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Research paper

An evaluation of garlic products available in Australian pharmacies–From the label to the laboratory

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ABSTRACT

Garlic is one of the most commonly used herbal medicines worldwide. There is medium quality evidence to support that specific garlic formulations at specific doses have an antihypertensive effect in a cohort of individuals with hypertension. There is lower quality evidence for garlic's hypolipidaemic effects. While there are many garlic products available in Australian pharmacies, it is unclear if these products are formulated based on the current evidence for use in such populations. The aim of this study was to evaluate garlic product formulations available in Australian pharmacies for quality indicators including: supporting evidence, labelling, product, safety and manufacturing information and the presence of key constituents previously identified as having hypotensive or hypolipidaemic properties. A qualitative evaluation of commercially available garlic products was conducted in accordance with the study aims. Thin-layer chromatography (TLC) was included in the evaluation to investigate the presence of alliin and *s*-allyl cysteine in both garlic products and raw garlic. The quality indicators evaluated in this study including evidence for the formulation used, labelling, product, safety and manufacturing information and key constituents varied significantly between the garlic products available in Australian pharmacies. These findings have a number of implications that relate to the formulations and doses chosen by herbalists, pharmacists and consumers who may consider using garlic products in the management of hypertension and/or dyslipidaemia.

1. Introduction

Garlic *(Allium sativum)* is one of the most commonly used herbal medicines in Australia (Goh et al., 2009). Allicin and *s*-allyl cysteine are the bioactive organosulfur compounds that have been identified in garlic and are attributed to the hypotensive and hypolipidaemic effects of the herb (Shouk et al., 2014; Chan et al., 2013). Both compounds have been shown to inhibit angiotensin converting enzyme and enhance the release of hydrogen sulphide and nitric oxide that act as vasodilators (Shouk et al., 2014). Allicin has also been shown to inhibit 3-hydroxy-3-methyl-glutaryl-coenzyme A reductase and improve lipid profiles (Chan et al., 2013). Collectively, these mechanisms of action have provided pharmacological plausibility for investigating the effects of garlic in people living with hypertension and dyslipidaemia. A range of garlic products are available in various formulations including garlic extract, garlic powder, essential oil, and garlic oil macerate (Amagase et al., 2001). The types of garlic formulation used has been shown to affect both efficacy and safety (Amagase et al., 2001). More recently, a specific garlic formulation that involves an ageing process and standardisation of the bioactive constituent *s*-allyl cysteine has shown promise in the management of hypertension (Chan et al., 2017). Specific garlic powder formulations have also shown promise in the management of dyslipidaemia (Chan et al., 2017).

Australians are one of the world's largest users of complementary medicine (CM) products (Harris et al., 2012). However, an earlier study reported that Australians lack clarity about the regulatory framework for these products (MacLennan et al., 2006). Approximately 50% (n = 3015) of Australian participants believed that CMs were independently evaluated by the Therapeutic Goods Administration (TGA) at the pre-marketing stage for efficacy, quality and safety (MacLennan et al., 2006). Until March 2018, the TGA had a two-tier classification system for CMs; listed or registered. Registered CMs have a higher

Abbreviations: ARTG, Australian Register Therapeutic Goods; CM, complementary medicine; GMP, Good Manufacturing Practice; Rf, retention factor; TGA, Therapeutic Goods Administration; TLC, thin-layer chromatography; USP, United States Pharmacopeia

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status and are subject to independent quality, safety and efficacy evaluation by the TGA, and as such are approved for specific indications prior to their inclusion in the Australian Register for Therapeutic Goods (ARTG) (TGA, 2013b). Very few CMs are of registered status. Currently, the majority of CMs are listed and restrictions are made regarding any therapeutic claims prior to their inclusion on the ARTG. (TGA, 2013a). Manufacturers of listed CMs are required to act in compliance with the Good Manufacturing Practice (GMP) and hold supporting evidence for product claims (TGA, 2013a). The TGA assesses manufacturers' compliance through random reviews of certain newly listed medicines and targeted reviews of CMs identified with potential non-compliance issues (ANAO, 2011). The 'light touch' approach in the regulation of listed CMs was criticised and concerns were raised about the potential quality of products and the evidence held to support their claims of efficacy and safety (Barnes et al., 2016). In March 2018, following a public consultation led by the Australian government (TGA, 2017b), a middle-tier was introduced to the regulatory framework for CMs (TGA, 2018). The new 'assessed listed medicines' pathway was implemented for sponsors to enter their products in the Australia Register of Therapeutic Goods (ARTG). Medicines listed through the assessed listed medicines pathway will not change in regards to self-certification of the safety and quality of the product, but a TGA pre-market assessment for efficacy of evidence supporting the proposed indications will be required.

Poor quality of products can result in poor treatment outcomes due to the lack of active constituents required for a therapeutic benefit. In addition, poor quality products may contain contaminants or adulterants that may cause toxic effects (Coghlan et al., 2015). In addition, there are possible drug herb interactions of garlic including the risk of potentiating the anticoagulant effect of aspirin and warfarin when taken concurrently (Agbabiaka et al., 2017). Therefore, the aim of this study was to evaluate the garlic products available in Australian pharmacies for quality indicators including: supporting evidence, labelling, product, safety and manufacturing information and the presence of key constituents specifically relevant to hypertension and hyperlipidaemia.

2. Materials and methods

2.1. Product availability and evaluation process

Garlic products listed in the Australian Register of Therapeutic Goods (ARTG) were identified using the search terms '*Allium sativum*' and 'garlic' on the TGA (TGA, 2017a) and online pharmacies' websites. A range of business models including independent, small and large chain pharmacies located in the wider metropolitan area of Sydney, Australia were visited to identify the most commonly stocked garlic products. The brand name, TGA listing number, sponsor name and retail price (calculated per tablet or capsule) were recorded. Garlic products that were common to all the pharmacies were identified and included in the analysis due to their accessibility by the broader community. Individual sponsors and manufacturers were contacted initially by email and followed by a telephone call requesting a certificate of analysis and/or any supporting evidence for their garlic product. The supporting evidence obtained was categorised in accordance with the current TGA categories of A to D evidence (TGA, 2017b). Category A includes resources such as herbal pharmacopoeia, herbal monographs and traditional reference texts. Category D evidence refers to higher levels of evidence including double-blind randomised controlled trials and systematic reviews. Product labels and information from the respective product sponsor and/or contract manufacturers' websites were reviewed and assessed for supporting evidence, labelling, product, safety and manufacturing information. The manufacturing practice evaluation was conducted according to a protocol adopted from the World Health Organization guidelines on GMP for herbal medicines (WHO, 2007).

2.2. Chemicals and materials for laboratory assessment

Two batches of each brand of garlic product were purchased in community pharmacies for the qualitative assessment of ingredients and batch-to-batch consistency. Fresh garlic bulbs were purchased in a local supermarket. Alliin, *s*-allyl cysteine, tert-butyl methyl ether, ninhydrin and isopropyl alcohol were purchased from Sigma-Aldrich (Castle Hill NSW, Australia). Glacial acetic acid was purchased from Chem-Supply Pty Ltd (Gillman, SA, Australia). Butan-1-ol was purchased from Ajax Finechem (Green Fields, SA, Australia). Methanol was purchased from ChemAlert (West Perth WA, Australia). Thin-layer chromatography (TLC) plates coated with silica gel 60 F_{254} were purchased from Merck (Frenchs Forest NSW, Australia) and Sigma-Aldrich (Castle Hill NSW, Australia). Filter paper (0.45 μm) was purchased from Fisher Scientific (North Ryde NSW, Australia).

2.3. Qualitative determination of alliin and s-allyl cysteine in raw garlic cloves and garlic products

The presence of alliin and *s*-allyl cysteine in raw garlic cloves and the garlic products was determined using TLC. Four garlic tablets (or contents of the capsules) or garlic cloves were pulverised in a mortar and pestle. The garlic product powder, or the ground garlic cloves, was then mixed in methanol and water (1:1) (70 mL). Undissolved materials in the solutions were removed using filter paper and the filtrates were concentrated to approximately 30 mL by rotary evaporation. The analytes were loaded onto silica-coated TLC plates and developed using a mobile phase of butan-1-ol, isopropyl alcohol, glacial acetic acid and water (3:1:1:1) (United States Pharmacopeial Convention, 2017). To visualise alliin and *s*-allyl cysteine, each plate was treated with 0.08 M ninhydrin in a mixture of butan-1-ol and glacial acetic acid (100:3) and heated for 5 min (100–105 °C) (Pirrung, 2006).

2.4. Uniformity of weight and physical appearance

The *inter*-batch uniformity of weight of garlic dose form was assessed by weighing 20 individual tablets or capsules from each batch using an electronic balance, from which the average weight was then determined. *Inter*-batch average weight difference was calculated using the following equation:

$$\text{inter-batch average weight difference} = \frac{\text{Batch A average weight} - \text{Batch B average weight}}{\frac{\text{Batch A average weight} + \text{Batch B average weight}}{2}} \times 100\%$$

Two batches were considered uniform if the *inter*-batch average weight difference was less than 5% for tablets and less than 10% for capsules (United States Pharmacopeial Convention, 2017).

The *intra*-batch uniformity of weight was assessed in accordance with the guidelines given in the United States Pharmacopeia (USP) (United States Pharmacopeial Convention, 2017). Uniformity of physical appearance was determined by careful visual examination of the tablets or capsules from each batch of garlic products to ensure consistency of colour and undamaged appearance. This process was conducted by two of the research team and recorded as yes or no for uniformity of physical appearance for each product.

3. Results and discussion (Table 1)

A total of 190 products containing garlic as an ingredient were registered as listed CM products on the ARTG. Twenty-six of these products were identified in the 94 community pharmacies visited in July 2017 and 25 were identified in 11 Australian online pharmacies in the initial phase of this project (Appendix Table 1 and 2 in Supplementary data). Of these, the four most widely available and promoted garlic products, with garlic being the principal ingredient were evaluated

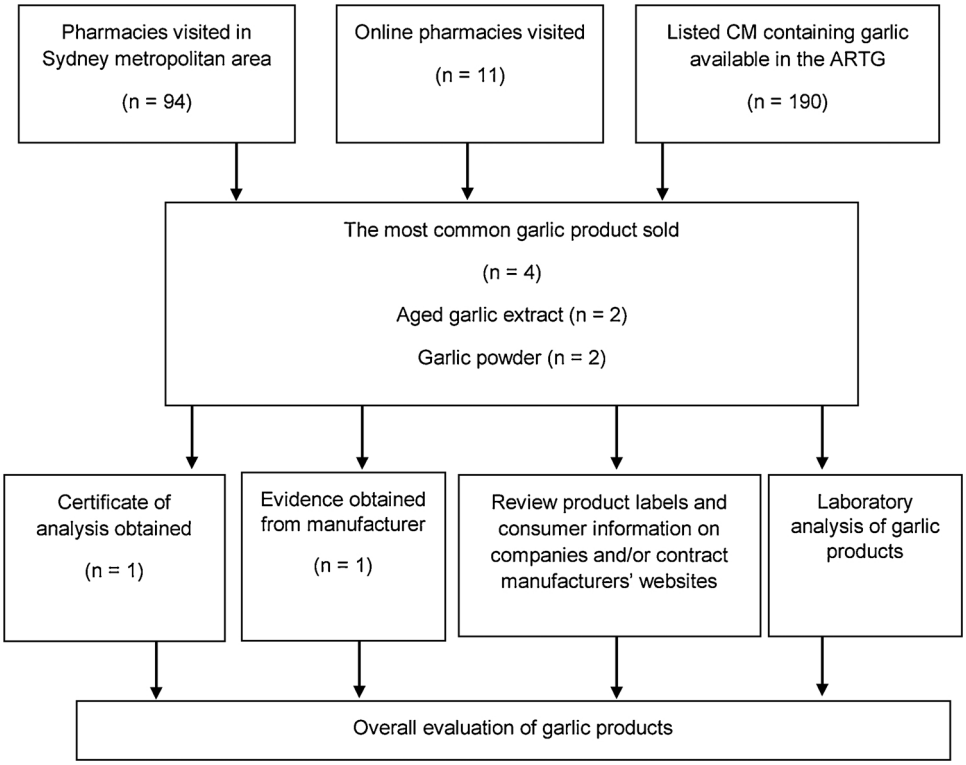

Fig. 1. Flow diagram of evaluation of garlic products.

Table 1
Garlic product description and cost comparison in the Australian community and online pharmacies in 2017.

		Product 1	Product 2	Product 3	Product 4
Product information	Formulation type	Dried garlic powder tablet	Dried garlic powder tablet	Aged garlic extract capsule	Aged garlic extract tablet
	No. of tab/cap	200	100	60	120
	Allium sativum content	Dried bulb concentrate 10 mg	-*	Bulb extract 240 mg	-*
	Equivalent *Allium sativum* content	Fresh bulb 30 mg	Dried bulb 10, 000 mg	Fresh bulb 874 mg	Fresh bulb 2, 000 mg
	Recommended daily dosage	1 – 2 tablet three times daily with meals	1 tablet daily with food	1 – 3 capsules daily with food	2 tablets daily during or immediately after meal
	Reported daily dosage of equivalent *Allium sativum* (mg)	90 – 180	10, 000	874 - 2622	4, 000
Community pharmacy (n = 94)	No. of pharmacies that sold the product	68	44	30	23
	Mean price ($AUD)**	14.98	18.81	20.4	35.7
	Mean price per tab/ cap ($AUD)	0.07	0.19	0.34	0.30
	Price range ($AUD)	5.00 - 21.99	12.99 - 29.99	17.99 - 19.99	29.99 - 49.95
Online pharmacy (n = 11)	No. of pharmacies that sold the product	9	10	5	5
	Mean price ($AUD)	13.31	15.9	19.35	33.56
	Mean price per tab/ cap ($AUD)	0.07	0.16	0.32	0.28
	Price range ($AUD)	9.24 - 14.99	11.47- 17.95	15.99 - 24.95	22.99 - 39.99

* Not provided by manufacturer.
** $AUD are correct as of 07/2017.

(Fig. 1). The selected formulations were either garlic powder or aged garlic extract. Garlic oil macerate and essential oil were excluded due to insufficient evidence for these formulations in the management of cardiovascular disease risk factors (Xiong et al., 2015). Details regarding product availability and costs are presented in Table 1. The quality indicators evaluated for selected products are presented in Tables 2–4.

3.1. Supporting evidence (Table 2)

The sponsor's policies varied with regards to the provision of the specific product information requested. Three of the four sponsors approached were unable or unwilling to provide certificates of analysis or supporting evidence due to intellectual property and commercial-in-confidence policies. Garlic product claims and supporting evidence that were published on sponsors' websites or obtained was evaluated (Table 2).

Monographs and articles reporting the therapeutic properties of garlic in supporting heart health, healthy blood flow, normal blood pressure and its effect on lowering elevated levels of lipids in blood were published on the manufacturers' websites or obtained directly from information provided following phone and/or email communication. Companies who produced products 1, 2 and 4 cited evidence

Table 2
Summary of types of supporting evidence provided by the sponsor for four commonly available garlic products in Australia.

		Product 1	Product 2	Product 3	Product 4
Formulation type		Dried garlic powder tablet	Dried garlic powder tablet	Aged garlic extract capsule	Aged garlic extract tablet
Supporting evidence	Supporting evidence	scientific monograph	Nil	2 dossiers with clinical trials, systematic reviews and meta-analysis; 1 product information page	WHO monographs; 2 publicised international regulatory authority monographs
	Product specific evidence			✓	
	Category of evidence*	B	N/A	D	B

Abbreviation: WHO, World Health Organisation.

* Category A includes traditional reference text, herbal monograph, herbal pharmacopoeia, Materia Medica, publicised international regulatory authority articles (Traditional use); category B includes non-systematic, generalised reviews (e.g. databases), publicised international regulatory authority articles, scientific evidence based reference text, scientific monographs, pharmacopoeias; category C includes observational studies, comparative studies (no control); category D includes double blind randomised controlled trials or cross-over trials, systematic reviews. (TGA, 2017b).

Table 3
Summary of labelling/ product information and safety information provided by the sponsor for four commonly available garlic products in Australia.

		Product 1	Product 2	Product 3	Product 4
Labelling/ product information	Botanical name	✓	✓	✓	✓
	Equivalent to the amount of *Allium sativum*	✓	✓	✓	✓
	List of standardised organo-sulphur compounds				
	Indication	✓	✓	✓	✓
	Dosage	✓	✓	✓	✓
	Formulation			✓	✓
	Duration	✓			✓
	AUSTL no.	✓	✓	✓	✓
	Include consumer information leaflet/ inserts/ monograph (hard copy)				
	Product webpage	✓	✓	✓	✓
	Storage condition	✓	✓	✓	✓
	Physical description of tablet	✓			
	Expiry date	✓	✓	✓	✓
Safety information	Adverse effect reporting				
	Pregnancy/ breastfeeding use	✓			✓
	Surgery	✓			
	Paediatric dosage	✓	✓		
	Warning signs and referral to consult healthcare professionals		✓	✓	
	Drug interactions				✓

Abbreviation: AUSTL no., Australian listed medicine number.

Table 4
Detailed analysis of the manufacturing practice provided by the sponsor for four commonly available garlic products in Australia using the World Health Organization guidelines for good manufacturing practice for herbal medicines (WHO, 2007).

		Product 1	Product 2	Product 3	Product 4
Manufacturing practice	Statement for GMP	✓	✓	✓	
	Details of source of plant (country or region of origin, cultivation, time of harvesting, collection procedure, possible pesticides used, batch number of raw product etc)		✓	✓	✓
	Part of plant used	✓	✓	✓	✓
	Analytical techniques (HPLC, GC, MS) to characterise herbal medicines		✓	✓	
	Identification test for active ingredients		✓	✓	
	Methods used to achieve standardisation			✓	
	Test of contamination (including pesticide, toxic metals, microbial contamination)	✓		✓	
	Sanitation and hygiene during manufacture (monitored water supply, regular waste disposal, equipment cleaning, adequate protective clothing of personnel eg gloves, caps, masks, work suits and shoes throughout manufacturing process)				
	Description of storage area of raw materials (temperature and humidity)				
	Description of production area (facilitate cleaning and avoid microbial and cross-contamination, temperature, humidity)				
	Processing instruction (description of different operations performed on the plant materials eg drying, crushing and milling)			✓	

Abbreviations: GC, gas chromatography; GMP, Good Manufacturing Practice; HPLC, high-performance liquid chromatography; MS, mass spectroscopy.

within monographs and articles that were not specific to the company's garlic formulation and/or dose. It could be argued that referencing positive outcome studies supporting specific formulations and doses that do not match the product being promoted is misleading and may contribute to inappropriate health recommendations and use.

Encouragingly, the comprehensive evidence provided by manufacturer of product 3 was product-specific peer-reviewed research including pre-clinical, double-blinded randomised clinical studies of its product, mode of action and pharmacokinetic research of its active constituents.

3.2. Manufacturing practice (Table 4)

Companies and manufacturers' websites were evaluated to obtain manufacturing practice information (WHO, 2007). Of the four CM assessed, only one CM manufacturer (product 3) displayed the certificate of GMP and risk management programme. One CM manufacturer provided the certificate of analysis (product 1). The certificate of analysis demonstrated rigorous physical and chemical testing to ensure physical uniformity and a contamination-free product. However, the specification of the active constituents of garlic were not assessed. The current study identified various CM manufacturers claimed its quality utilising phrases such as 'TGA certified facilities' (product 4), 'TGA accredited manufacturer' (product 1) and 'rigid quality system' (product 2) instead of providing the manufacturing practice criteria presented in Table 4. This information may easily be misinterpreted by Australian consumers.

Although CM manufacturers are mandated to manufacture in accordance with the GMP, a recent study which evaluated the content of Australian traditional Chinese medicine has found eight of the 11 listed traditional Chinese medicines exceeded safe upper levels of heavy metals (Coghlan et al., 2015). This highlights the importance of an evaluation of CM manufacturing in Australia.

3.3. Labelling and product information (Table 3)

Broad general indications were listed on labels including support general health and wellbeing (Products 1 and 4). Of the four products assessed, products 1 and 2 did not state the formulation used, and/or duration of treatment (Product 2 and 3). In addition, no product listed the amount of standardised organo-sulfur compounds such as alliin, allicin and *s*-allyl cysteine. Such information is essential for those wanting to make an informed decision about the likely efficacy of garlic in the management of hypertension and/or dyslipidaemia. (Ried et al., 2013; Sobenin et al., 2008). It is expected that the content of the key constituents and duration of treatment should be included on label and product information to assist in decision making by pharmacists and consumers.

Due to the current lack of information regarding standardised active constituents on the product labels of the four products included in this evaluation, a laboratory assessment was conducted to examine the presence of the bioactive constituents alliin and *s*-allyl cysteine, and *inter*- and *intra*-batch consistency.

3.4. Qualitative assessment of bioactive constituents of garlic (Table 5)

Allicin and *s*-allyl cysteine are two of the major bioactive organo-sulfur compounds shown to assist in the management of hypertension and dyslipidaemia (Chan et al., 2013; Shouk et al., 2014). Garlic powder contains a high abundance of alliin, which can be converted to allicin by alliinase (Amagase et al., 2001). The major water-soluble compound in aged garlic extract, *s*-allyl cysteine, is synthesised during the aging and extraction process of garlic (Amagase et al., 2001).

The current study conducted a qualitative examination of alliin and *s*-allyl cysteine by TLC (Appendix Fig. 1 in Supplementary). Fig. 2 shows the chemical structures of the two analytes. The calculated retention factor (Rf) values of standard samples of alliin and *s*-allyl cysteine were 0.44 and 0.65, respectively. Our results indicated that products 2 and 4 contained alliin, but none of the products contained *s*-allyl cysteine (Table 5). The absence of *s*-allyl cysteine in all of the products assessed may be due to the low content of *s*-allyl cysteine which may not have been detectable by TLC. As the product with the lowest stated *Allium sativum* content, the TLC results of product 1 indicated that there was no alliin or *s*-allyl cysteine when the sample was prepared from four tablets. Trace of an unknown constituent with an Rf = 0.5 was identified when the sample was prepared with 15 tablets.

This study also analysed the constituents of raw garlic. From our

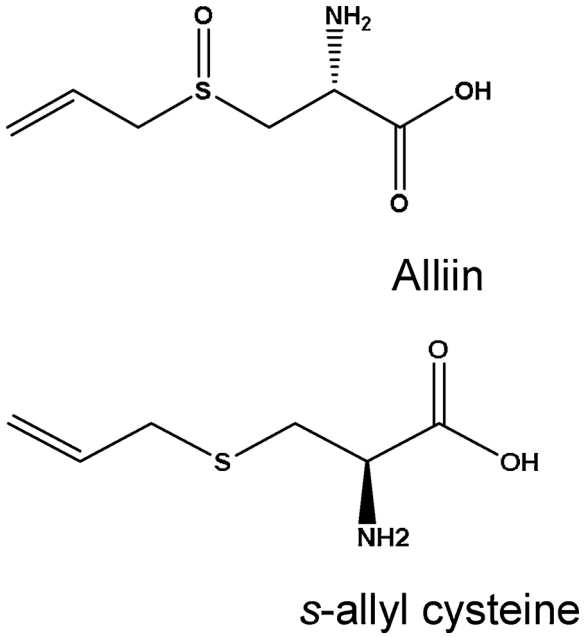

Fig. 2. Structure of analytes (alliin and s-allyl cysteine).

results, the raw garlic samples were shown to contain alliin, but not *s*-allyl cysteine. This is not unexpected, due to the lack of ageing and extraction process that aged garlic extracts usually undergo during their manufacture. Garlic powder is claimed to contain constituents similar to raw garlic (Amagase et al., 2001). However, the two products of garlic powder assessed in the current study demonstrated dissimilarity to the constituents of raw garlic samples. Both aged garlic extracts consistently identified with an unknown constituent with Rf = 0.54. This constituent was also identified in the raw garlic sample. The aged garlic extract product 4 was found to contain an unknown constituent at Rf = 0.39 which was not found in the raw garlic samples. This compound might possibly be a tablet excipient or a constituent synthesised during the ageing and extraction process.

3.5. Inter- and intra-batch consistency of weight and appearance

Inter- and *intra*-batch uniformity of weight and physical appearance was also examined (Table 5). A second batch of product 4 was unavailable, as such, two bottles of the same batch were purchased for *intra*-batch comparison only. Of the four products assessed, three of them were tablets; only product 3 was a hard-capsule formulation. *Intra*-batch uniformity of weight was assessed according to the USP standard and *inter*-batch uniformity of weight was assessed utilising the equation stated in the methods. The USP standards for tablet uniformity of weight requires that (i) no more than two of the tablets vary from the average weight by more than 5% and (ii) none of the tablets vary in weight by more than 10% of the average weight (United States Pharmacopeial Convention, 2017). For capsules, the uniformity of weight requirements state that each individual capsule weight must be within ± 10% of the average weight (United States Pharmacopeial Convention, 2017). All products assessed in this study demonstrated an *intra*-batch uniformity of weight. Product 1, 2 and 3 demonstrated an *inter*-batch uniformity of weight. The average weights of product 1 batches A and B were 0.524 and 0.517 g, respectively, with an *inter*-batch average weight difference of 1.5%. The average weights of product 3 batches A and B were 0.853 and 0.847 g, respectively, with an *inter*-batch average weight difference of 0.66%. Products $4A_1$ and $4A_2$ were identified to have average weights of 0.906 and 0.981 g, respectively. In contrast to the other products, the average weights of batches A and B for product 2 were 1.003 and 0.958 g, respectively, which gave

Table 5
Qualitative evaluation of Australian garlic products using TLC, uniformity of weight and physical appearance.

Brand (batch)	Product 1 (A)	Product 1 (B)	Product 2 (A)	Product 2 (B)	Product 3 (A)	Product 3 (B)	Product 4 (A_1)	Product 4 (A_2)
Presence of alliin by TLC			✓	✓			✓	✓
Presence of *s*-allyl cysteine by TLC								
Intra-batch uniformity of weight	✓	✓	✓	✓	✓	✓	✓	✓
Inter-batch average weight difference (%)	1.5		4.6		0.66		N/A	
Inter-batch uniformity of weight	✓		✓		✓		N/A	
Uniformity of physical appearance	✓	✓	✓	✓	✓	✓	✓	✓

an *inter*-batch average weight difference of 4.6%. While this result is within the 5% acceptable limit, this is an average of just two batches, and further testing may result in a non-compatible product. All products demonstrated uniformity in their physical appearance.

3.6. Cost

Products 1 and 3 were identified to have the lowest and highest price per tablet/capsule respectively ($AUD 0.07/tab and 0.3/cap) (Table 1). Despite the significant variation in cost, this did not align with any of the quality indicators measured in this study.

3.7. Implications to pharmacists and consumers

There is an increasing expectation that pharmacists are knowledgeable about CMs in order to inform appropriate and safe use (Ung et al., 2017b). However, many pharmacists report a lack of confidence in the quality, safety and efficacy of these products (Ung et al., 2017a). In addition, easy access to reliable and reputable information and non-bias CM resources was reported as lacking (Ung et al., 2017a). In this study, the lack of product and consumer information provided by CM sponsors is likely to contribute further to these issues. Importantly, the significant variation in labelling and product information including variations in dosage, formulation, and access to manufacturing standards information limits the ability for both pharmacists and patients/customers to make informed decisions about their appropriate and safe use.

The current study evaluated the garlic products that were most frequently available across pharmacies in Sydney, Australia. The substantial variability of these products may result in goals for therapy not being met for those patients who may be self-managing their cardiovascular disease risk factors. While the literature would support a potential role for specific formulations and dosages, the evidence held by three of the four manufacturers in this project did not align with the product formulations and dosages available to the general population.

These current limitations bring opportunities for improvement in regulatory standards of herbal products. Quality standards that ensure batch to batch consistency of constituents identified as having a therapeutic effect are important. Herbalists and pharmacists are encouraged to request evidence from the providers of herbal products about their quality assurance processes and to ask for a copy of the evidence to support their products indicated use.

3.8. Limitations

The current study conducted a qualitative examination of *s*-allyl cysteine and alliin, the precursor of the bioactive constituent allicin. It is known that allicin formation can be influenced by tablet disintegration rate and alliinase activity (Lawson and Wang, 2001). High-performance liquid chromatography was conducted in the current study; however, the results were not reproducible. As the ultimate aim of the current study was to detect the presence of alliin or s-allyl cysteine, the authors believe TLC was the most appropriate methodology for the current study.

Future research can consider additional measurements including a quantitative determination of these compounds such as high-performance liquid chromatography or liquid chromatography–mass spectroscopy or gas chromatography–mass spectroscopy to make a firm conclusion about the presence or absence of these constituents.

The limited amount of information that sponsors were willing and able to provide restricted the evaluation, range and depth of data reported.

4. Conclusion

The quality indicators evaluated in this study including supporting evidence, labelling, product, safety and manufacturing information, and presence of the key constituents of interest varied significantly between the four most common products available in Australian pharmacies. These findings have a range of implications for both pharmacists and consumers who may consider garlic as an adjunct therapy in the management of hypertension or hyperlipidaemia.

Conflict of interest

This project was funded by an honours student (WJC) allowance from The University of Sydney. Nial J. Wheate owns shares in a company that makes one of the products evaluated in this report.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.hermed.2018.09.004.

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