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## Detection and Quantification of Eurycomanone Levels in Tongkat Ali Herbal Products

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### ABSTRACT

Tongkat Ali is most famous for its aphrodisiac property and has gained reputation worldwide. Due to this, Tongkat Ali products are in demand and can be obtained in various forms. The quality of these products is not often authenticated. As Malaysia is one of the major producing countries of Tongkat Ali products, this study adapted a method which is used to determine the quality of Tongkat Ali products in the market. The quality of those products is based on the level of eurycomanone, the major compound in Tongkat Ali and the level should be around 0.8-1.5 w/v (%). A total of 41 products were obtained internationally and from Malaysia, with different pharmaceutical dosage, single or combined formulation. Those products were analyzed for eurycomanone content using HPLC, C18 column with acetonitrile and water as the mobile phase. The result indicated that 24 of the products contained eurycomanone. Eleven out of the 24 products complied (0.84-8.48% w/v) with the criteria set by Malaysian Standard and 9 of the products even have the eurycomanone level above (1.6-8.48% w/v) the set criteria. It was observed no eurycomanone was detected in some products even though the products have been registered with Malaysian herbal regulatory body, National Pharmaceutical Control Bureau (NPCB). In conclusion, this study suggests that the eurycomanone level should be utilized as a mandatory regulatory parameter for Tongkat Ali herbal preparation in the market besides the current parameters; microbial load and heavy metal contents alone.

**Key words:** *Eurycoma longifolia*, Tongkat Ali, eurycomanone, herbal products, aphrodisiac

### INTRODUCTION

In the past, only rural folks consume herbal remedies because conventional drug is expensive and health facilities are inaccessible. However nowadays, despite the great advances and ease of access towards modern medicine, there is growing interest towards the use of medicinal herbs as people are aware towards the adverse effects of conventional drugs. The herbal-based phytochemical industry is a new and upcoming industrial sector in Asian countries especially due to the open web market.

Tongkat Ali is the most popular tropical herbal plants (Bhat and Karim, 2010). The common herbal products in the market include Tongkat Ali and it has become a very valuable product in the phytochemical industry (Athimulam *et al.*, 2006). Tongkat Ali has gained its reputation as sexual performance enhancer based on traditional uses and personal experiences. Due to personal experience and some scientific studies (Ang and Sim, 1998; Ang and Cheang, 2001; Ang *et al.*, 2004; Tambi and Imran, 2009; Zanolli *et al.*, 2009; Wahab *et al.*, 2010; Low *et al.*, 2013), the demand for Tongkat Ali has increased worldwide.

There are four different species of Tongkat Ali plant, namely *Eurycoma longifolia*, *Eurycoma apiculata*, *Polyathia bullata* and *Goniothalamus* sp. Among the four, *Eurycoma longifolia* is the most commonly used species for the extract production (Athimulam *et al.*, 2006; Hassan *et al.*, 2012). Traditionally, people will boil the Tongkat Ali root chip and drink the decoction. However in line with modern life style, simple consumption method is preferred hence various Tongkat Ali products in the market can be found. To manufacture Tongkat Ali products, usually the root is dried and ground without involving any other chemical processing steps. However, it is also available in the form of standardized extract (Effendy *et al.*, 2012). In the health food market, the products are found as root powder or freeze dried extracts in capsule or pill, formulated drinks and packaged root chips. It has been practiced by some herbal drug producers to mix two or more herbs with perceived aphrodisiac activity into one remedy (Mohd-Fuat *et al.*, 2006) and Tongkat Ali product often is mixed with other herbs with aphrodisiac property such as Ubi Jaga (*Smilax myosiflora*), Maca (*Lepidium meyenii*) and Horney Goat weed (*Epimedium grandiflorum*).

Since, there is a good market for Tongkat Ali products and the production is so rampant, unscrupulous suppliers and manufacturers manipulate the situation by producing fake Tongkat Ali product or putting too little concentration of Tongkat Ali herbs to gain more profits. This is usually done by adding the stem, instead of the root of Tongkat Ali or putting too much filler such as wheat and rice. Due to the popularity of Tongkat Ali, discrepancy in labelling the product can occur where a product is named as Tongkat Ali even though Tongkat Ali is not the main ingredient in the product and some do not even contain Tongkat Ali. It is very usual for Tongkat Ali manufacturer to claim the quality of their products based on extraction ratio, testimonies in the website and some even claim that Tongkat Ali from certain countries is inferior or superior in quality compared to others. The extraction ratio is stated as x:y where x gram of sample producing y gram of extract. However this claim is not easily verified. The quality of commercial preparation is also somewhat questionable. Even worst, some commercial *E. longifolia* products may not even contain any bioactive components of *E. longifolia* (Abdul Rahman *et al.*, 2004). Due to this, the quality of Tongkat Ali products in the market needs to be regulated. Usually herbal products are regulated based on safety aspects such as microbial load, heavy metal and controlled drugs content. Besides safety, the quality of herbal products needs to be regulated to ensure that customers get the best of their purchase hence one verified method is required to ensure the quality of Tongkat Ali products.

Malaysia is the major country in producing Tongkat Ali products and one of the regulatory body in the country, (Malaysian Standard, 2011) set the quality of freeze dried

Tongkat Ali extract products based on several criteria; eurycomanone level, total polysaccharide, total protein and total glycosaponin. This study will utilize the eurycomanone level to determine the quality of Tongkat Ali product as eurycomanone, which is a quassinoid, is the major compound in Tongkat Ali, hence it can be a good indicator on the level of Tongkat Ali in a product. Malaysian Standard (2011) states that eurycomanone level in Tongkat Ali freeze dried extract should be around 0.8-1.5 w/v (%). In this study, the quantification of eurycomanone level in 41 products which were sourced from Malaysia and international market will be carried out.

## MATERIALS AND METHODS

**Sample sourcing:** A total of 41 Tongkat Ali products, in various pharmaceutical dosage forms, both registered and unregistered with NPCB Malaysia, were sourced from Malaysia and international market. Any products bearing the scientific (*Eurycoma longifolia*) and common name (Tongkat Ali) were chosen randomly from the market. Those products were categorized into; Malaysian Registered Products (MRP), Malaysian Unregistered Products (MUP) and International Products (IP). Two herbal products without Tongkat Ali but were promoted as having aphrodisiac effect, were bought as negative controls. Eight samples of premixed coffee, allegedly containing Tongkat Ali were sourced from various herbal outlets in Kuantan, Pahang. Tongkat Ali root sample was sourced from Bentong Pahang. The morphological comparison of the plant was done and found to be similar with the previous deposit at Forest Research Institute of Malaysia (FRIM) having voucher number of MTA 0001.

**Water extraction of Tongkat Ali:** Fifty gram of root chips were put in 600 mL deionized water. The sample then was boiled under reflux for 5 h, followed by filtration with Whatman No 1 filter paper and freeze drying process.

**HPLC analysis:** HPLC (Waters) with photodiode array was utilized and XBridge column (Supelcosil 5  $\mu\text{m}$ , 250 $\times$ 4.6 mm) was used. The mobile phase consisted of isocratic mixture of water and acetonitrile (86:14) with a flow rate of 0.8 mL min<sup>-1</sup>. Five milligram of each sample were dissolved in 1.5 mL water and filtered through 0.45  $\mu\text{m}$  nylon membrane filter. Ten microliter of each sample was injected into the HPLC system. Analysis of each samples were done in triplicate. Limit of Detection (LOD) and Limit Of Quantification (LOQ) for eurycomanone standard were calculated from eurycomanone standard calibration curve in Microsoft Excel.

**Eurycomanone standard preparation:** Five milligram eurycomanone standard (ChromaDex®, USA) was dissolved

in 2 mL deionized water. The stock solution then diluted serially to produce 0.5, 0.25, 0.125, 0.0625 and 0.01325 mg mL<sup>-1</sup> solution, respectively. Contents of eurycomanone were determined from calibration curve generated from the eurycomanone standard compounds.

### RESULTS

A total of 41 products were analyzed for eurycomanone content using HPLC. Eurycomanone level in all products were calculated based on calibration curve of eurycomanone standard in Fig. 1. Figure 2, 3 and 4 show the chromatograms of eurycomanone standard, freeze dried Tongkat Ali extract and product without any Tongkat Ali, respectively. LOD and LOQ for eurycomanone in this analysis are 0.0227 and 0.0690, respectively. HPLC analysis of all 41 products in this study showed data that is well above the LOD and LOQ of eurycomanone. Table 1 shows that 24 of these products contain eurycomanone while 17 without. From Table 2, it can

be observed that freeze dried Tongkat Ali extracts in this study has the highest content of eurycomanone than the rest of the products. Malaysian Standard (2011) stated that the level of eurycomanone should be from 0.8-1.5 w/v (%). Out of the 24 products that contain eurycomanone, 11 of the products have eurycomanone level well above the criteria set by

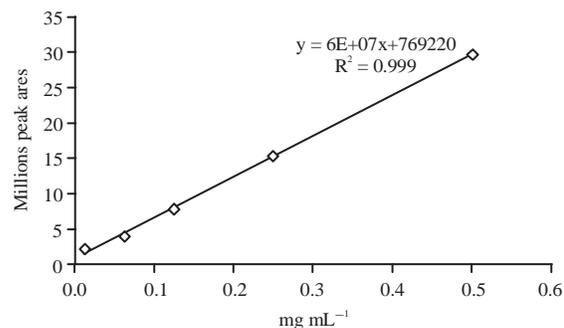


Fig. 1: Calibration curve of eurycomanone standard

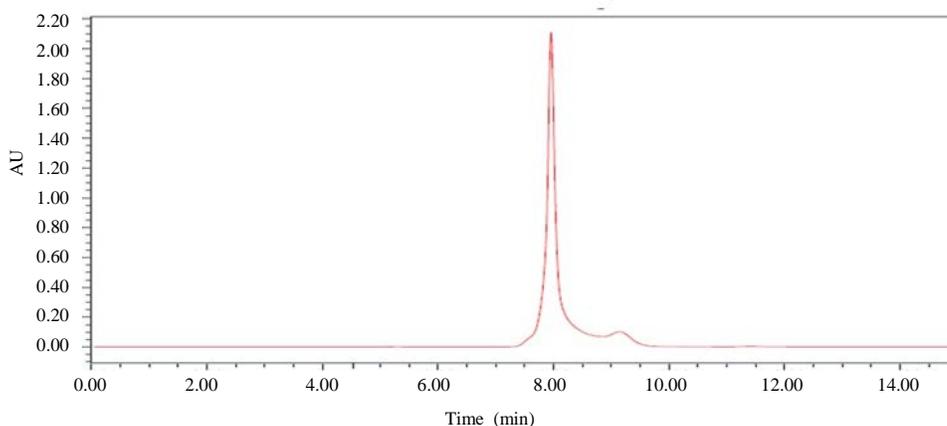


Fig. 2: HPLC chromatogram of eurycomanone standard

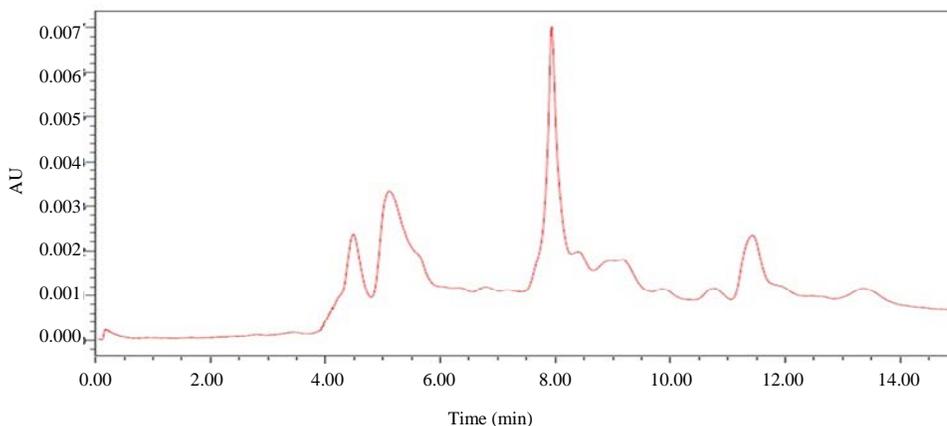


Fig. 3: HPLC chromatogram of freeze dried Tongkat Ali extracts

Table 1: Eurycomanone level in Tongkat Ali products

Sample	Pharmaceutical dosage form	Herbs content (as stated at the label of the packaging)	Eurycomanone level w/v (%)
Freeze dried Tongkat Ali extract (Positive control)	Powder	<i>Eurycoma longifolia</i>	15.15±0.20
Ubi Jaga (Negative control I)	Capsule	Ubi Jaga	nd
Gali Gali (Negative control II)	Capsule	<i>Cornus officinalis</i> , <i>Turnera diffusa</i> , and <i>Psychotriatum olacoides</i> and <i>Piper retrofractae</i>	8.48±0.08
Nii Prep Lelaki (C7) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i>	3.82±0.21
Ubi Jaga Tongkat Ali (C28) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Striga asiatica</i> , <i>Allium sativum</i> , <i>Angullia angullia</i> , <i>Zingiber officinale</i> and <i>Smilax myositiflora</i>	3.53±0.15
Fenugreek Tongkat Ali plus (C21) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , Horny Goat weed, Fenugreek, <i>Trigonella foenum graecum</i> and <i>Epimedium brevicornum</i>	3.33±0.37
Tongkat Ali Plus (C1) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> and <i>Epimedium sagittatum</i>	3.24±0.06
Wild Tongkat Ali (C29) <sup>MUP</sup>	Capsule	Tongkat Ali	2.95±0.26
Tongkat Ali Ginseng (C11) <sup>MUP</sup>	Capsule	Tongkat Ali and Ginseng	2.27±0.07
Eury Goal Tongkat Ali Capsule (C2) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i>	2.12±0.48
Indonesia Tongkat Ali (C41) <sup>IP</sup>	Capsule	<i>Eurycoma longifolia</i>	1.96±0.32
Tongkat Ali (C19) <sup>MUP</sup>	Capsule	Tongkat Ali	1.72±0.30
Pure D <i>Eurycoma longifolia</i> (C14) <sup>IP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Tribulus terrestris</i> , <i>Piper nigrum</i> , <i>Whitania somnifera</i> , <i>Eugenia aromatic</i> and <i>Centella asiatica</i>	1.66±0.30
Formulations For Men (C27) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Gonothalamus flubus</i> , <i>Smilax myositiflora</i> , <i>Smilax myositiflora</i> , <i>Smilax artabolyis</i> , <i>Freycinetia acuminata</i> , <i>Helminthostach zeylanica</i> , <i>Globia panicoides</i> and <i>Globia pendula</i>	1.03±0.24
Ubi Jaga Plus (C26) <sup>MRP</sup>	Capsule	<i>Helminthostach zeylanica</i> , <i>Globia panicoides</i> and <i>Globia pendula</i>	0.99±0.43
100% Tongkat Ali and Ubi Jaga (C16) <sup>MUP</sup>	Capsule	Tongkat Ali and Ubi Jaga	0.84±0.06
Herb Natural Tongkat Ali (C40) <sup>IP</sup>	Capsule	<i>Eurycoma longifolia</i>	0.75±0.37
Herba Tongkat Ali Plus (C6) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Artabolyris</i> sp., <i>Smilax myositiflora</i> , <i>Podocarpus nerifolius</i> , <i>Helminthostach zeylanica</i> and <i>Acalypha indica</i>	0.55±0.26
Tongkat Ali Doctor Formulated (C34) <sup>IP</sup>	Capsule	<i>Eurycoma longifolia</i>	0.40±0.20
Ramuan Akar Kayu (C18) <sup>MUP</sup>	Capsule	Tongkat Ali, Ranjang besi, Ranjang tembaga, Gajah beranak, Akar Pawang and Akar Gamat	0.36±0.14
Ubi Jaga Tongkat Ali Plus (C24) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Smilax myositiflora</i> , <i>Nigella sativa</i> , <i>Allomorpha malaccensis</i> , <i>Trigonella foenum graecum</i> , <i>Zingiber minus</i> , <i>Leptospermum flavescens</i> , <i>Acorus calamus</i> , <i>Coriandrum sativum</i> , <i>Piper longum</i> and <i>Trachyspermum ammi</i>	0.31±0.19
Jamu Sakti (C31) <sup>MUP</sup>	Capsule	Tongkat Ali, Ubi Jaga and Tongkat Ali Hitam	0.26±0.15
Ranjang besi, Tongkat Ali (C17) <sup>MUP</sup>	Capsule	Tongkat Ali, Ubi Jaga, Ranjang besi, Ranjang tembaga and Gajah beranak.	0.22±0.09
Ramuan 4 Jenis Akar (C15) <sup>MUP</sup>	Capsule	Tongkat Ali, Ubi Jaga, Ranjang besi and Akar pawang	0.19±0.33
Kapsul Tongkat Ali (C38) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i>	0.16±0.17
Orang kampung Tongkat Ali (C23) <sup>MUP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Pimpinella anisum</i> , <i>Cuminum cyminum</i> , <i>Zingiber officinale</i> , <i>Coriandrum sativum</i> , <i>Alpha galanga</i> , <i>Curcuma zadoaria</i> , <i>Garlic</i> , <i>Stipegus variegiatus</i> and <i>Piper nigrum</i>	0.08±0.22
Black Jack (C4) <sup>MUP</sup>	Capsule	<i>Eurycoma longifolia</i> and <i>Pohsahia bullata</i>	nd
Tongkat Ali Maca Plus (C8) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , Maca, Ginger, Rice Bran and Black seed	nd
Hurix's Tongkat Ali Plus (C9) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Epimedium brevicornum</i> , <i>Actinolitium</i> , <i>Cynomorium songaricum</i> , <i>Gistanche deserticola</i> , <i>Cuscuta chinensis</i> and <i>Cistanche Deseritcola</i>	nd
Tongkat Ali Hitam Plus (C20) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Nigella sativa</i> , <i>Foeniculum vulgare</i> , <i>Globia pendula</i> , <i>Curcuma domestica</i> , <i>Nigris fructus</i> and <i>Langkas galangal</i>	nd
Jamu Vigor For Men (C25) <sup>MRP</sup>	Capsule	<i>Freycinetia malaccensis</i> and <i>Curcuma xanthorrhiza</i>	nd
Jamu Tongkat Ali (C3) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Smilax myositiflora</i> , <i>Tinospora crispa</i> , <i>Ficus callicarpa</i> , <i>Nigella sativa</i> , <i>Zingiber officinale</i> and <i>Piper cubeba</i>	nd
Jabbar 101 (C35) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Cuminum cyminum</i> , <i>Nigella sativa</i> , <i>Smilax myositiflora</i> , <i>Acorus calamus</i> and <i>Pimpinella anisum</i>	nd
Tanduk Rusa (C10) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Ganoderma</i> , <i>Hypocampus pantrocinum</i> , <i>Yohimbea</i> , <i>Panax ginseng</i> , <i>Syngnathoides biaculeatus</i> and <i>Panurocinum</i>	nd
Kapsul Tongkat Ali Hitam (C22) <sup>MRP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Cuminum cyminum</i> , <i>Nigella sativa</i> , <i>Smilax myositiflora</i> , <i>Acorus calamus</i> , <i>Nigella sativa</i> , <i>Cortandrum sativum</i> , <i>Piper longum</i> , <i>Trachyspermum ammi</i> , <i>Pimpinella anisum</i> and <i>Crodon caudatum</i>	nd
Urat Madu (C30) <sup>MUP</sup>	Capsule	<i>Eurycoma longifolia</i> , <i>Mirisitica fragrans</i> , <i>Zingiber</i> sp. and <i>Curcuma</i> , <i>Yohimbin</i>	nd
Pure Tongkat Ali 200:1 Extract (C5) <sup>IP</sup>	Capsule	<i>Eurycoma longifolia</i>	nd
Tongkat Ali Root Extract (C12) <sup>IP</sup>	Capsule	<i>Eurycoma longifolia</i>	nd
Unleash Your Beast (C13) <sup>IP</sup>	Tablet	Tongkat Ali, Maca and Ginseng (Siberian/Korean)	nd
Testosterone Booster (C32) <sup>IP</sup>	Capsule	Tongkat Ali, Horny goat weed, Saw palmetto, Orchic substance, Wild yam, Sarsaparilla and nettle root	nd
Longjack (C33) <sup>IP</sup>	Capsule	Tongkat Ali, sarsaparilla, pumpkin powder, <i>Muira puama</i> , oat straw, nettle, cayenne paper, astragalus, Catauba, licorice, <i>Tribulus terrestris</i> and orchic oyster	nd
Unleash Power (C39) <sup>IP</sup>	Tablet	Tongkat Ali and panax ginseng, Horny Goat weed, Maca, <i>Xanthoparmelia scabrosa</i> , <i>Chnidium monieri</i> , <i>Mucuna pruriens</i> , guarana, wild yam, Eleutherococcus, <i>Avena sativa</i> , <i>Saw palmetto</i> , <i>Rhodiola rosea</i> , <i>Tribulus terrestris</i> , <i>Muira puama</i> Panax ginseng	nd
<i>Eurycoma longifolia</i> jack extract (C36) <sup>IP</sup>	Capsule	<i>Eurycoma longifolia</i>	nd
Make My Pepper Big (C37) <sup>IP</sup>	Capsule	Tongkat Ali, Maca, Ginseng (Siberian/Korean)	nd

C\*=: Product code, <sup>MRP</sup>Malaysian Registered Product, <sup>MUP</sup>Malaysian Unregistered Product, <sup>IP</sup>International product, nd: not detected

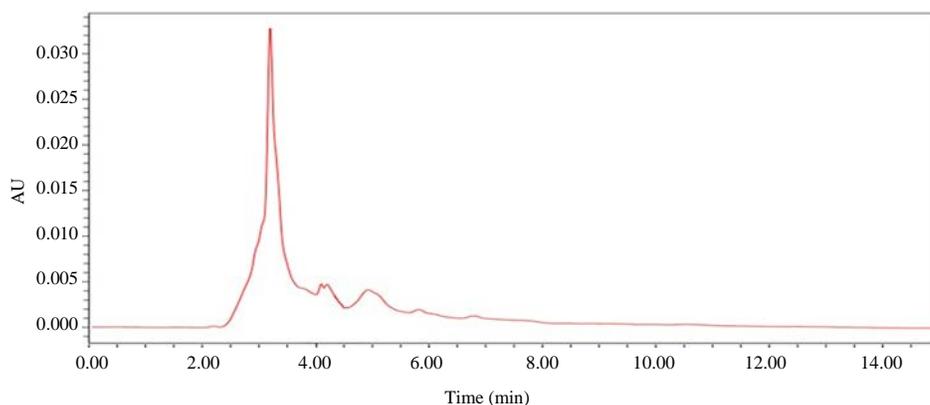


Fig. 4: HPLC chromatogram of a product without any eurycomanone.

Table 2: Summary of products with (+) and without (-) eurycomanone

Sample	(+) Eurycomanone	(-) Eurycomanone
MRP	10	6
MUP	10	3
IP	4	8
Total	24	17

Malaysian Standard. No eurycomanone were detected in nine samples of the premixed coffees (data not shown).

### DISCUSSION

Currently, regulatory control on herbal products ensures that herbal products are free from contaminant such as microbes and heavy metal (Poison Act 1952, Revised 1989), (<http://www.bpfk.gov.my/newst.html>) but does not take into account the quality of a product. Due to different geographical factor, extraction and processing method, quality of products may differ. People buy herbal products due to the assumed healing power and health enhancing property of particular herbs and quality of herbal products might influence its efficacy. This situation called for the quality of herbal products to be checked. It is also to prevent unscrupulous manufacturers from taking advantage of the demand towards Tongkat Ali by producing fake products. The production of herbal remedies is not controlled or regulated and quality assurance of testing for herbal adulteration is a novel task (Bogusz *et al.*, 2006). There are several publications (Abdul Rahman *et al.*, 2004; Ali *et al.*, 2005; Ang and Lee, 2006; Islam *et al.*, 2006; Razak and Aidoo, 2011; Venhuis *et al.*, 2012) that highlighted the quality and safety of herbal products.

41 samples were analysed in this study. There were 16 Malaysian Registered Products (MRP), 13 Malaysian Unregistered Products (MUP) and 12 International Products (IP). Briefly, 70% of the samples in this study were acquired in Malaysia, while 30% were acquired internationally. The large portion of Malaysian products in this study is partly because Tongkat Ali is indigenous to Malaysia (Bhat and

Karim, 2010) and it can be said that Malaysia is one of the major producer of Tongkat Ali products, so the sampling could signify the products that are consumed by people worldwide. It appears to be valid to adapt Malaysian Standard regulatory parameter due to similar reason.

Eurycomanone level was chosen as regulatory parameter in this study because it is the major compound in Tongkat Ali, thus it can signify the level of Tongkat Ali in a product. Furthermore, the analysis utilised High Performance Liquid Chromatography (HPLC), which is simple, highly sensitive and automated equipment.

It is interesting to note that only 4 (C14, C34, C40 and C41) out of 12 international products contain Tongkat Ali. These products were acquired from a reputable online selling website (amazon.com) and it can be said that most people worldwide acquire Tongkat Ali products from this website. It shows here that regulating the quality of Tongkat Ali product worldwide using eurycomanone can be a good indicator on the quality of Tongkat Ali products.

Some products (C11, C19 and C16) showed high level of eurycomanone even though the product did not register with Drug Control Authority (DCA), Ministry of Health (MOH) of Malaysia. This is partly because the processing steps of Tongkat Ali product are so simple, even the cottage industry can get involve easily and probably they do not aware of the necessities to register their product.

It can be observed that some of the products (C3, C8, C9, C20, C25 and C35) were devoid of eurycomanone even though the products have been registered with herbal regulatory body. Thus it can be generalized that product registration offers assurance on product safety but not the quality. It is a major concern when these products that have been registered with DCA, MOH, Malaysia but did not possess any eurycomanone. Although the products have passed the safety aspect set by MOH, it can be said that the product were low in quality as they did not contain any eurycomanone whereby eurycomanone can be indicative of the presence of Tongkat Ali altogether.

Table 2 shows that 6 (C7, C2, C29, C41, C19 and C14) out of 10 products with the highest eurycomanone content consist of products which contain solely Tongkat Ali. It can be generalized that single formulation has been found with higher amount of eurycomanone compared to those mixed herbal products.

## CONCLUSION

The eurycomanone level in 41 products was quantified and 24 viz 58% of these products contain eurycomanone while 17 viz 42% of did not contain any eurycomanone. The 14 of these products complied with the eurycomanone level set by Malaysian Standard (0.8-1.5 w/v (%)) where the eurycomanone level was from 0.99-8.48 w/v (%) while 10 of these products did not comply with the level stated where the amount were below 0.8 w/v (%). It is recommended that regulatory method applying eurycomanone level in determining the quality of Tongkat to be utilized worldwide. MS 2409: 2011 states that the level of eurycomanone should be around 0.8-1.5% (w/v). However, out of 24 products that contain eurycomanone, 11 of them had eurycomanone level higher than 1.5% (w/v). So to further increase the quality of Tongkat Ali products, it can be proposed that the standard may be raised as most of current products in the market have reached the current level easily.

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## REFERENCES

Abdul Rahman, A.S., M.M.S. Yap, A.Y.M. Shakaff, M.N. Ahmad, Z. Dahari, Z. Ismail and M.S. Hitam, 2004. A microcontroller-based taste sensing system for the verification of *Eurycoma longifolia*. Sensors Actuator. B: Chem., 101: 191-198.

Ali, N., N.H. Hashim, B. Saad, K. Safan, M. Nakajima and T. Yoshizawa, 2005. Evaluation of a method to determine the natural occurrence of aflatoxins in commercial traditional herbal medicines from Malaysia and Indonesia. Food Chem. Toxicol., 43: 1763-1772.

Ang, H.H. and H.S. Cheang, 2001. Effects of *Eurycoma longifolia* Jack on laevator ani muscle in both uncastrated and testosterone-stimulated castrated intact male rats. Arch. Pharmacol. Res., 24: 437-440.

Ang, H.H. and K.L. Lee, 2006. Contamination of mercury in tongkat Ali hitam herbal preparations. Food Chem. Toxicol., 44: 1245-1250.

Ang, H.H. and M.K. Sim, 1998. *Eurycoma longifolia* increases sexual motivation in sexually naive male rats. Arch. Pharm. Res., 21: 779-781.

Ang, H.H., K.L. Lee and M. Kiyoshi, 2004. Sexual arousal in sexually sluggish old male rats after oral administration of *Eurycoma longifolia* Jack. J. Basic Clin. Physiol. Pharmacol., 15: 303-309.

Athimulam, A., S. Kumaresan, D.C.Y. Foo, M.R. Sarmidi and R.A. Aziz, 2006. Modelling and optimization of *Eurycoma longifolia* water extract production. Food Bioprod. Process., 84: 139-149.

Bhat, R. and A.A. Karim, 2010. Tongkat Ali (*Eurycoma longifolia* Jack): A review on its ethnobotany and pharmacological importance. Fitoterapia, 7: 669-679.

Bogusz, M.J., H. Hassan, E. Al-Enazi, Z. Ibrahim and M. Al-Tufail, 2006. Application of LC-ESI-MS-MS for detection of synthetic adulterants in herbal remedies. J. Pharm. Biomed. Anal., 41: 554-564.

Effendy, N.M., N. Mohamed, N. Muhammad, I.N. Mohamad and A.N. Shuid, 2012. *Eurycoma longifolia*: Medicinal plant in the prevention and treatment of male osteoporosis due to androgen deficiency. Evidence-Based Complement. Altern. Med., Vol. 2012. 10.1155/2012/125761

Hassan, N.H., R. Abdullah, L.S. Kiong, A.R. Ahmad and N. Abdullah *et al.*, 2012. Micropropagation and production of eurycomanone, 9-methoxycanthin-6-one and canthin-6-one in roots of *Eurycoma longifolia* plantlets. Afr. J. Biotechnol., 11: 6818-6825.

Islam, A.K.M.S., Z. Ismail, B. Saad, A.R. Othman, M.N. Ahmad and A.Y.M. Shakaf, 2006. Correlation studies between electronic nose response and headspace volatiles of *Eurycoma longifolia* extracts. Sensor Actuators B: Chem., 120: 245-251.

Low, B.S., P.K. Das and K.L. Chan, 2013. Standardized quassinoid-rich *Eurycoma longifolia* extract improved spermatogenesis and fertility in male rats via the hypothalamic-pituitary-gonadal axis. J. Ethnopharmacol., 145: 706-714.

Malaysian Standard, 2011. Phytopharmaceutical Aspects of Freeze Dried Water Extract from Tongkat Ali Roots-Specification. Jabatan Standard Malaysia, USA., Pages: 12.

Mohd-Fuat, A.R., K.E. Aidoo, T.W. Calvert and A.A.G. Candlish, 2006. Mycoflora, cytotoxicity and DNA interaction of polyherbal products from Malaysia. Pharm. Biol., 44: 23-31.

Razak, M.F.A. and K.E. Aidoo, 2011. Toxicity studies of *Eurycoma longifolia* (Jack)-Based remedial products. Asian J. Pharm. Clin. Res., 4: 23-27.

Tambi, M.I. and M.K. Imran, 2009. Efficacy of the Malaysian ginseng US patented, standardised water soluble extract of *Eurycoma longifolia* jack in managing idiopathic male infertility. Proceedings of the 9th International Congress of Andrology, March 7-10, 2009, Barcelona, Spain, pp: 165-168.

- Venhuis, B.J., J. Tan, M.J. Vredenburg, X. Ge, M.Y. Low and D. de Kaste, 2012. Capsule shells adulterated with tadalafil. *Forensic Sci. Int.*, 214: e20-e22.
- Wahab, N.A., M.M. Norfilza, W.N.H.A. Halim and S. Das, 2010. The effect of *Eurycoma longifolia* Jack on spermatogenesis in estrogen-treated rats. *Clinics*, 65: 93-98.
- Zanoli, P., M. Zavatti, C. Montanari and M. Baraldi, 2009. Influence of *Eurycoma longifolia* on the copulatory activity of sexually sluggish and impotent male rats. *J. Ethnopharmacol.*, 126: 308-313.