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Research Article

Potential Health Risks for Consumers and Handlers of Poultry Products Fed with Poor Quality Feeds

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Abstract

In Burkina Faso, livestock farming contributes to the supply of animal protein and the improvement of household incomes. However, the poor quality of poultry feed not only leads to economic losses but also risks of microbial transmission to consumers. Therefore, the objective of this study was to assess potential health risks to consumers and handlers of poultry products according to the physicochemical and microbiological quality of poultry feed. Physicochemical and microbiological parameters analysis was performed using standard methods. Mean calculations, ANOVA and Tukey tests were performed using Excel 2016 XLSTAT 2016 software. The average water content was 5.42% for broiler feed and 5.03% for layer feed. The average dry matter was 94.58% for broiler feed and 94.77% for layer feed. The average pH was 7.44 for the broiler feed and 7.3 for the layer feed. The average acidity was 0.5% for broiler feed and 0.39% for layer feed. Microbiological analyses showed for broiler and layer feeds, mean loads respectively of $7.64x10^5$ CFU/g and $2.82x10^5$ CFU/g for Total Aerobic Mesophilic Flora, $7.76x10^4$ CFU/g and $1.58x10^4$ CFU/g for Sporulating Flora, $1.44x10^5$ CFU/g and $1.22x10^5$ CFU/g for yeast and Molds, $7.89x10^4$ CFU/g and $9.47x10^4$ CFU/g for Total Coliform, $2.27x10^4$ CFU/g and $8.38x10^3$ CFU/g for Thermotolerant Coliforms, and the presence of *Salmonella*. Compliance evaluation showed the following results: 100% of feeds analyzed were satisfactory in terms of Total Aerobic Flora, Total Coliforms, Yeasts and Molds. However, 100% of foods assessed were contaminated with Thermotolerant Coliforms and 40% with *Salmonella*. These high levels pose obvious risks to both poultry and consumers of poultry products. Therefore, compliance with good hygiene practices remains an absolute necessity for the protection of poultry and consumers of poultry products.

Keywords

Health Risks, Consumers and Handlers, Poultry Feed, Physicochemical and Microbiological Quality, Poultry Products

1. Introduction

Burkina Faso's economy is heavily dependent on the primary sector. Agriculture and livestock farming employ 86% of the working population and contribute around 40% to the gross domestic product [1]. The livestock subsector alone contributes 18.8% to national wealth creation, 14.2% to exports, and 38.8% to the monetary income of rural households [2]. Among livestock activities, poultry farming occupies an important place, with an estimated flock of 33,752,000 head of chickens in 2014 [3]. In urban centers, small-scale poultry farming is an important source of household occupa-

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tion and provides poultry farmers with substantial income [1]. Poultry farming provides a source of protein in the diet through chicken meat and eggs. It also helps to create jobs and reduce youth unemployment. Strong population growth, as well as increased consumption of poultry products by populations, have led to an increase in the demand for poultry meat and eggs [4]. Poultry farming is one of the main sources of animal protein in Burkina Faso, where the average per capita meat consumption is estimated at 9 kg/year [5]. However, artisanal poultry farming, characterized by its low productivity, remains dominant due to the poor organization of this important sector for the national economy [6, 7]. Given the increasing demand for animal protein, there is therefore an urgent need to develop the poultry farming sector to ensure significant meat production to cover animal protein requirements [8]. One of the main difficulties encountered in poultry farming undoubtedly remains the feeding of poultry, especially in urban areas. Not only is the supply of poultry feed expensive, but the types of feed generally available on the market do not always meet physicochemical, nutritional and microbiological quality standards [9]. Microbial contamination of certain feeds not only leads to high mortality rates among poultry farmers but also constitutes a potential source of danger for handlers and consumers. It leads to reduced growth performance and low egg productivity, as well as poor egg and meat quality [10]. Infection of chickens therefore constitutes a direct risk of transmission to humans for certain diseases such as salmonellosis and poisoning [11]. Contamination of the food with certain microbes, such as Bacillus cereus, leads to the aggravation of viral diseases in poultry [12]. Poultry feed quality is therefore important not only for reducing economic losses for poultry farmers but also for protecting consumers from direct and indirect infections through the handling or consumption of poultry products. It is therefore both necessary and essential to control the quality of feed used to feed poultry. In Burkina Faso, there isn't enough data on the physicochemical and microbiological quality of poultry feed and the risks to consumers. This study aimed to assess the potential health risks to consumers and handlers of poultry products according to the physicochemical and microbiological quality of poultry feed.

2. Materials and Methods

2.1. Study Period and Sample Collection

The samples consisted of layer feed and broiler feed collected from producers and retailers in the city of Ouagadougou during the period from January to May 2021. A total of 10 200 g each consisting of 05 samples of layer feed and 05 samples of broiler feed were collected (Table 1). The samples were packaged in plastic bags, coded, and stored at room temperature (25-37 ℃). Physicochemical and microbiological analyses were carried out at the Laboratory of Biochemistry and Applied Immunology (LaBIA) of Joseph KI-ZERBO University.

Table 1. *Coding of the samples collected.*

Feed type	Sample code	Quantity (g)
Broiler feed	CH1	200
	CH2	200
	CH3	200
	CH4	200
	CH5	200
Feed for layers	PO1	200
	PO2	200
	PO3	200
	PO4	200
	PO5	200

CH: Broiler feed; PO: Feed for layers

2.2. Determination of Physicochemical Parameters

Physicochemical analyses focused on moisture content, dry matter, pH, and acidity.

Moisture content (M) and dry matter were determined by differential weighing after steaming 5 g of each sample at 105 ℃ using the AOAC method [13]. Moisture content was determined according to formula (1):

$$M\ (\%) = \frac{TSW-(FW-EW)}{TSW} * 100 \quad (1)$$

M (%): Moisture content; TSW: Test sample weight; EW: Empty boat weight; FW: Final weight (basket + dehydrated sample).

Dry matter (DM) was determined according to formula (2).

$$DM\ (\%) = 100 - M\ (\%) \quad (2)$$

The hydrogen potential (pH) was determined by the potentiometric method using a pH meter (HANNA HI 2209 pH meter) that was accurate to ± 0.001 according to the AOAC international standard [14].

Acidity was determined by the international ISO 660 standard [15].

2.3. Determination of Microbiological Parameters

Microbiological analyses covered Total Mesophilic Aero-

bic Flora, Spore-forming Flora, Total Coliforms, Thermotolerant Coliforms, Yeasts and Molds, and *Salmonella*.

Total aerobic mesophilic fauna was enumerated on plate count agar (Liofilchem Diagnostic-ITALY) according to the international ISO 4833 standard [16].

The seeds were counted on plate count agar using the heat shock method after 24 to 48 hours of incubation at 37 ℃.

Total collagens were counted on Levine Agar (Liofilchem Srl Zona Ind.le-Rosetod.Abruzzi (TE) -ITALY) according to the international ISO 4832 standard [17].

Thermotolerant Coliforms were enumerated on Levine Methylene Blue Eosin agar (Liofilchemsrl Zona Ind.le-Rosetod.Abruzzi (TE)-ITALY) according to NF V08-60 standard [18].

The yeast and molds were counted on Sabouraud Chloramphenicol agar (Liofilchem srl Zona Ind.le-Rosetod. Abruzzi (TE) -ITALY) according to the international ISO 7954 standard [19].

Salmonella was enumerated on SS agar according to the international ISO 6579 standard [20].

Determination of Microbial Load Per Gram of Product

The number of germs per gram of product (N) was calculated according to the international ISO 7218 standard [21] as a weighted average using equations (3) and (4).

$$N = \frac{\sum C}{V.d(n1+0,1n2)} \quad (3)$$

(More than 15 colonies)

$$N = \frac{\Sigma C}{V*d} \quad (4)$$

(Less than 15 colonies)

ΣC: Sum of colonies on all boxes of two successive dilutions

V: Volume of inoculum

n1 and n2: Number of boxes for the first and 2nd dilutions respectively

d: dilution rate of the first box that produced countable colonies (low dilution)

2.4. Statistical Analysis

Data, means and standard deviations were calculated using Excel 2016 and analyzed using XLSTAT 2016 software. Analysis of variance (ANOVA) and Tukey's test were used to compare means, with a significance level of $p < 0.05$.

3. Results

3.1. Physicochemical Characteristics of Poultry Feeds

The results of the physicochemical analyses of poultry feeds are presented in Table 2. Water content ranged from 5.17 ±0.2 to 5.76 ±0.19% with an average of 5.42% for broiler feed and from 4.49 ±0.30 to 5.39 ±0.19% with an average of 5.03% for layer feed. Generally speaking, all the samples analyzed had water contents below 14 % and were therefore within the recommended limit. In terms of dry matter, the results ranged from 94.23 ±0.19 to 94.83 ±0.2%, with an average of 94.58% for broiler feed, and from 94.60 ±0.2 to 95.5 ±0.3%, with an average of 94.77% for layer feed. All feeds had dry matter content above the recommended minimum of 86% dry matter. The pH of the poultry feeds analyzed ranged from 7.03 ±0.02 to 7.74 ±0.01, with an average of 7.44 for broiler feed, and from 6.69 to 7.73 ±0.02, with an average of 7.3 for layer feeds. Generally speaking, all pH values were above neutral. As for acidity, results ranged from 0.3 ±0.02 to 0.62 ±0.15% with an average of 0.5% for broiler feed, and from 0.25 to 0.54 ±0.18% with an average of 0.39% for layer feed. Overall, the acidity of the broiler feeds analyzed was higher than that of the layer feeds.

Table 2. *Results of physicochemical analyses of poultry feeds.*

Samples	Moisture (%)	Dry Matter (%)	pH	Acidity (%)
CH1	5.76 ±0.19	94.23 ±0.19	7.66 ±0.00	0.58 ±0.03
CH2	5.28 ±0.09	94.72 ±0.09	7.74 ±0.01	0.40 ±0.11
CH3	5.67 ±0.27	94.32 ±0.27	7.73 ±0.01	0.30 ±0.02
CH4	5.20 ±0.00	94.80 ±0.00	7.05 ±0.00	0.56 ±0.19
CH5	5.17 ±0.20	94.83 ±0.20	7.03 ±0.02	0.62 ±0.15
Mean	5.42	94.58	7.44	0.50
PO1	5.39 ±0.20	94.60 ±0.20	7.62 ±0.01	0.38 ±0.01
PO2	5.39 ±0.19	94.61 ±0.19	7.71 ±0.00	0.25 ±0.00
PO3	5.28 ±0.09	94.72 ±0.09	7.73 ±0.02	0.54 ±0.18

Samples	Moisture (%)	Dry Matter (%)	pH	Acidity (%)
PO4	4.59 ±0.01	95.41 ±0.01	6.69 ±0.00	0.36 ±0.03
PO5	4.49 ±0.30	95.50 ±0.30	6.71 ±0.00	0.40 ±0.04
Mean	5.03	94.77	7.30	0.39
Limits*	≤ 14	≥ 86	-	-

pH: Hydrogen potential; *: (Malumba, 2001; Algerian Law n ‘88-09, 1988) [22, 23]

3.2. Microbiological Characteristics of Poultry Feed

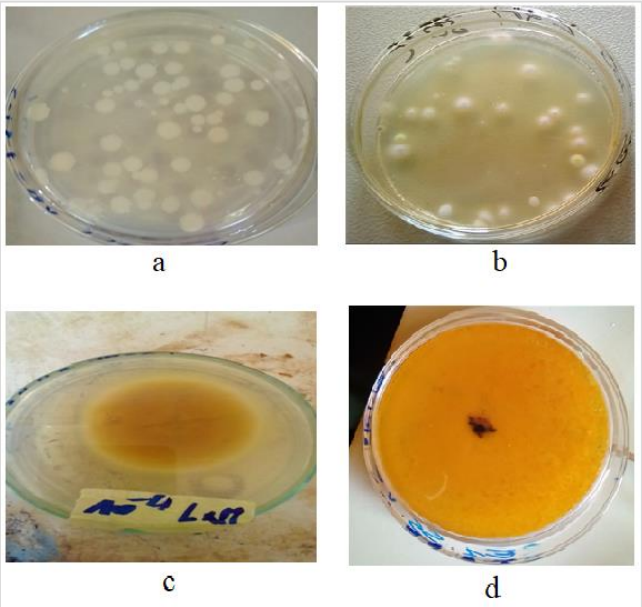
Table 3 shows the results of microbiological analyses of poultry feed. Total Aerobic Mesophilic Flora ranged from 5.53 ±5.4x10^5 to 1.02 ±0.59x10^6 CFU/g with an average of 7.64x10^5 CFU/g for broiler feeds, while loads on layer feeds varied significantly from 1.04 ±0.49x10^5 to 5.21 ±5.03x10^5 CFU/g with an average of 2.82x10^5 CFU/g. Sporulating Flora varied significantly from less than 10 to 1.49 ±1.39x10^5 CFU/g, with an average of 7.76x10^4 CFU/g for broiler feed, while loads of layer feed varied from 10 to 3.06 ±0.06x10^4 CFU/g, with an average of 1.58x10^4 CFU/g. About Yeasts and Molds, loads varied significantly from 6.81 ±2.76x10^4 to 3.33 ±0.58x10^5 CFU/g with an average of 1.44x10^5 CFU/g for broiler feed, while loads for layer feed varied from 2.26 ±0.64x10^4 to 1.36 ±0.55x10^5 CFU/g with an average of 1.22x10^5 CFU/g. Total Coliform loads ranged from 5.33 ±4.04x10^4 to 1.36 ±1.16x10^5 CFU/g with an average of 7.89x10^4 CFU/g for broiler feed, while layer feed loads ranged from 4.73 ±1.10x10^4 to 1.89 ±0.19x10^5 CFU/g with an average of 9.47x10^4 CFU/g. Statistical analysis revealed significant differences between broiler feed samples and layer feed samples. Regarding thermotolerant colonies, loads varied significantly from 1.02 ±0.94x10^4 to 3.22 ±0.59x10^4 CFU/g with an average of 2.27x10^4 CFU/g for broiler feeds, while layer feed loads varied from 4.80 ±0.69x10^3 to 1.43 ±0.1x10^4 CFU/g with an average of 8.38x10^3 CFU/g. In terms of *Salmonella, the* results showed the presence of germs in some samples.

Table 3. *Results of poultry feed microbiological analyses.*

Samples	TAMF (CFU/g)	SF (CFU/g)	YM (CFU/g)	TC (CFU/g)	TC (CFU/g)	SS
CH1	5.98 ±3.26x10^{5ab}	< 10	3.33 ±0.58x10^{5bc}	6.20 ±5.36x10^{4ab}	3.15 ±1.08x10^{4bcd}	Present
CH2	1.02 ±0.59x10^{6ab}	1.08 ±0.16x10^{5ab}	1.11 ±0.78x10^{5ab}	1.36 ±1.16x10^{5ab}	3.22 ±0.59x10^{4bd}	Absent
CH3	7.49 ±6.52x10^{5ab}	1.49 ±1.39x10^{5a}	1.24 ±0.6710^{5ab}	6.80 ±1.55x10^{4ab}	2.89 ±1.30x10^{4bcd}	Absent
CH4	5.53 ±5.40x10^{5ab}	6.40 ±5.71x10^{4a}	6.81 ±2.76x10^{4a}	7.53 ±3.00x10^{4ab}	1.02 ±0.94x10^{4abcd}	Present
CH5	9.01 ±4.81x10^{5ab}	6.73 ±4.56x10^{4a}	8.36 ±2.09x10^{4a}	5.33 ±4.04x10^{4a}	1.06 ±0.78x10^{4abcd}	Present
Mean	7.64x10^5	7.76x10^4	1.44x10^5	7.89X10^4	2.27x10^4	-
PO1	1.46 ±0.40x10^{5a}	< 10	2.26 ±0.64x10^{4abc}	1.89 ±0.19x10^{5ab}	7.73 ±2.83x10^{3ab}	Absent
PO2	5.21 ±5.03x10^{5ab}	2.73 ±2.367x10^{4a}	1.32 ±0.28x10^{5ab}	8.71 ±8.07x10^{4ab}	6.45 ±2.21x10^{3ab}	Absent
PO3	1.04 ±0.49x10^{5ab}	8.00 ±6.92x10^{3a}	2.28 ±1.49x10^{4abc}	8.94 ±2.65x10^{4ab}	1.43 ±0.10x10^{4abc}	Absent
PO4	2.92 ±0.94x10^{5ab}	3.06 ±0.06x10^{4a}	9.36 ±0.55x10^{4a}	6.09 ±1.66x10^{4ab}	8.62 ±6.42x10^{3abc}	Present
PO5	3.46 ±0.31x10^{5ab}	1.30 ±0.61x10^{4a}	1.36 ±0.55x10^{5ab}	4.73 ±1.10x10^{4a}	4.80 ±0.69x10^{3a}	Absent
Mean	2.82x10^5	1.58x10^4	1.22x10^5	9.47x10^4	8.38x10^3	-
Limits*	3x10^6	-	10^6	-	< 3.10^3	Absent

TAMF: Total Aerobic Mesophilic Flora; SF: Sporulating Flora; YM: yeast and Molds; TC: Total Coliforms; TC: Thermotolerant Coliforms. SS: *Salmonella*;
* (RE 142, 2011; AL n ‘88-09, 1988) [23, 24]

The microbial germs obtained in samples corresponding respectively to Total Aerobic Mesophilic Flora (a), Yeasts (b), Molds (c), and *Salmonella* (d) are illustrated in Figure 1.



a: TAMF; b: Yeasts; c: Mold; d: SS

Figure 1. *Aspects of some colonies observed in Petri dishes.*

3.3. Poultry Feed Conformity Assessment

The two-class evaluation of the results showed that all feeds were satisfactory in the total aerobic mesophilic flora, yeasts and molds (Figure 2). However, there was significant overall contamination with Thermotolerant Coliforms. Regarding Salmonella, the evaluation of the results showed that 40% of the poultry feeds analyzed were all contaminated by the presence of germs.

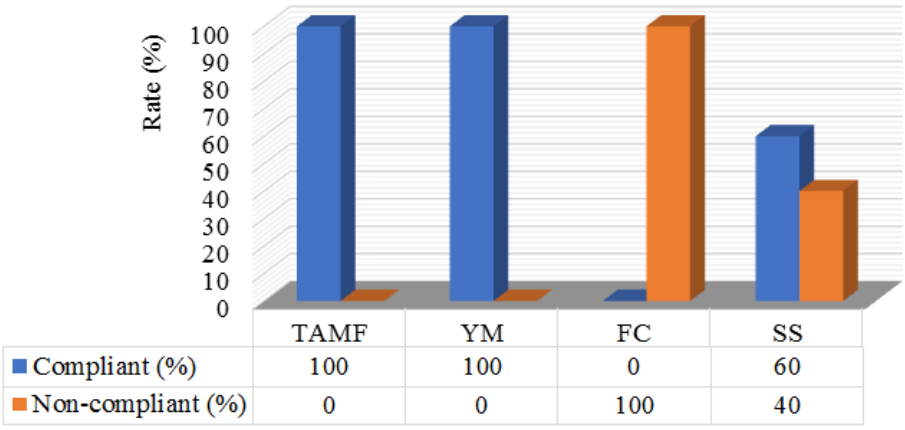


Figure 2. *Compliance assessment of foods tested.*

4. Discussion

The moisture content obtained in the poultry feeds analyzed showed a low water activity overall. The results obtained were lower than those obtained by Malumba (2001) [22] in Congo, who had reported an average moisture of 9.13% in his study on complete feeds formulated for poultry. The results were therefore satisfactory overall, as the water content obtained was also well below the recommended 14% moisture content for poultry feed [23]. These results reflect a residual moisture

content favorable to good preservation against microorganisms. Relative humidity below the recommended limit would also influence yield [25, 26]. The dry matter content also complied with the recommendations for flours intended for consumption by broilers and laying hens [23]. The dry matter values obtained in this study were higher than those obtained by Bastianelli *et al.*, (2005) [27], who reported an average of 89.8% dry matter for broiler feed and 89.7% dry matter for layer feed in their study on poultry feed. Regarding the pH and acidity values of poultry feeds, the results obtained generally showed that poultry feeds were close to neutral. All the average values obtained in this study were higher than those obtained by Malumba (2001) [22] in the Congo, who reported an average pH of 5.6 in his study. These pH and acidity values in poultry feed could be explained by the use of certain raw materials such as food processing by-products, microbial supplements, and fermentation extracts (dried soluble fermentation extracts) [11]. The presence of certain fermentative microorganisms in by-products used in processing plants would therefore influence the acidity of poultry feed. Regarding the evaluation of microbiological quality, the total aerobic mesophilic flora obtained in this study was higher than that reported by Malumba (2001) [22] in Congo in his study of complete poultry feeds, with total aerobic mesophilic flora ranging from $2.84x10^3$ to $3.36x10^3$ CFU/g. However, the overall results for total aerobic mesophilic flora remained below the recommended limits [24]. These results can be explained by the low water content of the feed analyzed, which hinders the development of microorganisms in general. Statistical analysis revealed no significant differences for broiler feed. However, the comparison between the values obtained for the layers showed a significant difference, which could be explained by the use of highly charged raw materials in the feed production process, leading to higher values. The results obtained for Total Coliforms and Thermotolerant Coliforms showed that all the feeds analyzed were contaminated with these germs. However, the results obtained in this study were lower than those obtained by Ibrahim *et al*. (2009) [28] in their study on the bacteriological quality of poultry feed in Senegal. Statistical analyses revealed no significant differences between broiler feed samples. However, feeds for laying hens were significantly different for Total Coliforms and Thermotolerant Coliforms. These differences could be explained by the non-standardization of production, with different practices from one producer to another. The presence of fecal germs, saprophytes of the human digestive tract, in poultry feed is generally indicative of poor application of good hygiene practices during feed formulation, which would have led to contamination by germs potentially dangerous to humans [29]. A minimum of hygiene during the production process could reduce the transient flora by over 40% [30]. The toxins produced by certain germs can affect consumers, as certain toxins have often been found in contaminated poultry meat and eggs [31]. The results for yeasts and molds also showed that all foods were satisfactory. Statistical analysis showed that the samples were significantly different, which could be explained by the difference in raw materials used by the producers, in particular processing by-products containing yeasts and molds. The abundant presence of yeasts in particular is significant, as several studies have shown that the incorporation of yeasts into poultry feed improves feed intake and increases the live weight of reared chickens [32-35]. On the other hand, some molds secrete toxins that have harmful effects on poultry after ingestion of contaminated feed [10]. These same risks exist for consumers, who could therefore absorb them [31]. Concerning *Salmonella*, 40% of corrupted samples could also be explained by the lack of hygiene during production, which is responsible for contamination by germs of fecal origin. Poor hygiene on the part of certain employees, and easy access to production areas for all kinds of rodents and insects, have been responsible for the high presence of salmonella in poultry products [30]. Poultry feed, when contaminated, is therefore an important route of consumer exposure to salmonellosis [11]. It is therefore clear that infection in poultry has a direct impact on the transmission of disease to humans through the meat, pâtés, and eggs they produce.

5. Conclusion

The results of the physicochemical analyses showed that all the feeds analyzed complied with the recommendations for water content, dry matter, pH and acidity. Microbiological analyses also showed that poultry feed was satisfactory in terms of total flora, spore-forming flora, total coliforms, yeasts and molds. However, high levels of fecal contamination and *Salmonella* were obtained. Thus, the risk of transmission of these germs to consumers is obvious and must be monitored. To improve the quality of poultry feed, it would therefore be important to assess the nutritional quality of poultry feed for potential fungal toxins.

Abbreviations

AL: Algerian Law

AOAC: Association of Official Agricultural Chemists

CEDEAO: Communauté Economique des Etats de l'Afrique de l'Ouest [Economic Community of West African States]

CILSS: Comité inter-Etat de lutte contre la sécheresse au sahel [Inter-State Committee for Drought Control in the Sahel]

FAO: Food and Agriculture Organization

FEWS NET: Famine Early Warning Systems Network

ISO: International Organization for Standardization

MAHRH: Ministère de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques [ministry of agriculture, hydraulics and halieutic resources]

MRA: Ministère des Ressources Animales [ministry of animal resources]

NF: Normes Françaises [French standards]

OMS: Organisation Mondiale de la Santé [World Health Organization]

PNSAN: Politique Nationale de Sécurité Alimentaire et Nutritionnelle [National Food and Nutritional Security Policy]

PNUD: United Nations Development Program

RE: European Regulation

USAID: United States Agency for International Development

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Conflicts of Interest

The authors declare no conflicts of interest.

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