nutraceuticals

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Review

A Comprehensive and Comparative Metabolomic Study of Two Nutraceutical-Containing Plants; *Moringa oleifera* and *Solanum lycopersicum*: A Review

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Abstract: *Solanum lycopersicum* and *Moringa oleifera* are two essential nutraceutical-containing plants from two different families, and are sources of abundant metabolites. They have a variety of applications in medicines, functional food additives and even water purification. This review aims to complement earlier reviews by comparing the metabolite profiles and modern-day pharmacological relevance of both plants. The metabolome of *Moringa oleifera* was compared to that of *Solanum lycopersicum*, to evaluate the common metabolites found within the two plants and how these compounds can be used for same pharmacological and nutritional benefits. While these plants contain similar metabolites, they also contain different compounds of the same class that differ in terms of their biological functions. In such instances, *Moringa oleifera* and *Solanum lycopersicum* may have similar applications, but remain distinguishable from each other in terms of pharmacological potential.

Keywords: nutraceuticals; metabolites; *Moringa oleifera*; *Solanum lycopersicum*

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1. Introduction

Moringa oleifera and *Solanum lycopersicum* are vegetable crops that are in high demand in the agricultural sector for various economic, social, and cultural purposes. Furthermore, *Moringa oleifera* and *Solanum lycopersicum* are abundant sources of bioactive compounds and are therefore essential nutraceuticals [1,2]. Their edible nature makes them popular; for instance, *Moringa* pods are commonly used in Thailand for sour soup (also known as Keang-Som) while in other countries the leaves, flowers, and seeds of *Moringa oleifera* are boiled and served as side dishes for chili pastes [3]. Additionally, *Moringa* leaves, flowers, and seeds are made into dry powder and packed in capsules or tea bags for infusion drinks [3]. Similarly, *Solanum lycopersicum* is a common staple in many countries, with a global production of over 42.3 million tons [4]. A large portion of its produce is served as vegetable drinks, sauces, salads, or stews in restaurants and supermarkets. Hence, *Moringa oleifera* and *Solanum lycopersicum* both serve as pivotal nutritional supplements for the well-being of mankind [5,6].

The nutritional qualities of *Moringa oleifera* and *Solanum lycopersicum* are derived from their phytochemical composition. The metabolic profile of *Moringa oleifera* includes proteins, vitamins, beta-carotene, amino acids, and various phenolics [7]. Similarly, metabolites such as systemin, phenolic acids such as ferulic acids, flavonoids, organic acids, and glycoalkaloids have been reported in *Solanum lycopersicum* [1,8]. A common feature of *Moringa oleifera* and *Solanum lycopersicum* is the abundance of flavonoids and phenolic acid metabolites in both. Flavonoids and phenolic acids have been observed to exhibit antioxidant properties [9]. For instance, Ojiako et al. [10] reported that extracts of *Moringa oleifera* contained abundant phenolic-based antioxidants such as vitamins A, C, and E, which

inhibited bacterial infections, reduced inflammation, and eliminated toxins associated with venomous bites and gout.

Previously, reviews by Tomás-Barberán et al. [11], Fernández-Moriano et al. [12], Chutulo et al. [13], and Kazmi et al. [14] have reported on the phytoconstituents and bioactivities of plants including *Arthothelium awastii*, *Parmotreme tinctorum*, *Azadirachta indica*, *Nigella sativa*, and *Prunus avium*. However, to the best of our knowledge, there no review has placed emphasis on differences and similarities in flavone, phenolic acid, or alkaloid metabolic profiles of plants obtained from different families, particularly Moringaceae and Solanaceae. Hence, this review aims to complement earlier reviews by providing collective information, comparing and contrasting the metabolic profiles and metabolic relevance in the modern era of compounds obtained from *Moringa oleifera* and *Solanum lycopersicum*. The reader is presented with an update on the health-promoting applications of phenolic and alkaloid-based metabolites obtained from *Moringa oleifera* and *Solanum lycopersicum*. Thereafter, challenges and recommendations are discussed to educate the reader on how better to handle and obtain the most nutritional value from these versatile nutraceuticals, *Moringa oleifera* and *Solanum lycopersicum* [11–14].

2. Comparison of Polyphenolic Profiles of *Solanum lycopersicum* and *Moringa oleifera* and Thier Resultant Antioxidant Activities

Structural Variation in Phenolic Acids and Flavones in Solanum lycopersicum and Moringa oleifera

Solanum lycopersicum and *Moringa oleifera* have been reported to contain polyphenolic phytochemicals. These include quinic and hydroxylated or methoxylated cinnamic acid derivatives [15–18]. Common polyphenols in *Solanum lycopersicum* and *Moringa oleifera* include cinnamic acids (phenolic acids), some of which include gallic, ferulic, caffeoyl, and p-coumaric acids, and cyclic polyphenols such as quinic acids. *Solanum lycopersicum* and *Moringa oleifera* were both reported to contain the esterification product of cinnamic acid and quinic acid. One example of an ester is caffeoyl quinic acid (CQA), which is derived from the reaction of quinic acid and caffeic acid, and has been reported in *Solanum lycopersicum* [19,20]. Examples include 5-CQA [21], CQA and tricaffeoylquinic acid [22], 3-CQA [23], 3-CQA, 5-CQA, and 4-CQA [16], diCQA, and p-coumaroylquinic acid [24].

Hamany-Djande et al. [25] reported identification of three chlorogenic acids in *Moringa oleifera*; caffeoyl quinic acid (CQA), coumaroyl quinic acid (CoQA), and feruloyl quinic acid (FQA). Rodriguez-Perez et al. [26] characterized eleven phenolic acids and derivatives from *Moringa oleifera*. Seven of the identified phenolic acids were identified for the first time in *Moringa oleifera* leaves and in the Moringaceae family. They reported four isomers of CQA and two isomers of FQA, characterized for the first time in *Moringa oleifera* leaves. One fragment corresponded to [M-CH3-CO2-H]- from ferulic acid and another fragment corresponded to the loss of ferulic acid and five isomers of CoQA, with one fragment being identified as 4-p-CoQA, also identified for the first time in *Moringa oleifera* and the Moringaceae family [26]. A study by Bennett et al. [27] identified 3- and 5- CQA in *Moringa oleifera* leaves. Ziani et al. [28] also reported the presence of 3-CQA, 4-CQA and 3-CoQA in *Moringa oleifera* leaves.

Flavonoids are a wide-ranging group of metabolites with estimates of over 10,000 compounds reported [29,30], some of which have been observed in *Moringa oleifera* and *Solanum lycopersicum*. From this cluster, 6500 of these flavonoids are made up of a 15-carbon skeleton [31]. The flavonoids highlighted therein can be further broken down into flavonols, flavones, flavanones, isoflavones, anthocyanidins, chalcones, aurones, and flavanols [32]. The basic skeletal design of flavonoid molecules is based on the (2-(2′-phenyl)-chromen-4-one) which consists of two benzene rings denoted as A and C, connected by a three-carbon chain that forms a closed pyran ring (B ring), which fuses with ring A as shown in Figure 1 [33]. Additionally, the skeleton (2-(2′-phenyl)-chromen-4-one) structure of flavonoids consists of a C2–C3 double bond and 3-hydoxy group with 4-Oxo group in ring B. The basic skeletal structure (2-(2′-phenyl)-chromen-4-one) is so versatile that it permits other combinations of multiple hydroxyls, methoxyl, and glycoside sub-

stituents to attach to R′ (Figure 1), some of which include solabiose (galactose + glucose+ rhamnose), chacotriose (glucose + rhamnose + rhamnose), and rutinoside (rhamnose + glucose) [33]. Examples of flavones include isorhamnetin, quercetin, kaempferol, and myricetin; Isorhamnetin-3-O-rutinoside was reported in *Moringa oleifera* [34] while the carbohydrate side chain linked to isorhamnetin at carbon 3, sophoroside (glucose + glucose), was detected in *Solanum lycopersicum* [35]. This indicates that though the aglycone unit of the flavones may be the same, the arrangement of glycosides attached there can differ, giving rise to unique biological properties [33].

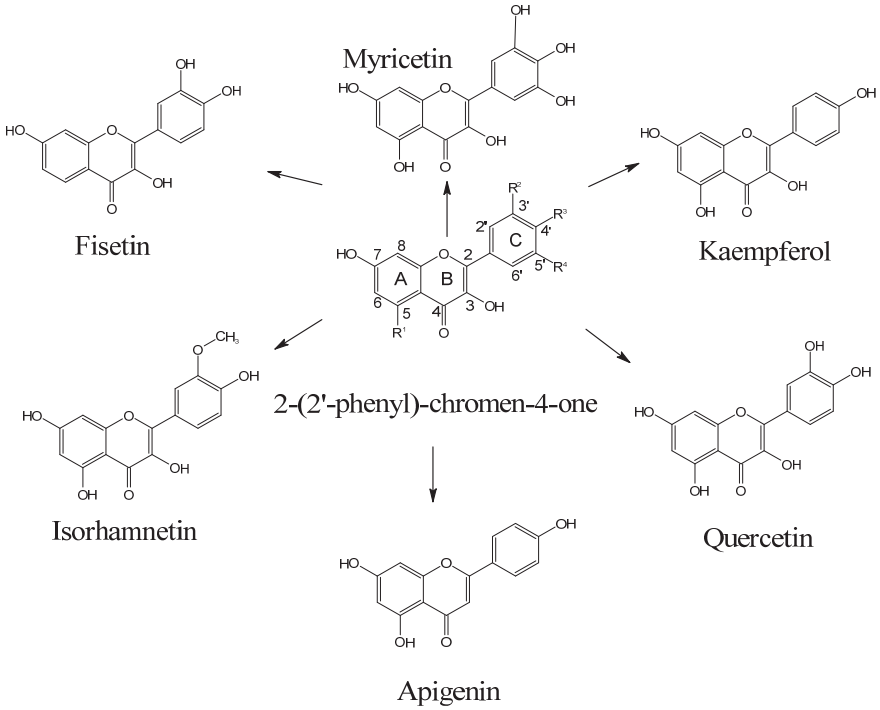

Figure 1. Flavones reported in *Moringa oleifera* and *Solanum lycopersicum*. Mechanistic antioxidant activity of phenolic acids and flavones obtained from *Solanum lycopersicum* and *Moringa oleifera*.

Polyphenolic compounds in both *Solanum lycopersicum* and *Moringa oleifera* are renowned for their anticancer and anti-inflammatory activities [36–38]. Table 1 lists metabolites derived from *Moringa oleifera*, such as kaempferol, isorhamnetin, and quercetin, which can provide antioxidant activity, reduce human leukeamia cells, and promote anti-inflammatory and anti-alzheimer's activity, respectively [39,40]. For instance, flavones such as quercetin, morin, fisetin, and rutin from *Solanum lycopersicum* [39,40] and kaempferol, isorhamnetin, myrecytin, and apigenin from *Moringa oleifera* leaves were observed to form hydrogen bonds with bovine serum albumin [41]. This indicated that the higher free-radical-scavenging and antioxidant abilities of flavones were probably due to the presence of the 4′-OH group on ring C, as well as the 3-OH group on ring B, in addition to other hydroxyl groups on ring C (Figure 1). Kitagawa et al. [42] studied the inhibitory effect of flavonoids on P-gp-mediated transport in KB-C2 cells and found that the inhibitory effect on P-gp decreased in the order kaempferol > quercetin > myricetin > fisetin. Results revealed that the double bonds between C2–C3, 3-OH, 5-OH, 7-OH, and 4′-OH groups (Figure 1) were responsible for the higher activity of flavones, whereas the presence of other hydroxyl group at ring C with the exception of 4′-OH resulted in decreased activity. Flavones in *Moringa oleifera* including kaempferol, isorhamnetin, and quercetin were reported to prevent DNA damage [40], reduce human leukaemia cells [43–45]. *Solanum lycopersicum*, through querctin glucoside and kaempferol rutinoside, has been reported to provide inhibition of sodic-alkaline stress [46]. This arises due to the pro-oxidant action and electrophilic conjugation reaction of polyphenols. For instance, electrophilic conjugation reaction includes the

oxidation of flavonol into electrophilic quinones. The quinones then function as effective electron-pair acceptors, to form nucleophiles such as thiols, amino-containing proteins, and glutathiones yielding biologically active flavonol adducts. The chemical sites responsible for anti-inflammatory activity are the C2–C3 double bond, 5-OH and 7-OH groups at ring A, and the 4′-OH group at ring B (Figure 1). Furthermore, as indicated in Table 1, both *Solanum lycopersicum* and *Moringa oleifera* have been observed to produce cinnamic acids such as chlorogenic acid (caffeoyl quinic acid), gallic acid, and caffeic acid, which have been reported to inhibit galectin-3, trichorderma harzianum, and diabetes.

Solanum lycopersicum and *Moringa oleifera* were observed to contain common polyphenolic metabolites including gallic, ferulic, caffeoyl, and p-coumaric acids, quercetin, and kaempferol derivatives, the majority of which have been shown to be efficient antioxidants. Additionally, mono/polysaccharides attached to the (2-(2′-phenyl)-chromen-4-one) were reported with various bioactivities (Table 1). There were also differences in polyphenolic composition between *Moringa oleifera* and *Solanum lycopersicum*, with isorhamnetin-3-O-rutinoside and isorhamnetin sophoroside observed in *Moringa oleifera* and *Solanum lycopersicum*, respectively, as a result of differences in the arrangement of the carbohydrate sugar side chains glycosylated to (2-(2′-phenyl)-chromen-4-one) (Table 1).

Table 1. Bioactivities exhibited by flavones and phenolic acids in *Solanum lycopersicum* and *Moringa oleifera*.

Plant Species	Flavones	Phenolic acids	Bioactivity	Reference
Moringa oleifera	Apigenin	-	Anti-inflammatory, anti-Alzheimer's activity	[7]
	-	Caffeic acids; gallic acid	Anti-diabetic and anti-obese properties; inhibits gluCose-6-phosphate translocase in rat liver	[39]
	Isorhamnetin	-	Reduces human leukaemia cells	[40]
	Kaempferol	-	Prevents DNA damage, antioxidant	[40,43]
Solanum lycopersicum	Quercetin glycoside	-	Inhibition of sodic-alkaline stress	[46]
	Kaempferol rutinoside	-	Inhibition of sodic-alkaline stress	[46]
	-	Chlorogenic acids	Inhibition of galectin-3	[47]
	-	Ferulic acids	Inhibition of galectin-3	[47]
	-	Gallic acid	Inhibition of trichoderma harzianum	[48]
	-	Salicylic acid	Inhibition of trichoderma harzianum	[48]
	-	Caffeic acid	Nematode (*Meloidogyne incognita*) resistance	[49]
	-	Phenylalanine	Resistance to drought stress	[50]
	-	Tyrosine	Resistance to drought stress	[50]

3. Similarities and Differences Due to Cytotoxic Potency against Cancerous Cells of Alkaloids Contained in *Moringa oleifera* and *Solanum lycopersicum*

3.1. Alkaloids in Moringa oleifera and Solanum lycopersicum

Alkaloids are nitrogen-containing organic compounds present in plants. Steroidal alkaloids (SAs) are derived from steroids and are hence classified as tropanes. Alkaloids of this class are prevalent in a range of plants within the Solanaceae family. The synthesis of SAs originated from glycosylation (addition of mono-/polysaccharides) to sterols, contained in the cell cytosol, yielding steroidal glycoalkaloids, as reported by Okamoto et al. [51]. Steroidal glycoalkaloids derived from *Solanum lycopersicum* can provide a chemical barrier against a broad range of pathogens [16,52,53]. Some of the SGAs derived from *Solanum lycopersicum* are shown in Figure 2a, including tomatidine, tomatine, dehydrotomatine, dehyrotomatidine, esculeoside A and esculeoside B, most of which except for the latter two contain spirosolane as the aglycone unit. For instance, α-tomatine, an SGA reported to be obtained from *Solanum lycopersicum*, can be responsible for the disruption of membranes of cancerous cells, leakage of electrolytes, and depolarization of the membrane potential [54]. Although toxic to humans, the presence of α-tomatine is not toxic to the plant itself possi-

bly due the existence of sterol glycosides and acetylated sterol glycosides in tomato cell membranes [55]. Other SGAs have been shown to inhibit roundworms (nematodes), as described by Kirwa et al. [56], and fungi, as reported by Almadiy et al. [57]. Esculeode A and esculeode B were reported by Zhou et al. [58] to inhibit skin-related cancers.

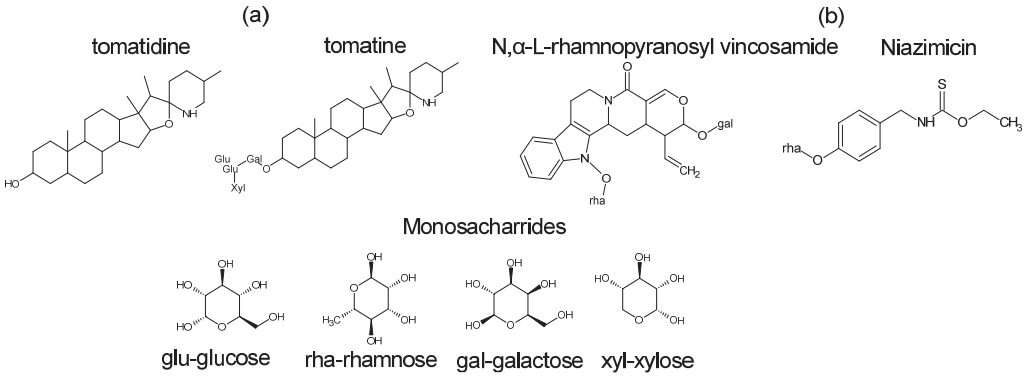

Figure 2. Examples of alkaloids reported in (**a**) *Solanum lycopersicum* and (**b**) *Moringa oleifera*, and common monosaccharides reported to glycosylate the alkaloids.

Alkaloids reported in *Moringa oleifera* have also been found to reduce blood pressure and treat hypertension [59]. Some of the alkaloids that have been isolated from *Moringa oleifera* leaves include *N*,α-L-rhamnopyranosyl vincosamide, phenylacetonitrile pyrrolemarumine,4′-hydroxyphenylethanamide-α-L-rhamnopyranoside, and its glucopyranosyl derivative [39] (Figure 2b). Of these, *N*,α-L-rhamnopyranosyl vincosamide (VR), as studied by Panda et al. [60], was isolated from Moringa leaves and demonstrated cardioprotective potential in rats. This beneficial action of *N*,α-L-rhamnopyranosyl vincosamide (VR) was due to its free-radical-scavenging properties [61].

As discussed in this section, both *Solanum lycopersicum* and *Moringa oleifera* produce alkaloids. A common trait among the two is that *Solanum lycopersicum* and *Moringa oleifera* have both been reported to contain glycosylated alkaloid metabolites with sugars such as glucose, rhamnose, galactose, and xylose, as seen in Figure 2 [16,52,53]. The distinguishing factors between the plants are the aglycone units of the alkaloids, for instance *Solanum lycopersicum* has been observed to produce alkaloids containing 6-fused rings, such as tomatine, tomatidine, dehydrotomatine, eucleoside A, and eucleoside B, whereas *Moringa oleifera* generally contains 5-fused rings (Figure 2a).

3.2. Comparison in Mechanism of Alkaloid Bioactivities of Solanum lycopersicum and Moringa oleifera

Alkaloids obtained from *Solanum lycopersicum* and *Moringa oleifera* have been shown to be bioactive [21,61,62]. The alkaloid α-tomatine, derived from *Solanum lycopersicum*, was reported by Yelken et al. [63] to show inhibitory activity on cell proliferation of human breast MCF-7 cancer cells. In the same paper, they further indicated that α-tomatine−cholesterol interactions within the cell membrane of MCF-7 cancer cells played a vital role in the anticarcinogenic effect of α-tomatine [63]. In another study by Friedman et al. [64], animals receiving a tomatine diet had reduced plasma LDL cholesterol levels with increased dietary tomatine content. This was due to the complexation ability of cholesterol to tomatine [64]. Furthermore, dehydrotomatine, the oxidized form of tomatine, was reported by Pinela et al. [65] to inhibit acetylcholinesterase, an enzyme responsible for catalyzing the production of the neurotransmitter acetylcholine, which is also responsible for cancer [21]. Similarly, alkaloids from *Moringa oleifera* such as niazimicin were reported by Oleg et al. [62] to demonstrate anticancer activity. Panda et al. [60] reported on the cardioprotective behavior of the alkaloid *N*,α-L-rhamnopyranosyl vincosamide. *Moringa oleifera* alkaloids were also reported by Kasolo et al. [66] to be efficient in their antimicrobial activity, achieved by the ability of the alkaloids to intercalate with the DNA of microorganisms.

Glycoalkaloids from *Solanum lycopersicum* have also been reported to disrupt active transport of ions through membranes, proceeding to cause disorders in general body metabolism [67]. For instance, Blankemeyer et al. [55] evaluated the effect of exposure of varying concentrations of α-tomatine and tomatidine on frog embryos and frogs. The study revealed that α-tomatine increased the fluorescence-measured membrane permeability of frog embryos by approximately 600% compared with control values; the corresponding value for tomatidine was about 150%. An illustration of how glycoalkaloids such as α-tomatine incurred damage in the cells of frog embryos is shown in Figure 3a,b. Two phases were involved in the damage caused by α-tomatine in cell membranes. The first involved permeation by α-tomatine through the infected cell membrane by potential hydrogen bond interaction between the carbohydrate side chain of α-tomatine and the polar compartment of the cell-membrane lipid bilayer (Figure 3a) [55]. The alkaloid portion of tomatine interacts with cholesterol, while the sugar groups remain outside the bilipid membrane due to its hydrophilic nature [67]. The extracellular polysaccharides interact with each other through hydrogen bonding, forming a matrix (Figure 3a). Secondly, penetration of the toxic aglycone unit into the cytosol (inner cell compartment) of frog embryos resulted in "loss of barrier function" in the cellular membrane and subsequent changes in ion flux and interstitial currents between neighboring cells (Figure 3b). Therefore, the enhanced activity of α-tomatine relative to tomatidine was due to its sugar moiety, with pores being formed in the lipid bilayer in frog embryos [55]. Thereafter, the increasing porosity of the cell membrane allows permeation of extracellular fluid into the cell, compromising the cytosol's chemistry [68]. This leads to eventual cell death; examples include inhibition of larval growth of *Tribolium castaneum* as reported by Weissenberg et al. [69], and inhibition of acetylcholinesterase as described by Pinela et al. [65].

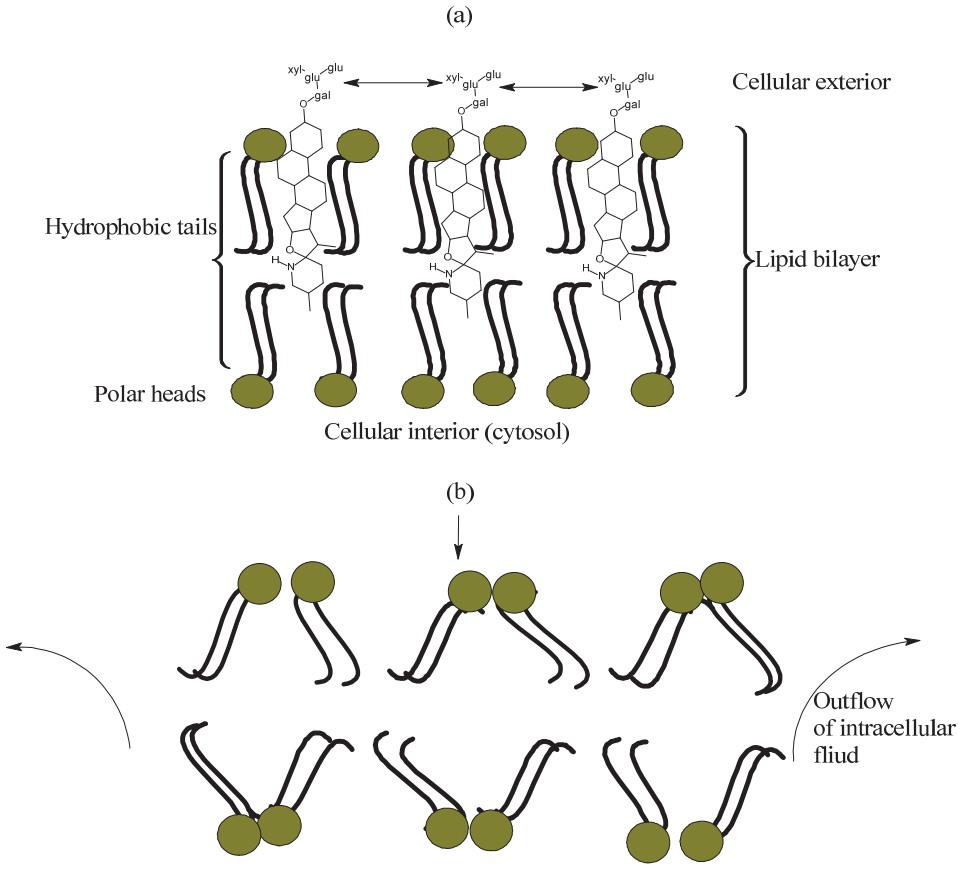

Figure 3. Mechanism of α-tomatine toxicity in cells of frog embryos: (**a**) Hydrogen-bond interaction of α-tomatine polysaccharide chains; (**b**) damage to structural integrity of cell membranes.

Alkaloids have been studied for other bioactivities, as shown in Table 2, which arise from various mechanistic actions. For example, mechanisms of action for alkaloids derived from *Solanum lycopersicum* involve complexation, disruption of active transport of ions through cell membranes, permeation through the infected cell membrane, and penetration of the toxic aglycone unit into the cytosol [65–67]. Alkaloids from *Moringa oleifera* have a different mode of action to those discussed for *Solanum lycopersicum*, including intercalation with the DNA of pathogens [62,70]. This probably indicates that the structural design of the alkaloids, such as 6- and 5-fused rings of *Solanum lycopersicum* and *Moringa oleifera* respectively, and the nature of the sugars attached, all determine the mode of action and subsequent efficiency of the bioactivity. Table 3 presents the dosage concentrations, dosage period, and type of bioactivity of various flavones and alkaloids. Sun et al. [71] reported on minute concentrations (80 μM) of fisetin that were required for anti-cancer activity.

Table 2. Some alkaloids reported in *Solanum lycopersicum* and *Moringa oleifera*.

Plant Species	Alkaloids	Chemical Formula	Bioactivity	Reference
Solanum lycopersicum	Dehydrotomatidine	$C_{27}H_{43}NO_2$	Defensive against fungi and bacteria	[8]
	Dehydrotomatine	$C_{50}H_{81}NO_{21}$	Inhibition of acetylcholinesterase	[21]
	Tomatidine	$C_{27}H_{45}NO_2$	Blocked cell-signalling pathways in macrophages	[21]
	Solasodine	$C_{27}H_{43}NO_2$	Inhibition of nematode Meloidogne incognita	[56]
	Esculeoside A	$C_{58}H_{95}NO_{29}$	Anti-hyaluronidase activity	[58]
	Esculeoside B	$C_{56}H_{93}NO_{22}$	Inhibition of dermatitis	[58]
	Tomatine	$C_{50}H_{83}NO_{21}$	Inhibited larval growth of Tribolium castaneum	[69]
Moringa oleifera	*N*, α-L-rhamnopyranosyl vincosamide.	$C_{32}H_{40}N_2O_{13}$	Cardio-protective activity	[61]
	N, α-L-rhamnopyranosyl vincosamide	-	Antitumor promoter; antimicrobial activity	[62]
	Niazimicin	$C_{16}H_{23}NO_6S$	Anticancer activity	[62]
	Pterygospermin	$C_{22}H_{18}N_2O_2S_2$	Hyperthyroidism, anti-herpes simplex	[62]

N,α-L-rhamno.vin.: *N*,α-L-rhamnopyranosyl vincosamide, 4-(α-L-rham:4-(α-L-rhamnosyloxy)benzyl isothiocyanate.

Table 3. Dosage, period, and bioactivity of some flavones and alkaloids.

Metabolite	Vivo/Vitro	Dosage	Period	Bioactivity	Reference
Fisetin	vitro	0–80 μM	24–48 h	Anti-cancer	Sun et al. [71]
Kaempferol	vitro			Anti-diabetes	Sharme et al. [72]
Quercetin	vitro	2.618 μM		Anti pseudorabies virus	Sun et al. [73]
Tomatidine	vitro	5000 μM	≈26 h	Chikungunya virus	Troost et al. [74]
Tomatine	vitro	0.1–1 μM	24 h	Anti-metastatic melanoma	Serrati et al. [75]
Niazimicin	vivo	250 mg kg^{-1}	15 days	Neuroprotection	Abdelsayed et al. [76]

4. Challenges and Recommendations

Moringa oleifera and *Solanum lycopersicum* both contain efficient and diverse flavone antioxidants, and have been studied to treat the same ailments including liver damage, detoxification of the body's digestive system, and reduction of brain inflammation [77,78]. For instance, Buabeid et al. (2022) reported that hepatoprotection from *Solanum lycopersisum* was induced by isoniazid and rifampicin (INH + RIF), resulting in significant elevation of serum hepatic enzymes including aspartate aminotransferase (AST), alanine amino-transferase (ALT), alkaline phosphatase (ALP), and total bilirubin, while decreasing the albumin level [79]. Additionally, Fattah et al. (2020) reported that hepatoprotection from *Moringa Oleifera* occurred through reduction of oxidative stress–induced DNA damage via amelioration of NF-kB and TNF-α, which maintained hepatocyte integrity and reduced hepatic enzyme activity in serum [80]. However, underlying questions remain of interest to

metabolomics researchers, particularly which between the two plants may be more potent for treatment of ailments such as liver or brain injury, and what other modes of action may be at play within their antioxidant activity due to polyphenols, or anti-pathogen activity due to alkaloids. Furthermore, taking the view that there are a variety of mechanisms present in *Moringa oleifera* and *Solanum lycopersicum* involved in counteracting pathogens and bacteria, there are also questions about what conditions favor one mode of action over another.

The flavones in *Moringa oleifera* and *Solanum lycopersicum* contain the (2-(2′-phenyl)-chromen-4-one) backbone. Additionally, variable mono- and polysaccharide chains with unique arrangements are linked to this (2-(2′-phenyl)-chromen-4-one), diversifying the large cluster of related metabolites. Hence, analysis of the similarities and differences in the metabolic profiles of *Solanum lycopersicum* and *Moringa oleifera* needs to be scrutinized. Fortunately, advancements in technology have led to the development and availability of instruments such as those for ultra-high-performance liquid chromatography–quadrupole time-of-flight mass spectroscopy (UHPLC-QTOF-MS). The appliance of UHPLC-QTOF-MS would permit better isolation from tens of thousands of metabolites and the subsequent characterization of closely related compounds involving geometric and positional isomers, in comparison to conventional instruments such as the ^{1}H-NMR spectrometer. Furthermore, using state-of-the-art analytical tools for UHPLC-QTOF-MS, comprehensive correlations in the metabolic fingerprinting of plants (*Moringa oleifera* and *Solanum lycopersicum*) from two distinct families can be identified. For instance, isomers such as quercetin 3-glucoside and quercetin 3-galactoside can conclusively be determined based on ultra-high performance liquid chromatography–quadrupole time-of-flight mass spectrometry (UHPLC-QTOF-MS) rather than conventional H1-NMR. Bearing in mind that these plants can produce a wide range of complex compounds, it is inevitable that racemic mixtures would be obtained that are extremely difficult to separate using chromatographic techniques. Recently, even more advanced techniques have been developed for the isolation of racemic compounds with unique potential for pharmacological applications. This can be achieved by calculating ion-mobility arrival-time distributions and surface collisional cross sections (CCS), using ultra-high-performance liquid chromatography photodiode array detection ion-mobility high-resolution mass spectrometry (UHPLC-PDA-IM-HR-MS).

5. Conclusions

Solanum lycopersicum and *Moringa oleifera* are two invaluable natural products, due to their metabolite profiles and subsequent nutraceutical potential. Owing to the significant presence of bioactive polyphenols and alkaloid compounds in both plants, it is imperative that the naturally derived metabolites be exploited for various applications. Both *Solanum lycopersicum* and *Moringa oleifera* contain a range of polyphenols. For instance, these plants produce flavonols such as kaempferol and quercetin derivatives that can be glycosylated by different sugars. However, the two plants differ in terms of their alkaloid composition, which results in their capability for different biological functions. While these plants can be used to perform the same pharmacological and nutritional functions resulting from the flavonols they have in common, they remain distinguishable by their alkaloid composition.

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