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ORIGINAL ARTICLE

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Effect of incorporating *Lippia javanica* (*Zumbani*) on physical, nutritional, microbiological, and sensory properties of instant soup mix powder

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ABSTRACT

Background: *Lippia javanica* (commonly known as *Zumbani*) is a nutrients-rich plant with various pharmacological characteristics, including antioxidant, anti-cancer, anti-diabetic, anti-microbial, and bio-pesticidal effects, making it a valuable addition to consumer products. **Aims:** The aim of the study was to evaluate the effect of incorporating *Lippia javanica* powder into Instant Soup Mix (ISM) powder on its functional, nutritional, microbiological, and sensory properties. **Methods:** Four (4) 100 g treatment formulations were prepared using a constant base of 70 g *Lippia javanica* powder blended with corn flour in varying proportions: 0:70 g (zum–0), 2:68 g (zum–2), 5:65 g (zum–5), and 10:60 g (zum–10), while maintaining all other ingredients constant. **Results:** The incorporation of *Lippia javanica* significantly reduced the bulk density of the ISM Powder (p = 0.0098), with values ranging from 0.67 to 0.69 g/mL. Water absorption capacity (WAC) and fat content decreased as the proportion of *Lippia javanica* increased. Conversely, ISM Powders containing *Lippia javanica* powder exhibited significantly higher levels of ash, protein, crude fiber, calcium, compared to the control (zum-0). Among the samples, zum–10 displayed the highest content of total phenolic compounds and achieved the highest sensory acceptability scores. Microbiological analysis revealed no bacterial presence in any of the treatments. **Conclusion:** The inclusion of *Lippia javanica* powder enhanced the functional, nutritional, and sensory properties of the ISM powders. Sample zum–10 demonstrated superior nutritional value, functional characteristics, and consumer acceptability, making it the most recommended formulation for potential use.

Keywords: *Lippia javanica*, instant mix soup powder, physico-chemical, sensory properties.

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1 Introduction

Lippia javanica ordinarily identified as Lemon bush (English), Zumbani (Shona) and Umsuzwane (IsiNdebele) (Kling et al., 2013) is a versatile herb widely utilized for its culinary, medicinal, and therapeutic properties. Its leaves are frequently employed as a food additive, consumed as a vegetable, brewed into tea for refreshment, and used as a home remedy for respiratory ailments. Extensive research on *Lippia javanica* has revealed its diverse pharmacological characteristics, including antioxidant, anti-cancer, anti-diabetic, anti-malarial, antimicrobial and pesticidal properties (Maroyi, 2017; Nyagumbo et al., 2022; Shikanga et al., 2010). The leaf extract is traditionally utilized for treating respiratory conditions such as pneumonia, asthma, the common cold, and tuberculosis (Nyagumbo et al., 2022). Recently, it has gained attention for alleviating respiratory symptoms associated with coronavirus disease (COVID-19) caused by the novel severe acute respiratory syndrome coronavirus (SARS-CoV-2) (Nyagumbo et al., 2022). Moreover, *Lippia javanica* is a rich source of polyphenols, including phytochemical molecules such as alkaloids, flavonoids, as well as essential minerals. These compounds are renowned for their antioxidants, anti-allergic, and anti-inflammatory properties (Shikanga et al., 2010). The plant, which exemplifies its potential as a functional and therapeutic resource (*Lippia javanica*), is depicted in Figure 1.

Studies of the pharmacological and phytochemical properties have validated the use of *Lippia javanica* in traditional medicine although there are knowledge gaps that can be addressed through further research (Singini, 2019). Leaves of *Lippia javanica* have an extensive range of macro- and micro-nutrients, such as proteins, fats, carbohydrates, vitamins, and minerals. They are a good source of minerals such as calcium, iron, magnesium, manganese, zinc and selenium (Mahlangeni et al., 2018). Due to its significant concentrations of important minerals, *Lippia javanica* can be incorporated to augment the nutritional and medicinal quality of various foodstuffs that include instant soup mixes.

Malnutrition is a global crisis affecting millions of people (UNICEF, 2019) and may be partly addressed through the use of a nutrient supplement in the form of Instant Soup Mix. The regular soup mixes currently available on the market are deficient in important minerals as well as lacking anti-oxidants and anti-carcinogens. For instance, Calcium is essential for bone health, but inadequate intakes have also been linked to other health outcomes, including pregnancy complications, cancers, and cardiovascular disease (Shlisky et al., 2022). Risks of iron deficiency in pregnant women include anaemia that leads to premature birth and low birth weight in infants (Barragán-Ibañez et al., 2016). These deficiencies can be remedied by introducing an instant soup mix supplemented with the required nutrients. Apart from being consumed as a food in itself, an herbal Instant Soup Mix can be used as an ingredient in stews and pie fillings.

Figure 1. Plant of *Lippia javanica*

Several investigations have been carried out to determine the composition of Southern African herbs including *Lippia javanica* (Maroyi, 2017; Nyagumbo et al., 2022; Shikanga et al., 2010; Singini, 2019; Mahlangeni et al., 2018; Van Wyk, 2011). However, there is inadequate information on the incorporation of these herbs into commonly consumed modern-day foods. The aim of the study was to investigate the effect of incorporating *Lippia javanica* on the physico-chemical, nutritional, microbiological and acceptability of formulated instant soup mix powder.

2 Materials and Methods

2.1 Sample collection

The condiments and spices utilized in the preparation of the ISM powder were purchased from MS Patel Spice Bazaar, located in Bulawayo, Zimbabwe. *Lippia javanica* was harvested from the Matabeleland South Province along the Lumene Riverbanks in Mtshabezi area. Fresh *Lippia javanica* leaves (2 kg) were collected, placed in zip-lock bags, and transported in a cooler bag to the University of Zimbabwe. Upon arrival at the laboratory, the leaves were thoroughly washed with distilled water and subsequently oven-dried at 65 °C until a constant mass was achieved, which occurred after approximately four hours. Thereafter, the dry leaves were then pulverized using a porcelain pestle and mortar. Each ingredient used in the preparation of the ISM powder were weighed individually using a Mettler PC 220 mass balance, combined, and stored in hermetically sealed plastic jars.

2.2 Preparation of instant soup mix

Three (3) instant soup mix formulations, each weighing 105 g, were prepared using a fixed 70 g base comprising a blend of *Lippia javanica* and corn flour in varying proportions of 0:70 g, 2:68 g, 5:65 g and, 10:60 g.

Table 1. Instant soup mix (ISM) powder formulation

Ingredients	Control Zum-0/g	Sample Zum-2/g	Sample Zum-5/g	Sample Zum-10/g
Lippia Javanica	0	2	5	10
Corn flour	70	68	65	60
Chicken powder	10	10	10	10
Garlic powder	10	10	10	10
Thyme Powder	5	5	5	5
Onion Powder	5	5	5	5
Coriander Powder	1	1	1	1
Curry powder	2	2	2	2
Pepper Powder	1	1	1	1
Salt	1	1	1	1
Total	105	105	105	105

Three of the formulations incorporated *Lippia javanica* at different concentrations while the corn flour was adjusted to account for the increased proportion of *Lippia javanica,* as shown in Table 1. An additional formulation, prepared without the inclusion of *Lippia javanica* (0:70 g), served as the control.

2.3 Analysis of physical properties

2.3.1 Bulk density

The bulk density of the ISM powder samples was determined following the method described by Falade & Adedeji (2022). A 10 g sample of ISM powder was carefully weighed and transferred into a 10 ML graduated measuring cylinder. The cylinder was gently tapped against a workbench repeatedly until the sample settled and was compactly packed. Bulk density was expressed in g/mL. The analysis was carried out in triplicates to ensure accuracy and reliability. The bulk density of the sample was calculated using the following formula:

$$\text{Bulk density} = \frac{\text{Weight of sample}}{\text{Volume of sample}}$$

2.3.2 Water Absorption Capacity (WAC)

Water absorption capacity (WAC) was determined by weighing one (1) g of the ISM sample into a pre-weighed centrifuge tube, followed by addition of 10 mL of water. The mixture was allowed to stand for 30 minutes to ensure sufficient hydration. Centrifugation was subsequently conducted for 30 minutes at 3500 g and the sample weights were measured after decanting free water. The analysis was conducted in triplicates to ensure precision and reliability. Water absorption capacity (WAC) was calculated as follows:

$$\text{WAC} = \frac{\text{water absorbed}}{\text{initial sample weight}} \times 100$$

2.4 Proximate analysis

The ISM samples were analyzed for moisture, ash, crude protein, crude fat, crude fiber, and carbohydrate content using standard methods, including oven drying, muffle furnace ashing, Kjeldahl analysis, Soxhlet extraction, acid-base digestion followed by filtration drying and ashing in a muffle furnace and difference methods respectively as described in the *Official Methods of Analysis* (AOAC, 2005). All analyses were conducted in triplicates to ensure accuracy and reliability. Moisture content was quantified by oven drying to constant mass at 105 °C. Ash was determined by combusting the samples in porcelain crucibles within a muffle furnace at 550 °C until a greyish-white ash was formed. Total nitrogen was determined using the Kjeldahl method, and crude protein was calculated by multiplying the total nitrogen content by a conversion factor of 6.25. Crude fat content of the samples was determined using the Soxhlet extraction method, using petroleum ether as the solvent over a 6-hour extraction period. The solvent was subsequently evaporated using a water bath in a fume hood, followed by oven drying and weighing of the residue. Crude fiber was determined by digesting the samples sequentially in 1.25% sulfuric acid, then 1.25% sodium hydroxide, followed by filtration and drying of the residue in a crucible porcelain placed in an oven. The crucible was then cooled in a desiccator, weighed and placed in a muffle furnace at 600 °C for one hour. Crude fiber was calculated as the percentage loss in weight upon ashing. The available carbohydrate content was calculated by subtracting the sum of crude protein, crude fat, crude fiber, and ash from 100% of the dry weight of the sample (James, 1999).

2.5 Mineral Analysis

Calcium and iron concentrations were determined in triplicates using an Atomic Absorption Spectrophotometer (Model Spectronic 21, Milton Roy Company, USA) following the digestion of ashed ISM samples in acidic medium as per the protocols outlined in AOAC (2005) and James, (1999).

Mahlangeni et al., (2018) have identified *Lippia Javanica* as a rich source of calcium and iron. The researchers aimed to verify this finding while addressing the increasing global prevalence of calcium and iron deficiencies (Van Wyk, 2011; Falade &_Adedeji, 2022) The study explored whether the developed ISM could contribute to meeting these essential dietary requirements.

2.6 Total phenolic content

The total phenolic content was determined in triplicates using a method described by Randihir et al., (2004). One milliliter of ethanolic extract was transferred into a test-tube and thoroughly mixed with 5 mL of distilled water. Subsequently, 0.5 mL of Folin-Ciocalteu reagent (0.2N solution) was added, followed by thorough mixing. After five minutes, 1.5 mL of 5% Na_2CO_3 solution was added to the reaction mixture, which was then left to stand for 60 minutes. The absorbances of the solutions were measured at 765 nm using a UV-Visible spectrophotometer (Shimadzu Corporation, Tokyo Japan, model UV-3101PC). The measured absorbances were converted to total phenolic content and expressed as milligrams of garlic acid equivalent (GAE) per gram of dry sample weight. Standard curves were prepared by measuring absorbances of various concentrations of garlic acid in 95% ethanol. The total phenolic concentrations of the samples were calculated by interpolating their absorbances on the calibration curve.

2.7 Sensory evaluation

A total of 100 semi-trained panelists, aged between 21 to 55 years and comprising 60 women and 40 men, participated in the sensory evaluation of the formulated ISM products. All participants voluntarily consented to partake in the experiment. The evaluation was carried out to assess consumer perceptions of taste, aroma, appearance, mouthfeel, and overall acceptance of the ISM formulations after cooking, as the product cannot be consumed raw.

The samples were coded with random numbers: 261, 106, 259, and 370, corresponding to formulations with 0%, 2%, 5%, and 10% *Lippia javanica* (zum–0%, zum–2%, zum–5%, and zum–10%), respectively. Sensory attributes were rated on the basis of a nine-point hedonic scale. Panelists were provided with bottled water to cleanse their plates between the assessment of each sample to ensure accurate evaluations.

2.8 Total bacterial count

A one-gram portion of each formulation was serially diluted in peptone water to create a series of dilution ratios, including 0.1, 0.01, 0.001, 0.0001, 0.00001, 0.000001, 0.0000001, 0.00000001, 0.000000001, and 0.0000000001. From each dilution, 1 mL was inoculated onto nutrient agar plates. The plates were incubated at 37 °C for 24 hours, after which bacterial colonies were enumerated and recorded (Harrigan, 1998). The analysis was carried out on days 1, 7, 14, and 28 of the storage periods for the ISM powder. During this time, the samples were stored at room temperature in sealed plastic jars.

2.9 Statistical analysis of data

Data were analyzed using Microsoft Excel 2013 and GraphPad Prism 5.0. The mean values for each analysis of the various ISM treatments were compared using a one-way Analysis of Variance (ANOVA). For means that exhibited significant differences, post hoc separation was performed using Turkey's test at 95% confidence level.

3 Results

3.1 Physical properties

The physical properties of ISM formulated by partial replacement of corn flour with *Lippia javanica* are presented in Table 2.

The bulk densities of ISM samples ranged from 0.67 to 0.69 g/mL showing statistically significant differences among the formulations (p = 0.0098). However, the bulk densities of the control sample (zum–0) and zum–2 were not significantly different (p=0.1108). The WAC of the formulations ranged from 1.33 to 2.01 mL/g and exhibiting a significant decrease (p < 0.0001) as the level of *Lippia javanica* incorporation increased.

3.2 Proximate composition

The proximate composition of the ISM powders formulated with partial replacement of corn flour with *Lippia javanic*a is presented in Table 3.

Moisture content ranged from 7.9% to 8.9% with sample Zum–0's moisture being significantly different (p = 0.0133) from those of other three developed ISM powders. A post-hoc one-way ANOVA revealed no significant differences (p = 1.000) in moisture content among samples zum–2, zum–5, and zum–10. Ash content of the ISM powders ranged from 10.33% to 12.5%, with significant differences (p = 0.005) observed across all samples. However, the ash contents of samples zum–0 and zum-2 were not significantly different (p = 0.1307), nor were the ash contents of samples zum–5 and zum–10 (p = 0.3787).

The protein content of the samples ranged from 7.06% to 10.1%, showing statistically significant differences (p < 0.0001). The incorporation of *Lippia javanica* resulted in an increase in protein content from 7.06% in the control sample (zum–0) to 10.10% in sample zum–10. The crude fat contents of the formulations, ranging from 1.92 to 2.19% showed a decreasing trend with higher levels of *Lippia javanica* incorporation. However, no statistically significant differences (p = 0.9959) were observed among the fat contents of ISM samples, indicating that the addition of *Lippia javanica* leaf powder exhibited no significant effect on fat content.

Crude fiber contents, which ranged from 14.9% to 20.85%, increased significantly (p = 0.0005) with higher levels of *Lippia javanica* incorporation. The highest crude fiber content (20.85%) was obtained for treatment zum–4 while the lowest content of 14.9% was recorded for the control, zum–0. Carbohydrate content decreased as corn flour was partially replaced with *Lippia javanica.* All samples showed significantly different carbohydrate levels (p = 0.0005; Table 3). The reduction in the carbohydrate content is attributed to the substitution of corn flour, the primary carbohydrate source with *Lippia javanica* in the ISM formulation.

Table 2. Physical properties of ISM powder made by partial replacement of corn flour with *Lippia javanica*

Samples	Bulk density (g/mL)	Water absorption (mL/g)
Zum-0	0.69 ± 0.01^b	2.01 ± 0.02^d
Zum-2	0.68 ± 0.01^b	1.89 ± 0.01^c
Zum-5	0.67 ± 0.01^a	1.48 ± 0.01^b
Zum-10	0.67 ± 0.01^a	1.33 ± 0.01^a
p-value	0.0098	<0.0001

Data in the same column with different superscript letters are significantly different at p < 0.05. Results expressed as mean ± standard deviation.

Table 3. Proximate composition of instant soup made by partial replacement of corn flour with *Lippia javanica*

Samples	Moisture %	Ash %	Crude Protein %	Crude Fat %	Crude Fiber %	Carbohydrates %
Zum–0	7.90 ± 0.10^a	10.33 ± 0.84^a	7.06 ± 0.06^a	2.19 ± 1.55^a	14.19 ± 1.73^a	58.2 ± 0.10^d
Zum–2	8.90 ± 0.11^b	11.33 ± 0.35^a	8.08 ± 0.10^b	2.13 ± 1.95^a	17.62 ± 1.31^b	51.9 ± 0.13^c
Zum–5	8.90 ± 0.30^b	12.17 ± 0.29^b	8.73 ± 0.03^c	2.07 ± 0.11^a	18.86 ± 0.35^b	50.7 ± 0.02^b
Zum–10	8.90 ± 0.57^b	12.5 ± 0.50^b	10.1 ± 0.03^d	1.92 ± 1.37^a	20.85 ± 0.01^c	45.6 ± 0.57^a
p – value	0.0133	0.005	< 0.0001	0.9959	0.0005	< 0.0001

Data in the same column with different superscript letters are significantly different at $p < 0.05$. Results expressed as mean ± standard deviation.

3.3 Micronutrients and total phenolics

3.4.1 Micronutrients

The micronutrient composition of ISM powders prepared by partially replacing corn flour with *Lippia javanica* is presented in Table 4. Calcium content ranged from 12.41 to 13.87 mg/kg, with statistically significant differences among the samples ($p < 0.0001$). The calcium content increased with higher levels of *Lippia javanica* incorporation.

Table 4. Micronutrient and total phenolic content data of instant soup made by partial replacement of corn flour with *Lippia javanica*

Samples	Calcium (mg/kg)	Iron (µg/g)	Total phenols (mg/mL GAE)
Zum–0	12.41 ± 0.01^a	1.91 ± 0.08^a	0.52 ± 0.10^a
Zum–2	13.17 ± 0.04^b	1.97 ± 0.11^a	0.66 ± 0.05^b
Zum–5	13.56 ± 0.03^c	2.01 ± 0.17^a	0.77 ± 0.18^b
Zum–10	13.87 ± 0.04^d	2.03± 0.19^a	0.79 ± 0.02^b
p – value	< 0.0001	0.7553	0.047

Data in the same column with different superscript letters are significantly different at $p < 0.05$. Results expressed as mean ± standard deviation.

Iron contents varied between 1.91 to 2.03 µg/g but showed no statistically significant differences ($p = 0.7553$) among the formulations and displayed higher levels with increasing amount of *Lippia javanica* incorporation.

3.4.2 Total phenolic content

The total phenolic content of ISM powders, prepared by incremental substitution of corn flour with *Lippia javanica* is presented in Table 4. Sample zum–0 exhibited a total phenolic content of 0.518 mg GAE/mL and significantly differed ($p = 0.047$) from samples zum–2, zum–5 and zum–10 with total phenolic contents of 0.655 mg GAE/mL, 0.773 mg GAE/mL and 0.797 mg GAE/mL respectively. However, there were no significant differences ($p = 0.3091$) among the total phenolic contents of samples zum–2, zum–5, and zum–10. Among the four ISM powder formulations, sample zum–0 showed the lowest total phenolic content while zum–10 recorded the highest total phenolic content.

3.4 Sensory evaluation

The aroma scores for the formulations (zum–0 to zum–10) ranged from 4.332 to 8.420 and were significantly different ($p < 0.0001$) (Table 5). However, no significant difference ($p = 0.3240$) was observed between aroma of sample zum–0 and zum–2 (Table 5). The highest appearance score was observed for sample zum–0, while zum–10 received the lowest score. Appearance scores across all treatments (zum–0 to zum–10) were significantly different ($p < 0.0001$), except between zum–2 and zum–5, where the difference was not significantly different ($p = 0.1696$). Mouthfeel scores ranged from 5.501 to

Table 5. Sensory evaluation of ISM powder made by partial replacement of corn flour with *Lippia javanica*

Samples	Aroma	Appearance	Taste	Mouthfeel	Overall Acceptability
Zum–0	6.33 ± 0.05^a	9.01 ± 0.03^a	5.01 ± 3.05^a	8.40 ± 1.11^a	6.20 ± 1.23^a
Zum–2	5.88 ± 0.66^a	6.39 ± 0.29^b	5.41 ± 2.20^a	6.20 ± 0.41^b	6.30 ± 0.61^a
Zum–5	4.33 ± 0.12^b	5.98 ± 0.31^b	5.12 ± 2.12^a	5.50 ± 0.71^b	6.50 ± 0.06^a
Zum–10	8.42 ± 0.2^c	5.32 ± 0.1^c	6.18 ± 0.72	7.10 ± 1. 51^b	7.11 ± 0.33^a
p – value	< 0.0001	< 0.0001	0.9097	0.0394	0.4417

Data in the same column with different superscript letters are significantly different at $p < 0.05$. Results expressed as mean ± standard deviation.

8.401, with significant difference (p = 0.0394). Sample zum–0 received the highest scores for mouthfeel while zum–5 had the lowest scores. However, the mouthfeel acceptability of samples zum–2 and zum–5 was not significantly different (p = 0.2197). Regarding overall acceptability, sample zum–10 achieved the highest score, which was not significantly different (p = 0.4417) from the scores of the other samples.

Total bacterial count

No bacterial growth was detected in any of the samples tested for total bacterial counts throughout the 28-day storage of the ISM powder prepared by incremental replacement of corn flour with *Lippia javanica*.

4 Discussion

The bulk densities of the ISM powders, ranging from 0.67 to 0.69 g/mL, align with findings of Kumari et al. (2023), who reported no significant differences in bulk densities of developed soup, which ranged from 0.49 to 0.50g/mL. These results suggest that the partially substituted corn flour possesses bulk density characteristics identical to those of *Lippia javanica* leaf powder. The observed decrease in bulk density of the ISM powder may be attributed to increase in *Lippia javanica* powder that entrap air spaces rendering the ISM powders bulkier and less dense. Lower bulk densities of the developed soup sample powders enhance suitability for packaging and distribution, as they result in reduced product weight (Dhanalakshmi et al., 2011). The reduction in WAC from 2.01 to 1.33 mL/g with increased incorporation of *Lippia javanica* could be attributed to the diminished presence of corn flour, that presents superior water-binding properties compared to the leaf powder. This behavior is likely influenced by hydrophilic components, such as polar or charged side chains, proteins, and carbohydrates, which play a key role in modifying water absorption capabilities (Dereje et al., 2020). This suggests that corn flour, as the base starch source, readily forms hydrogen bonds with water and binds water molecules effectively (Singh et al., 2021), Consequently, its partial replacement with *Lippia javanica* leaf powder leads to a decline in WAC.

The observed increase in moisture content following the addition of *Lippia javanica* indicates that the herb impacted the moisture content of ISM. The moisture content of the control sample (zum–0) was significantly lower than that of the other formulations. This suggests that the oven-drying method influenced the overall moisture content of both the herb and the developed ISM powder. However, the slight increase in moisture content will not affect the product's shelf stability, as microbial activity is significantly reduced at moisture levels below 20% (Dudley, 2022). The ash content ranging from 10.33 to 12.50%, reflects the decrease in corn flour and the increase in *Lippia javanica* resulted in increase in ash content of the products. The higher level of ash content could be attributed to high mineral content of the leaves (Farzana et al., 2017). High ash content may indicate elevated levels of calcium, aluminum, manganese, or iron deposition in food products. According to Mahlangeni et al., (2018), *Lippia javanica* leaves are a rich source of essential minerals such as calcium, iron, magnesium, manganese, zinc, and selenium.

The incorporation of *Lippia javanica* increased the protein content from 7.06% in sample zum–0 to 10.10% in sample zum–10. This indicates that at 10 g level of *Lippia javanica* inclusion, the ISM provides a valuable source of protein, aligning with the recommended daily intake range of 9 – 71% (Ryan-Harshman & Aldoori, 2006). Regarding the fat content, the recommended daily intake (RDI) is 117 g, while the fat content of the developed soup powder ranged from 1.92 to 2.19%. This suggests that none of the formulations meets the RDI (Ryan-Harshman & Aldoori, 2006) for fat, making a soup a poor source of dietary fat. This low-fat content could benefit individuals aiming to reduce their fat intake.

The fiber content of the *Lippia javanica*-fortified ISM (17.62 to 20.85%) is higher than that of soup powders prepared from soy, mushroom, and Moringa flour (1.1 – 2.3%) (Mohajan et al., 2018) and ogbono mix powder (0.26 – 1.52%) (Bamidele et al., 2015). This positions the soup mix as an excellent source of dietary fiber. A high intake of dietary fiber has been shown to reduce the risk of developing non-communicable diseases such as coronary heart disease, stroke, hypertension, diabetes, obesity, and certain gastrointestinal disorders (Anderson et al., 2009). Thus, the consumption of *Lippia javanica*-fortified soup powder has the potential to contribute to the prevention of these conditions due to its high fiber content. The observed decrease in carbohydrate content resulting from the addition of *Lippia javanica* suggests a corresponding reduction in calories (Carson & Edwards, 2009). The carbohydrate content of developed ISM powder ranged from 45.6% to 58.2%, while the RDI falls between 61 and 210 g (Carson & Edwards, 2009). This makes the soup an appropriate dietary supplement for individuals monitoring their calorie and carbohydrate intake. Moreover, when consumed with complementary foods such as bread or rice, portion sizes can be easily managed to avoid exceeding the recommended carbohydrate intake.

The calcium content of the ISM powders ranged between 12.41 – 13.87 mg/kg, which is significantly below the RDI of 210 – 1,000 mg for individuals aged 4 – 65 years, regardless of sex (Ryan-Harshman & Aldoori, 2006). Although calcium is present in the formulated products, the developed soup mix powder cannot be considered a rich source of this essential micronutrient. Even at the highest observed concentration of

13 mg/kg in the ISM powder with 10 g of *Lippia javanica*, it fails to meet the daily calcium requirement. The low calcium levels observed may be attributed to the limited quantity of *Lippia javanica* used during formulation. Nonetheless, the available calcium could still provide functional benefits, as plant-based calcium has been shown to reduce the risk of osteoporosis (Cashman, 2002).

The iron content of the ISM powders ranged from 1.91 to 2.03 µg/g, which is also below the RDI of 8.00 – 27.00 mg for all age groups of men and postmenopausal women aged 55 – 75 years (Ryan-Harshman & Aldoori, 2006). These results indicate that the iron levels in the products are insufficient to meet daily dietary requirements. Moreover, the bioavailability of non-heme iron was low, suggesting that the ISM powder would not improve the iron nutritional status of consumers. These results contrast with those of Mahlangeni et al., (2018) who reported *Lippia javanica* as a rich source of iron (595 – 1499 µg/g) after extracting 200g *Lippia javanica* varieties in 50 mL of deionized water and boiling for 10 minutes. The lower iron content observed in this study may be attributed to the shorter steeping time employed during ISM preparation. Extending the extraction time during processing could potentially enhance the release of minerals such as iron from *Lippia javanica* leaves. To compensate for these deficiencies, consumers may include additional dietary sources of calcium, such as dairy products, and heme-iron, found in red meat, which are more bioavailable and can complement the nutritional profile of the developed ISM powder.

The levels of phenolics in the ISM powders (0.518 – 0.797 mg/mL GAE) observed in the current study were significantly lower than the 14.8 mg/mL GAE reported by Shikanga et al., (2010) for *Lippia javanica* leaf extracts. The reduced phenolic levels in the ISM powders are likely attributable to the dilution of the *Lippia javanica* leaf powder by other ingredients, such as corn flour, chicken powder, and garlic powder. These findings suggest that phenolic compound recovery from plant materials could be optimized by modifying extraction parameters, including time and temperature.

Polyphenols, particularly flavonoids, phenolic acids, and tannins, are known to inhibit α-glucosidase and α-amylase, which are key enzymes in the hydrolysis of carbohydrates into glucose (Aleixandre et al., 2022). Polyphenols play a significant role in regulating glucose metabolism which is particularly beneficial for diabetic patients. Additionally, phenolic compounds are recognized for their antioxidant properties (Balasundram et al., 2006), which are associated with reduced risks of cancer and cardiovascular diseases. A major limitation with regards to phenolic compounds lies in their potential role as anti-nutrients. They can precipitate proteins and form complexes with metals such as iron, thereby reducing the bioavailability of essential nutrients (Reddy & Cook 1991; Ferguson, 2001; Samman et al., 2001). Given that the ISM powders are suggested to be consumed alongside red meat, a food rich in heme iron, the inclusion of phenolic-rich ingredients in high concentrations may have counterproductive effects by antagonizing the absorption of heme iron.

Sensory evaluation revealed that sample zum–10, containing 10 g of *Lippia javanica* was the most favorable in terms of aroma, taste, mouthfeel and overall acceptability. This may be attributed to preference of panelists for a more pronounced and distinctive flavor. Similar findings were reported by Chawafambira & Jombo (2024), who demonstrated that mahewu fortified with varying levels of *Lippia javanica* was more acceptable than an unfortified control. These findings indicate that incorporation of *Lippia javanica* enhances the sensory acceptability of food products.

To ensure microbiological safety, the developed ISM powder samples were stored in sealed plastic jars under room temperature and pressure conditions. The extended shelf life of the soup powders may be a result of inhibition of microbial growth, likely due to their low moisture content (Wójcik-Stopczyńska et al., 2002). In addition, the washing and drying processes during sample preparations may have further contributed to a reduction in microbiological load.

5 Conclusion

The incorporation of *Lippia javanica* into instant soup mix powder formulations resulted in a reduction in bulk density and water absorption capacity. However, its addition significantly enhanced the nutritional profile of the ISM powder, leading to increased levels of protein, calcium, iron, and total phenolics. Furthermore, *Lippia javanica* contributed to notable improvements in the sensory attributes of the product, including aroma, taste, mouthfeel, and overall acceptability. Among the formulations, the sample containing 10 g of *Lippia javanica* emerged as the most favorable, excelling in both nutrient composition and sensory properties.

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