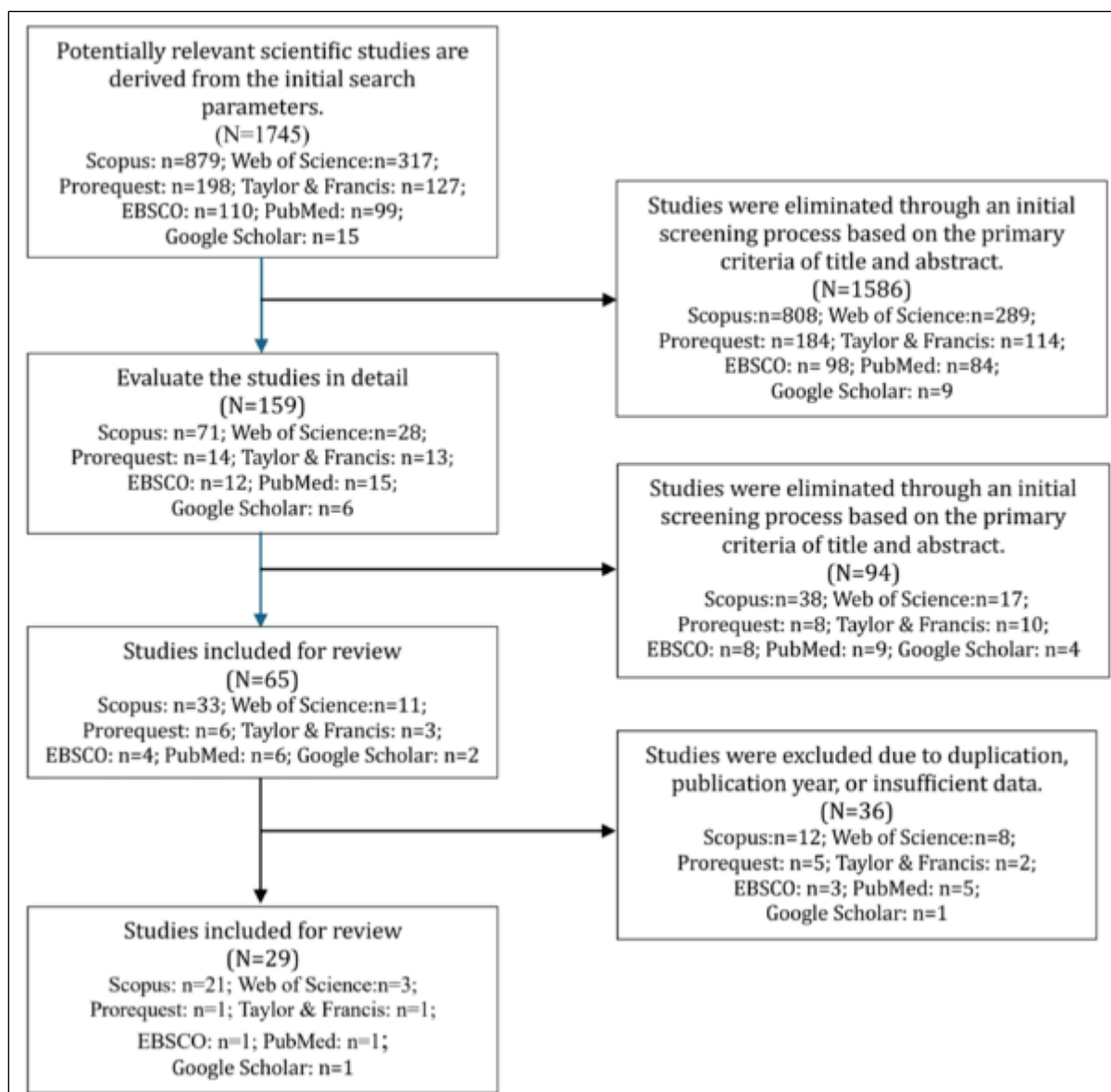


Figure 1: PRISMA Systematic Flowchart

3.2 Study Characteristics

Of the 29 studies, 25 (86.2%) were published between 2020 and 2026, indicating increasing attention to this topic. Based on focus, 11 studies addressed safflower, 7 product enrichment or formulation with plant-based ingredients, 5 cocoa and chocolate science, and 6 consumer acceptance or SME innovation (Table 1). Based on design, approximately 15 studies were experimental, 11 were study reviews, and 3 were surveys or SME studies (author classification based on study summaries).

Table 1: Distribution of 29 selected studies by focus

Focus	Number	Studies
Potential ingredients (safflower) Consumers, innovation, and SMEs	11	Salem et al. (2011); Peng et al. (2017); Clemente et al. (2026); Cafaro et al. (2025); Li et al. (2023); Teklu et al. (2026); Bacchetti et al. (2020); Emongor & Emongor (2023); Hadjadj et al. (2023); Hong et al. (2021); Adamska & Biernacka (2021)
Formulation and enrichment with plant-based ingredients	7	Langkong et al. (2020); El Ghouizi et al. (2023); Baycar et al. (2022); Asmediana et al. (2026); Indiarito et al. (2023); Okstaviyani et al. (2024); Gramza-Michałowska et al. (2021)
Cocoa and chocolate science	5	Savitri et al. (2022); Perez et al. (2022); Di Mattia et al. (2017); Toker et al. (2020); (Tuigunov, et al., 2025).
Consumers, innovation, and SMEs	6	Purba et al. (2018); Guiné et al. (2021); Albertsen et al. (2020); Ali et al. (2021); Naradda Gamage et al. (2020); Retnaningsih et al. (2024)

3.3 Sintesis tematik

Tabel 2: Themes, key findings, and implications for product concepts

Theme	Main findings	Implications
1. Bioactivity and variability of safflower	High levels of polyphenols, flavonoids, HSYA, and karthamin (Salem et al., 2011; Hadjadj et al., 2023; Adamska & Biernacka, 2021). Content is influenced by genotype, flower color, planting time, and density (Li et al., 2023; Cafaro et al., 2025; Clemente et al., 2026). Biphasic effects: antioxidant at low doses, pro-oxidant at high doses (Bacchetti et al., 2020). Hot water extracts are superior to ethanol at several endpoints (Hong et al., 2021).	Ingredients need to be standardized; dosages must be within the safety window; water extracts are relevant for SMEs
2. Enriching chocolate with plant-based ingredients	Phenolic and antioxidant contents increase (Okstaviyani et al., 2024; Indiarito et al., 2023; Gramza-Michałowska et al., 2021), accompanied by increases in hardness, viscosity, water content, and color changes (Baycar et al., 2022; Okstaviyani et al., 2024). The optimal point is around 5% in analogous studies (Langkong et al., 2020; Indiarito et al., 2023). Encapsulation masks the herbal flavor (El Ghouizi et al., 2023). The processing stage determines the final antioxidant content (Di Mattia et al., 2017).	There is a functional–sensory trade-off; the point of attachment and the shape of the material are design variables.
3. Consumer acceptance	Relative advantage, naturalness, and novelty increase perceived value; unfamiliarity increases risk (Albertsen et al., 2020). Innovation needs to maintain the identity of traditional foods (Guiné et al., 2021); sensory factors determine chocolate acceptance (Savitri et al., 2022).	Communication of naturalness and local narrative; need for direct sensory testing.
4. Innovation capabilities of SMEs	R&D and chocolate content are priorities for the competitiveness of chocolate SMEs (Purba et al., 2018). Product innovation is more prominent in large companies; collaboration supports SMEs (Ali et al., 2021). Local food SMEs are able to modify their products (Retnaningsih et al., 2024); survival strategies include diversification (Naradda Gamage et al., 2020).	Phased and partnership-based development; costs and supply have not been studied in the literature.

None of the 29 studies examined the combination of safflower and chocolate directly. This indicates that the topic is in its early stages of development and underscores the novelty of the proposed concept. Scientific support for the concept rests not on a single study, but rather on the convergence of four complementary and transferable lines of evidence to the context of safflower-combined chocolate. The first line is the bioactivity of safflower, consistently reported across 11 studies, particularly the antioxidant activity of phenolics, flavonoids, HSYAs, and karthamin. The second line is the enrichment of chocolate and related products with phenolic-rich plant ingredients, which has repeatedly demonstrated enhanced functional value in experimental studies. The third line is the consumer acceptance framework for natural food innovations, which explains the conditions that drive the acceptance of new products. The fourth line is the innovation capabilities of food SMEs, which suggests a realistic product development pathway. These four lines point in

the same direction, allowing the chocolate–safflower concept to be formulated as a well-founded working hypothesis worthy of experimental testing.

3.4 Supporting Interview Results

Informants from Makalate Chocolate industry SMEs in Makassar conveyed three points: (1) safflower is known as a medicinal ingredient with potential for combination with processed chocolate products; (2) the plant is easily found; and (3) this combination has the potential to enhance chocolate's position as a food that functions like medicine, as shown in Table 3.

Table 3: Summary of Interview Results and Interpretation

Topic	Summary of informant's answers	Interpretation of SLR
Safflower-chocolate combination	Potential to be combined with processed chocolate products	Converging with the pattern of chocolate enrichment with plant-based ingredients (Okstaviyani et al., 2024; Indiarito et al., 2023); still perceptual, technically untested
Ingredients availability	Plants are readily available	Supports initial feasibility (Emongor & Emongor, 2023), but quality varies (Li et al., 2023; Cafaro et al., 2025); needs verification of source, form, price, and continuity
Product positioning	Potential to enhance chocolate's position as a food with medicinal properties	Chocolate has the potential to be developed into a functional food with health benefits, through enrichment with bioactive components such as polyphenols, fiber, probiotics, prebiotics, and plant extracts (Tuigunov, et al., 2025).

4 DISCUSSION

4.1 Justification for the potential of the safflower-chocolate combination

The justification rests on four mutually reinforcing analogous arguments. First, the pathway for enriching chocolate with phenolic-rich plant materials has been shown to enhance functional value (Okstaviyani et al., 2024; Indiarito et al., 2023; Gramza-Michałowska et al., 2021), and safflower has a phenolic and flavonoid profile that could potentially follow a similar pathway (Hadjadj et al., 2023; Bacchetti et al., 2020). Second, safflower pigments are relevant to the trend of natural colorants in chocolate, as demonstrated by red beetroot powder (Baycar et al., 2022). Third, safflower already has precedent for application in other food matrices (yogurt; Hong et al., 2021). Fourth, bioactives from oil-producing plants remain underexplored in functional chocolate (Asmediana et al., 2026), underscoring the novelty of the topic. The views of SME informants align with this argument from a practitioner's perspective. However, this conclusion remains inferential: there is no direct evidence regarding the stability of bioactives, physicochemical effects, or sensory acceptability of safflower chocolate.

Two important cautionary notes are warranted. First, the claim that enrichment does not compromise sensory performance is not fully supported: analogous studies have shown changes in viscosity, hardness, color, and aroma preferences (Baycar et al., 2022; Okstaviyani et al., 2024; Langkong et al., 2020), so the appropriate trade-off must be optimized. Second, most evidence for safflower bioactivity comes from in vitro and pharmacological studies; clinical trials are still needed (Bai et al., 2025).

4.2 Product innovation concept

Based on a synthesis of four themes, the proposed concept is a premium functional botanical chocolate based on local resources. Each element of this formulation is based on the findings of the review. The botanical element refers to the use of cassava calyx as a source of phenolics, flavonoids, HSYA, and natural pigments (Salem et al., 2011; Hadjadj et al., 2023; Adamska & Biernacka, 2021). The functional element refers to the measured antioxidant value of the final product, as is the case with chocolate enrichment with other plant-based ingredients (Okstaviyani et al., 2024; Indiarito et al., 2023), with claims limited to content. The premium element is a differentiation strategy: SMEs whose limited R&D and scale make it difficult to compete on price (Purba et al., 2018; Ali et al., 2021) can rely on added value, standardized quality, and product diversification (Naradda Gamage et al., 2020; Retnaningsih et al., 2024). The local resource-based element refers to the use of Sulawesi cocoa and kasumba, a plant known in Sulawesi as kasumba turate (Hansur et al., 2024).

Utilizing local resources offers three scientifically justified benefits. First, clear provenance supports product provenance, which aligns with findings that food innovation needs to maintain the identity and value of traditional foods (Guiné et al., 2021). Second, the use of natural ingredients from plants already known to the community can reduce the risk of unfamiliarity, which, according to Albertsen et al. (2020), is a barrier to the acceptance of food innovation. Third, sourcing supplies from areas close to SMEs has the potential to shorten supply chains and facilitate partnerships with farmers (Ali et al., 2021; Emongor & Emongor, 2023). These three benefits are still implications from the literature and have not been tested on chocolate-safflower products. The availability of ingredients stated by informants must also be verified first regarding source, form, price, and continuity of supply. The conceptual components are shown in Table 4.

Table 4: Components of the product innovation concept

Components	Recommendation	Basic and status
Material form	Phase 1: dried calyx powder; Phase 2: dried hot water extract; Phase 3: encapsulation/liposome (optional). Oil/seed pulp outside the initial scope	Hong et al. (2021); El Ghouizi et al. (2023); Indiarito et al. (2023). Stepwise sequence: hypothesis
Chocolate base	Two variants: dark chocolate (functional position) and white chocolate/compound (revealing natural color)	Baycar et al. (2022); Okstaviyani et al. (2024). Final choice through experimentation
Addition point	Final stage of processing (after conching, before tempering). Range: 1–5% w/w with measurable bioactive content	Di Mattia et al. (2017). Hypothesis
Initial dose	Range: 1–5% w/w with measurable bioactive content	Langkong et al. (2020); Indiarito et al. (2023); Bacchetti et al. (2020). Working hypothesis
Test parameters	Moisture content, viscosity, particle size, color (CIELab), hardness and melting point, bloom, total phenolics/flavonoids, DPPH/ABTS, HSYA content, hedonic test, shelf stability	Based on analog study parameters
Positioning	Premium functional botanical chocolate: natural ingredients, “contains natural antioxidants from kasumba petals”, the identity of Sulawesi cocoa– <i>Carthamus tinctorius</i> (safflower).	Albertsen et al. (2020); Guiné et al. (2021); content claims, not disease claims

4.3 Research Gaps

The most fundamental gap is the lack of chocolate-safflower formulation studies, so all conceptual formulations in this study still need to be tested experimentally. An appropriate design is a factorial design or response surface methodology (RSM), which simultaneously tests the material form (powdered petals or dried aqueous extract), concentration, and point of addition to the process, with responses being antioxidant activity, physical properties, and sensory acceptability. This approach allows the authors to identify optimum conditions and interactions between factors with an efficient number of trials, which is important for SMEs with limited materials and equipment. The next gap is the optimal dosage. The biphasic effect of safflower, namely antioxidant at low concentrations and pro-oxidant at high concentrations (Bacchetti et al., 2020), has never been tested in a chocolate matrix, while dosages in analogous studies only provide a preliminary range (Langkong et al., 2020; Indiarito et al., 2023; Okstaviyani et al., 2024). Therefore, a dose-response curve with bioactive compound measurements (e.g., HSYA) is necessary to ensure the selected dose falls within the window of benefit.

The second gap concerns compound behavior and product physical properties. The stability of HSYA and karthamin to heat, pH, and fat matrices has not been reported in the 32 selected studies, even though chocolate undergoes thermal processing and is a fatty matrix with a low moisture content, and processing stages have been shown to influence the final antioxidant content (Di Mattia et al., 2017). The differences in the solubility of safflower bioactive compounds compared to cocoa butter also raise questions about their dispersion and stability, which need to be addressed through process and storage stability testing. On the physicochemical side, analogous studies indicate that the addition of plant-based ingredients changes the viscosity, hardness, and moisture content of chocolate (Baycar et al., 2022; Okstaviyani et al., 2024). Their impact on tempering and bloom risk in safflower chocolate is unknown and can be assessed through rheological testing, particle size analysis, melting point analysis, and observation during storage.

The third gap relates to market and application aspects. A food innovation acceptance framework exists (Albertsen et al., 2020; Guiné et al., 2021), but consumer acceptance and willingness to purchase for safflower chocolate have not

been tested, so hedonic and willingness-to-purchase tests in relevant consumer segments are needed. Finally, economic feasibility, continuity and quality of ingredient supply (Li et al., 2023; Cafaro et al., 2025), consumption safety, including the reported anticoagulant effect and regulatory status have not been examined in the selected literature. In terms of sequencing, formulation and stability gaps should be prioritized as prerequisites for consumer testing, while regulatory, supply, and cost assessments should be conducted early to avoid stalling development late in the process.

4.4 Limitations

Research limitations include: the lack of direct chocolate-safflower studies; the heterogeneity and limited number of studies (32); the quality assessment of articles whose results have not yet been presented; the absence of laboratory, sensory, and consumer tests; and the interview data, which came from a single informant, therefore, cannot be generalized.

5 CONCLUSION

The synthesis of 29 studies based on PRISMA 2020 indicates that the concept of chocolate product innovation combined with *Carthamus tinctorius* Linn is conceptually feasible and needs to be experimentally tested as a functional food for cocoa processing SMEs. Although no studies have directly tested this combination, indirect evidence suggests that safflower has antioxidant activity, phenolic-rich plant ingredients can enhance the functional value of chocolate, consumer acceptance is influenced by superiority, naturalness, novelty, and familiarity, and SME innovation capabilities are strongly influenced by R&D and collaboration.

The formulated concept is a premium functional botanical chocolate based on local resources, namely Sulawesi cocoa and *Carthamus tinctorius*, with gradual development through dried calyx powder, dried water extract, and encapsulation. Formulations can be developed based on dark or white chocolate/compounds, with claims limited to natural antioxidant content and no medicinal claims. Implementation needs to be carried out in stages through regulatory verification, ingredient specifications, and partnerships with universities and farmers.

This research has produced an initial conceptual framework and a research gap map as a basis for product development. The concept remains a working hypothesis based on indirect evidence, and therefore needs to be validated through research on formulation, dose-response, active compound stability, physicochemical properties, consumer acceptance, economic feasibility, safety, material supply, and regulations to determine its suitability as a product that can be produced and marketed by cocoa SMEs.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors of this manuscript declare no conflict of interest.

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