Research performance evaluation of leading higher education institutions in Malaysia

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We carried out a research performance analysis of leading higher education institutions in Malaysia using bibliometric data from the latest (2014) release of the Scimago Institutions Rankings (SIR). We tracked the complete performance chain: input–output–excellence–outcome–productivity using indicators that represent quantity, quality and productivity dimensions. The quantity dimensions are size-dependent, whereas the quality and productivity dimensions are size-independent. The largest active institutions, the most productive institutions and the fastest improving institutions over the period 2009–2014 were also identified.

Keywords: Bibliometrics, higher educational institutions, performance chain, research performance.

IN most countries, the higher education institutions (HEIs) taken together are the biggest contributors to academic research output. In the latest Scimago Institutions Rankings (SIR) World Reports (http://www.scimagoir.com/), all 22 of the top research organizations in Malaysia ranked by output belonged to this sector. These can be considered as significant research-intensive organizations. The first global university rankings of HEIs became available in 2003 when Shanghai Jiao Tong University published the results in what is now known as the Academic Ranking of World Universities (http://www.shanghairanking.com/ARWU2014.html). The Shanghai ARWU rankings, as well as many other similar rankings, e.g. the Leiden rankings, the Taiwan Higher Education Accreditation Evaluation Council University ranking (HEEACT), and the EU Assessment of University-Based Research (AUBR) are based mainly on research indicators and focus predominantly on indicators related to the research function of the universities.

The SIR rankings stand out in that they are comprehensive and rigorous, and also transparent as they are based on Scopus data. One new feature that has been introduced is the indicator called the scientific talent pool (STP), which is the number of authors from an institution in the total publication output of that institution during a particular period of time. This indicator can be taken as a reasonable proxy of the input that goes into scientific research activity.

The SIR reports also give output indicators which can be interpreted as belonging to quantity (size-dependent) and quality (size-independent) dimensions. This allows us to compute a size-dependent composite performance indicator which is the measure of the outcome of the research effort. The ratio of the outcome to the input then becomes a measure of the productivity of the institution, and this is expected to be a size-independent indicator. Also, note that the ratio of the quantity of output to input is another proxy for productivity but without taking into account the quality of research. We thus have an end-to-end performance analysis based on the input–output–excellence–outcome–productivity depending on six-indicators.

The Malaysian higher education system has evolved gradually from its first public university established in 1959 to 20 public universities at present. Since the 1990s, the increasing student demand in Malaysia for university education has led to the changing higher education scenario in the country. The Malaysian parliament passed The Private Higher Educational Institutions Act and the National Accreditation Board Act in November 1996, which led to the establishment of private universities – Multimedia University, as well as branch campus of foreign universities such as Monash University, University of Nottingham and University of Newcastle among others. In parallel, there also exist many private colleges with offer split degrees with international universities in various modes.

In 2006, the Ministry of Higher Education (now merged with the Ministry of Education) identified four research universities – University of Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM) and Universiti Putra Malaysia (UPM) as part of the National Higher Education agenda to enhance the traditional teaching universities to promote research activities and postgraduate training, and meet the aspirations of the country to establish world-class universities. In line with this, these four universities were provided an additional research funding of about RM100 million yearly. In 2012, Universiti Teknologi Malaysia (UTM) was identified as the fifth research university in Malaysia.

In parallel, the annual research budget to the Minisitry of Science, Technology and Innovation (MOSTI) and Ministry of Higher Education (MOHE) has been increased significantly in the last 7 years to assist researchers from universities and research institutions[1–5].

Recent biblometric studies[6] show that Malaysian research productivity has seen an unprecedented growth in research papers indexed by Scopus as well as the Thomson-Reuters *Web of Science* since 2005.

The latest version of the SIR report which has been released on-line in August 2014, allows us to see the time evolution of leading research institutions over a six-year

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Table 1. The scientific talent pool (STP) of the leading 22 Malaysian universities from 2009 to 2014

	STP						
University	2009	2010	2011	2012	2013	2014	SLOPE
International Islamic University Malaysia	0.64	0.81	1.07	1.42	1.82	1.89	275.14
International Medical University			0.35	0.38	0.40	0.42	23.00
MARA University of Technology	0.72	1.09	1.95	2.79	3.82	4.06	735.14
Monash University, Bandar Sunway		0.28	0.33	0.38	0.46	0.47	51.00
Multimedia University	0.94	1.04	1.14	1.21	1.25	1.22	60.00
National University of Malaysia	2.44	2.99	3.53	4.44	5.27	5.47	654.29
Northern University of Malaysia				0.35	0.43	0.45	50.00
Science University of Malaysia	3.02	3.52	4.28	5.04	5.76	5.93	629.43
Technical University of Malaysia Melaka				0.49	0.61	0.63	70.00
Tenaga National University		0.41	0.48	0.54	0.59	0.62	53.00
Tun Hussein Onn University of Malaysia			0.36	0.49	0.64	0.67	108.00
Universiti Putra Malaysia	3.10	3.86	4.51	5.52	6.21	6.40	701.71
University Malaysia Sabah	0.32	0.38	0.46	0.55	0.62	0.61	64.57
University of Malaya	2.83	3.26	3.71	4.34	5.02	5.16	501.71
University of Malaysia, Pahang			0.33	0.48	0.61	0.66	112.00
University of Malaysia, Perlis		0.32	0.46	0.66	0.92	0.97	176.00
University of Malaysia, Sarawak		0.42	0.50	0.63	0.70	0.73	82.00
University of Malaysia, Terengganu			0.39	0.50	0.58	0.58	65.00
University of Nottingham, Malaysia Campus		0.22	0.27	0.32	0.37	0.37	40.00
University of Technology Malaysia	1.38	1.71	2.27	3.12	3.96	4.15	612.86
University of Technology Petronas	0.39	0.54	0.82	1.19	1.42	1.47	240.29
University of Tunku Abdul Rahman			0.36	0.49	0.61	0.64	96.00

window (2009 to 2014). For each of these years, the data used to generate the indicators cover a five-year period; thus, in the report for the year 2014, the results used are those for the five-year period 2008–2012. All variables in the SIR are normalized on the 0–100 scale with the leading institutions in each category having the highest score of 100. Although no direct raw data are given, it is still possible to see how institutions have performed over the years, relative to the leading institutions in each indicator category.

The total number of authors from an institution in the total publication output of that institution during a particular period of time (STP) is a size-dependent indicator which gives a measure or proxy of the input that goes into scientific research activity. Throughout the period 2009 to 2014, Centre National de la Recherche Scientifique (CNRS) of France was listed as the largest institution in the world with the score of 100. From Table 1 we can see that most of the institutions in Malaysia are small by CNRS standards. The Universiti Putra Malaysia is seen to be the largest institution in terms of active scientific researchers. This is followed by USM, UKM and UM. Table 1 also shows the change in STP of the leading 22 Malaysian universities from 2009 to 2014. The SLOPE function available in Excel is used to compute the progress or decline in the size of STP of the the various institutions (Table 1). The MARA University of Technology (UitM) is the fastest growing in this regard. As a general rule, we see that the larger universities are growing faster than the smaller ones. We also see from Table 1 that only 10 HEIs appear continuously in all the report years from 2009 to 2014. Only those institutions that have published over 100 scholarly articles indexed in Scopus during the last year of that period of time are counted. Thus only 10 out of the 22 universities have made this cut in all six years.

The *O* (or output) indicator in SIR is a measure of the quantity or size of the publication output of an institution and is the total number of documents published in scholarly journals indexed in Scopus. It is size-dependent. Again, throughout the period 2009–2014, CNRS was listed as the largest institution in the world with a score of 100 from the output point of view. Table 2 shows how the output of the leading 22 Malaysian universities has varied from 2009 to 2014. We expect that larger institutions will have correspondingly larger output, but with provisions made for variations in productivity. Thus, now UM registers the largest output, having switched places with UPM, which goes to the fourth place. The SLOPE function in Excel shows the high-output universities are also increasing their output at a commensurate rate.

Hendrix[7] has shown that the ratio *O*/STP is a productivity measure that is size-independent. Table 3 captures the time series of the output–productivity (*O*/STP) of the leading 22 Malaysian universities from 2009 to 2014. The reference value for output–productivity is that of CNRS at 1.00. The only two institutions that exceed this norm in 2014 are the University of Nottingham, Malaysia Campus with *O*/STP = 1.135 and the Monash University, Bandar

Table 2. The output of the leading 22 Malaysian universities from 2009 to 2014

	Output						
University	2009	2010	2011	2012	2013	2014	SLOPE
International Islamic University Malaysia	0.31	0.42	0.54	0.74	1.02	1.34	204.29
International Medical University			0.17	0.2	0.24	0.27	34.00
MARA University of Technology	0.32	0.43	0.68	1.18	1.73	2.43	427.14
Monash University, Bandar Sunway		0.22	0.28	0.34	0.43	0.51	73.00
Multimedia University	0.74	0.82	0.89	0.96	1.01	1.01	56.86
National University of Malaysia	1.31	1.68	2.28	2.92	3.95	4.9	725.71
Northern University of Malaysia				0.14	0.2	0.28	70.00
Science University of Malaysia	1.78	2.09	2.5	3.3	4.19	5.08	674.29
Technical University of Malaysia Melaka				0.17	0.26	0.32	75.00
Tenaga National University		0.19	0.29	0.37	0.45	0.52	82.00
Tun Hussein Onn University of Malaysia			0.13	0.26	0.41	0.54	138.00
Universiti Putra Malaysia	1.41	1.75	2.35	3.01	3.9	4.72	676.00
University Malaysia Sabah	0.21	0.24	0.29	0.35	0.43	0.47	55.14
University of Malaya	1.91	2.19	2.65	3.31	4.2	5.12	649.71
University of Malaysia, Pahang			0.12	0.25	0.4	0.53	138.00
University of Malaysia, Perlis		0.16	0.22	0.32	0.5	0.76	148.00
University of Malaysia, Sarawak		0.19	0.24	0.31	0.37	0.44	63.00
University of Malaysia, Terengganu			0.18	0.24	0.31	0.39	70.00
University of Nottingham, Malaysia Campus		0.15	0.22	0.29	0.35	0.42	67.00
University of Technology Malaysia	0.67	0.96	1.24	1.75	2.48	3.27	516.29
University of Technology Petronas	0.15	0.25	0.37	0.63	1	1.26	230.29
University of Tunku Abdul Rahman			0.16	0.26	0.37	0.47	104.00

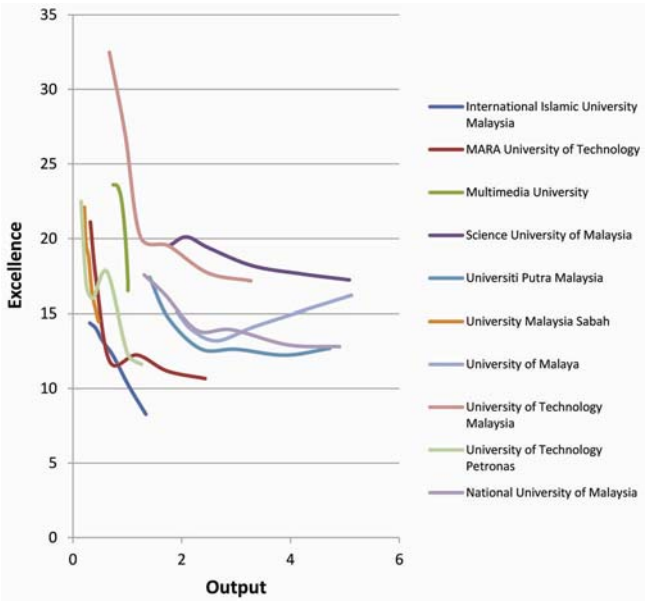

Figure 1. Excellence–output trajectories for the group of high-output universities.

Sunway with *O*/STP = 1.085. Of the purely home-grown universities, UM nearly reached this benchmark in 2014.

So far we have not introduced the quality angle. SIR has several indicators which are proxies of the quality of academic research output, but here we restrict attention to the indicator called the excellence rate, which is the percentage of an institution's scientific output that is included into the set formed by 10% of the most cited papers in their respective scientific fields. It serves as a measure of the high-quality output of research institutions. Again, for each year, these values are normalized so that the highest ranking performer has a score of 100. The first position has changed hands during period the 2009–2014: the Broad Institute of MIT & Harvard occupied the top rank with an excellent rate score of 100 in 2009 and from 2012 to 2014, while the Whitehead Institute for Biomedical Research was credited with a score of 100 in 2010 and 2011. We indicate this normalized quality indicator by *q*.

Table 4 displays the excellence indicator (*q*) of the leading 22 Malaysian universities from 2009 to 2014. Going by this indicator, the highest quality of research is performed at the University of Nottingham, Malaysia Campus and the Monash University, Bandar Sunway. Curiously, the SLOPE indicator reveals that in both institutions, there has been a perceptible decline over the years. Indeed, in all, 16 out of the 22 universities are registering a decline. It is important to keep in mind that these relative declines have to be rationalized in term of the very high standards set by the Broad Institute of MIT & Harvard, which occupied the top rank from 2012 to 2014, and the Whitehead Institute for Biomedical Research which was credited with a score of 100 score in 2010 and 2011.

Figures 1 and 2 capture the excellence–output trajectories for the group of high-output and low-output universities on a two-dimensional map. We see that while most universities have been growing in size, very few have been able to sustain a high level of impact or quality.

Table 3. The output–productivity of the leading 22 Malaysian universities from 2009 to 2014

	Output/STP						
University	2009	2010	2011	2012	2013	2014	SLOPE
International Islamic University Malaysia	0.484	0.519	0.505	0.521	0.56	0.709	36.15
International Medical University			0.486	0.526	0.6	0.643	54.51
MARA University of Technology	0.444	0.394	0.349	0.423	0.453	0.599	29.14
Monash University, Bandar Sunway		0.786	0.848	0.895	0.935	1.085	68.51
Multimedia University	0.787	0.788	0.781	0.793	0.808	0.828	7.84
National University of Malaysia	0.537	0.562	0.646	0.658	0.75	0.896	67.69
Northern University of Malaysia				0.4	0.465	0.622	111.11
Science University of Malaysia	0.589	0.594	0.584	0.655	0.727	0.857	51.66
Technical University of Malaysia Melaka				0.347	0.426	0.508	80.50
Tenaga National University		0.463	0.604	0.685	0.763	0.839	90.91
Tun Hussein Onn University of Malaysia			0.361	0.531	0.641	0.806	144.46
Universiti Putra Malaysia	0.455	0.453	0.521	0.545	0.628	0.738	56.04
University Malaysia Sabah	0.656	0.632	0.63	0.636	0.694	0.77	21.80
University of Malaya	0.675	0.672	0.714	0.763	0.837	0.992	60.85
University of Malaysia, Pahang			0.364	0.521	0.656	0.803	145.31
University of Malaysia, Perlis		0.5	0.478	0.485	0.543	0.784	63.22
University of Malaysia, Sarawak		0.452	0.48	0.492	0.529	0.603	34.93
University of Malaysia, Terengganu			0.462	0.48	0.534	0.672	68.71
University of Nottingham, Malaysia Campus		0.682	0.815	0.906	0.946	1.135	103.78
University of Technology Malaysia	0.486	0.561	0.546	0.561	0.626	0.788	49.18
University of Technology Petronas	0.385	0.463	0.451	0.529	0.704	0.857	90.42
University of Tunku Abdul Rahman			0.444	0.531	0.607	0.734	94.57

Table 4. The excellence indicator of the leading 22 Malaysian universities from 2009 to 2014

	Excellence indicator						
University	2009	2010	2011	2012	2013	2014	SLOPE
International Islamic University Malaysia	14.4	14	13.2	12.2	10.2	8.27	–1229.71
International Medical University			8.63	11.4	12.5	12.2	1173.00
MARA University of Technology	21.1	17.1	11.8	12.2	11.2	10.7	–1991.43
Monash University, Bandar Sunway		23.1	24.1	24.9	24.3	20.9	–436.00
Multimedia University	23.6	23.5	22.7	20.3	17.2	16.5	–1624.00
National University of Malaysia	17.6	16.3	13.9	13.9	12.9	12.8	–970.00
Northern University of Malaysia				8.01	7.66	5.79	–1110.00
Science University of Malaysia	19.5	20.1	19.4	18.2	17.6	17.2	–575.71
Technical University of Malaysia Melaka				23.5	18.1	15.4	–4055.00
Tenaga National University		17.1	19.9	20.3	19.8	18	175.00
Tun Hussein Onn University of Malaysia			10.3	13.1	16	14.6	1583.00
Universiti Putra Malaysia	17.4	14.7	12.7	12.6	12.2	12.7	–889.43
University Malaysia Sabah	22.1	19.6	18.7	16.4	15.1	14.5	–1543.71
University of Malaya	15.1	13.9	13.2	14.1	15.2	16.2	286.57
University of Malaysia, Pahang			10.3	14.4	14.8	14.6	1319.00
University of Malaysia, Perlis		19.7	21.4	20.2	18.6	19	–426.00
University of Malaysia, Sarawak		18.9	19.1	20.6	17.6	16.1	–704.00
University of Malaysia, Terengganu			6.08	7.9	11.1	11.6	1962.00
University of Nottingham, Malaysia Campus		39.8	36.8	35.8	31.9	31.3	–2190.00
University of Technology Malaysia	32.5	27	20.1	19.5	17.7	17.2	–3002.29
University of Technology Petronas	22.5	16.8	16	17.8	12.4	11.6	–1883.43
University of Tunku Abdul Rahman			21.6	17.8	17.1	15.5	–1897.00

So far, we have introduced STP as the primary input-side quantity indicator, and O and q as the primary output-side quantity and quality indicators respectively. One can think of O as a zeroth-order indicator of performance and qO as a first-order composite indicator of performance. Prathap[8] has shown that it is possible to generate a single-valued composite outcome indicator, which is a second-order indicator called the exergy term combining the quantity and quality indicators, $X = q^2O$. Thus, in addition to the output-based productivity indicator O/STP, we can also have an outcome-based one computed as X/STP. Tables 5 and 6 show how the various

Table 5. The exergy indicator of the leading 22 Malaysian universities from 2009 to 2014

	Exergy indicator						
University	2009	2010	2011	2012	2013	2014	SLOPE
International Islamic University Malaysia	64.1	82.7	94.2	109.8	106.3	91.6	6406.65
International Medical University			12.7	25.9	37.3	40.1	9355.60
MARA University of Technology	142.6	126.3	94.4	176.8	215.9	276.1	29104.52
Monash University, Bandar Sunway		117.8	162.9	211.5	254.3	221.9	29967.22
Multimedia University	412.5	453.2	457.0	395.2	297.8	275.6	-34642.81
National University of Malaysia	404.4	446.4	439.9	566.6	659.4	802.8	78793.97
Northern University of Malaysia				9.0	11.7	9.4	202.17
Science University of Malaysia	679.6	845.2	938.0	1090.7	1303.8	1508.1	162025.29
Technical University of Malaysia Melaka				93.9	84.8	75.8	-9044.91
Tenaga National University		55.3	114.6	151.7	175.9	168.3	28726.08
Tun Hussein Onn University of Malaysia			13.8	44.3	105.2	115.3	36513.25
Universiti Putra Malaysia	426.9	379.7	376.1	479.4	583.3	758.9	67835.28
University Malaysia Sabah	102.6	92.4	101.7	94.4	97.8	98.5	-322.31
University of Malaya	436.7	423.7	461.0	658.1	964.0	1343.7	181513.93
University of Malaysia, Pahang			12.7	51.9	87.5	112.5	33492.62
University of Malaysia, Perlis		62.2	100.4	130.4	173.4	273.2	49494.82
University of Malaysia, Sarawak		67.7	87.6	131.4	115.1	113.8	11980.76
University of Malaysia, Terengganu			6.7	15.0	38.3	52.0	15940.46
University of Nottingham, Malaysia Campus		237.2	298.6	372.3	356.6	410.9	40542.18
University of Technology Malaysia	706.8	700.4	502.5	667.5	777.0	964.0	48024.61
University of Technology Petronas	75.9	70.5	94.6	198.7	152.8	169.8	23452.35
University of Tunku Abdul Rahman			74.6	82.6	108.1	113.1	14094.98

Table 6. The outcome-based productivity indicator of the leading 22 Malaysian universities from 2009 to 2014

	Exergy/STP						
University	2009	2010	2011	2012	2013	2014	SLOPE
International Islamic University Malaysia	100.2	102.1	88.1	77.3	58.4	48.5	–11429.76
International Medical University			36.2	68.3	93.3	95.4	20260.52
MARA University of Technology	198.1	115.9	48.4	63.4	56.5	68.0	–23240.63
Monash University, Bandar Sunway		420.7	493.6	556.5	552.9	472.2	16217.10
Multimedia University	438.8	435.8	400.9	326.6	238.2	225.9	–49471.49
National University of Malaysia	165.7	149.3	124.6	127.6	125.1	146.8	–4696.10
Northern University of Malaysia				25.7	27.3	20.9	–2402.30
Science University of Malaysia	225.0	240.1	219.2	216.4	226.4	254.3	2924.13
Technical University of Malaysia Melaka				191.6	139.0	120.3	–35645.56
Tenaga National University		134.9	238.8	281.0	298.1	271.4	33246.52
Tun Hussein Onn University of Malaysia			38.5	90.5	164.4	172.0	47463.76
Universiti Putra Malaysia	137.7	98.4	83.4	86.8	93.9	118.6	–3013.95
University Malaysia Sabah	320.5	243.1	221.2	171.6	157.7	161.5	–31447.30
University of Malaya	154.3	130.0	124.3	151.6	192.0	260.4	21258.92
University of Malaysia, Pahang			38.6	108.2	143.4	170.5	43096.78
University of Malaysia, Perlis		194.4	218.2	197.6	188.4	281.7	14465.29
University of Malaysia, Sarawak		161.1	175.1	208.6	164.5	155.8	–2110.18
University of Malaysia, Terengganu			17.1	30.0	66.0	89.7	25393.63
University of Nottingham, Malaysia Campus		1078.4	1105.9	1163.4	963.8	1110.7	–7752.33
University of Technology Malaysia	512.2	409.6	221.4	213.9	196.2	232.3	–58484.63
University of Technology Petronas	194.5	130.5	115.4	167.0	107.6	115.5	–11776.43
University of Tunku Abdul Rahman			207.2	168.5	177.2	176.7	–8286.13

institutions have performed in terms of the size-dependent X and the size-independent X/STP. On X the best performing universities are USM and UM.

Using SIR 2014 data, we have carried out a systematic end-to-end performance analysis of the leading HEIs in Malaysia: input–output–excellence–outcome–productivity using indicators that represent quantity, quality and productivity dimensions[7]. The quantity dimensions are size-dependent, whereas the quality and productivity dimensions are size-independent. The largest active institutions, the most productive institutions and the fastest improving institutions over the period 2009–2014 have been identified.

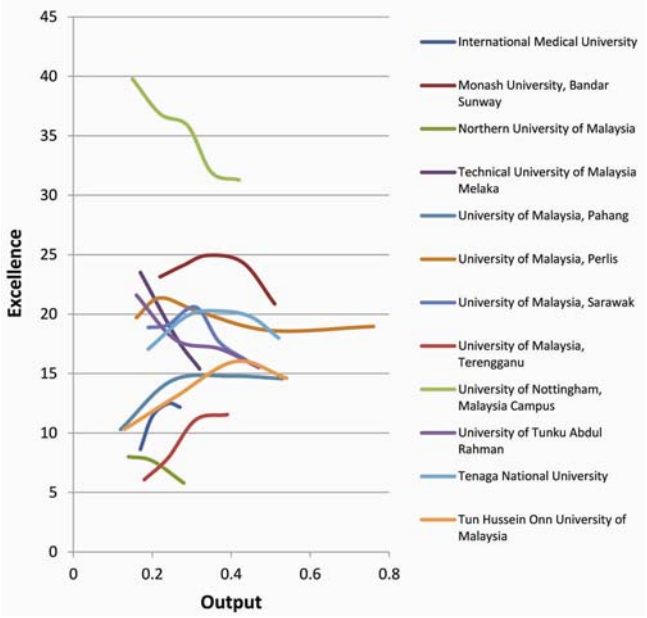

Figure 2. Excellence–output trajectories for the group of low-output universities.

The present study confirms the generally accepted notion that UM and USM are the leading public universities. These two universities are the oldest in Malaysia, established in 1959 and 1969 respectively. In fact, both these universities were ranked at the top 200 in the first THES-QS Best Universities ranking in 2004. UM continues to be ranked in the top 200 of the 2014 QS Best Universities ranking.

In 2012, UM became the first university to be ranked in the Shanghai Jia Tong AWRU top 500 universities. It is now ranked in the 301–400 list of the AWRU 2014. In 2014, the USM was included in the top 500 for the first time.

It is expected that private universities will continue to strengthen their research productivity to enhance their image locally as it will be a good marketing strategy.

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Effect of processing condition on the quality and beany flavour of soymilk

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Soymilk is a water extract of soybean and contains good-quality proteins, fat, minerals and phytochemicals. Regular use of soymilk enhances and protects human health. However, soymilk prepared by traditional method of cold-water grinding has a characteristic beany flavour which may not be acceptable to all consumers. This flavour could be minimized using appropriate processing technology. The present study shows that soymilk with almost negligible flavour could be produced using hot-water grinding and deodorization. Shelf-life of soymilk is about a week when it is pasteurized and stored in a refrigerator. The sensory quality parameters such as appearance, flavour, taste and overall acceptance of soymilk prepared by hot-water grinding followed by deodorization were good, indicating high consumer acceptance.

Keywords: Beany flavour, deodorization, lipoxygenase, phytochemicals, soymilk.

SOYMILK is a water extract of soybean, a grain legume and one of the oldest known food sources of the world to human beings. It contains good-quality ingredients for food, feed and pharmaceuticals and other industrial applications[1,2]. Phytochemicals present in soybean are health-promoting. Soybean is nutritious, economical and eco-friendly. The edible portion of soybean contains about 40% protein, 27% complex carbohydrates, 20% oil, 8%

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