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Proximate composition of Malaysian underutilised fruits

(Komposisi proksimat buah-buahan nadir Malaysia)

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Abstract

The proximate compositions of 42 varieties of underutilised fruits were analysed including *ceri terengganu* (5 varieties), *bambangan* (*Mangifera pajang)* (3 varieties), *dabai* (6 varieties), *asam gelugur (Garcinia atroviridis)* (11 varieties), *durian* (5 varieties), *isu* (5 varieties), *nyekak* (4 varieties) and *sukang* (3 varieties). The moisture content of the fruits ranged from 0.24% to 56.68% with *asam gelugur* Taiping having the lowest and *ceri terengganu* PK24 the highest. *Asam gelugur* Kampung Layang-layang also had the lowest ash content (1.36%) while *ceri terengganu* PK42 had the highest (4.44%). The lowest fat content was in *bambangan* ovoid fruit (0.2%) while the highest was in *durian* 1-89 variety (40.14%). The highest protein content was also found in *durian* 1-89 variety (8.81%) while *asam gelugur* Kampung Biong fruit had the lowest (1.06%). The carbohydrate content ranged from 37.86% (*ceri terengganu* PK4) to 95.26% (*asam gelugur* Bota Kanan). The energy content of the fruits ranged from 166.85 Kcal (*ceri terengganu* PK4) to 567.12 Kcal [*dabai niah (soaked*)]. The proximate compositions of these fruits are useful for developing a Malaysian underutilised food composition database.

Introduction

Consumers are increasingly aware about health to improve the quality of life. Diet is not the only factor that affects well-being and health, but it is one of the most important. The aim is to have a balanced and varied diet containing safer and healthier foods which have pleasant mouth-feels. Consumers who have high purchasing power and greater health problems are very eager to take part in any initiative to keep healthy (Jimenez-Colmenero et al. 2001). The increasing awareness of health modification through diet has led to an upsurge in the availability of nutritionally functional foods that have potential health benefits beyond the basic nutrition (Hasler 1998).

Increased fruit and vegetable consumption has been promoted extensively because of health benefits of many non-nutrient phytochemicals associated with health maintenance and prevention of chronic diseases (Kaur and Kapoor 2001). Consumers are encouraged to take colourful fruits due to the presence of various beneficial phytochemicals that have been studied for their possibilities to prevent certain diseases such as cardiovascular, cancer and eye disorders (Amy et al. 1995).

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A potential source of nutrients, which has not been studied extensively, is the underutilised fruit group which can be found abundantly in Malaysia. Currently, research and development activities on underutilised fruits varieties have become priority areas in developing and developed countries. They are characterised by the fact that they are locally abundant but globally rare, and the scientific information and knowledge about them is limited (Gruere et al. 2009).

Malaysia has a rich multiplicity of underutilised fruits which can be found wild in the regions of Peninsular Malaysia, Sabah and Sarawak. Many of these fruits were eaten locally, having a broad range of flavours and colours with potential health benefits (Ikram et al. 2009). Some of the underutilised fruits which have potential to be exploited for commercial production are the *ceri terengganu* (*Lepisanthes alata*), *bambangan* (*Mangifera pajang* Kosterm.), *dabai* (*Canarium odontophyllum* Miq.), *asam gelugur* (*Garcinia atroviridis*) and wild *durian* (*Durio* spp.)

Ceri terengganu is a non-seasonal fruit which can be found throughout the year. The fruits are arranged closely and attractively in a big bunch or cluster which consists of about 20 fruits/bunch. Each fruit contains 1 – 3 seeds and its flesh is soft and tastes fairly sweet. The tree is small but can reach medium height with spreading out canopy. The purplish colour of the young leaves adds to the attractiveness of the tree (FRIM 2012).

Mangifera pajang Kosterm. belongs to the Anacardiaceae family, ovoid in shape and had the largest fruit among the mango species. The trees of *M. pajang* can grow up to 30 m tall and bear hundreds of fruit and are commonly seen in East Kalimantan (Indonesia) and Borneo Island (Sabah, Sarawak and Brunei). The fruit pulp, which represents 50 – 67% of the total weight, is fibrous and juicy and can be eaten fresh, has a specific aromatic flavour and strong smell while the peel is used for cooking curry. The fruit is commonly referred to as *bambangan* in Malay language and is considered highly seasonal and perishable with limited postharvest shelf-life (Ibrahim et al. 2010).

Canarium odontophyllum Miq. which belongs to the family Burseracea, is locally known as dabai or 'Borneo olives' in Sarawak. It is a seasonal fruit and indigenous to East Malaysia. *Dabai* has male and female flowers borne on different trees and fruits are blue-black in colour when ripe. They are oblong in shape and have a thin, edible skin. The flesh is either white or yellow which covers a large three-angled seed. The fruit is delicious with a unique flavour and oily texture just like an avocado (Dayang et al. 2012).

Garcinia spp. is one of the underutilised fruits used frequently in medicine for reducing weight and excess body fat by halting the glycogen process (Anthony 2012). *Garcinia atroviridis* known as *asam gelugur, asam gelugo* or *asam keping* in Malay is a large rainforest tree native to Peninsular Malaysia. This species grows wild throughout Peninsular Malaysia but is also widely cultivated, especially in the northern states, owing to its economic and medicinal values. The *asam gelugur* tree grows to a height of 20 m and has long trunk, smooth grey bark and drooping branches. The leaves are dark green, shiny, long narrow with a pointed tip and upturned edges. The flowers are dark red and the round yellow to orange fruits are borne singly on twig ends and are 7 – 10 cm in diameter (Anthony 2012).

Durian is widely known and referred to as the 'king of fruits' in Southeast Asia. The durian is distinctive for its large size, unique odour and formidable thorn – covered husk. The fruit can grow as large as 30 cm long and 15 cm in diameter, and typically weighs about 1 – 3 kg/fruit (Michael 1997). Its shape ranges from oblong to round, the colour of its husk green to brown, and its flesh pale yellow to red, depending on the species (Michael 1997). Although the *durian* is commercially cultivated, its wild relative has not been extensively exploited.

Isu is one of the wild *durian* varieties which are found growing wild mostly in the lowland rainforests of Borneo, Peninsular Malaysia and Sumatra. The fruit is medium sized (10 – 12 cm) with yellowish-green skin, many long sharp spines and yellow flesh which are thicker than most *durians* (Frutipedia 2012).

Nyekak is another durian variety found growing wild in mixed dipterocarp forest in central and northern Sarawak. They are also cultivated in these regions. The tree is small to medium with low branching habit growing to a height of 12 – 20 m (DOA 2014). *Sukang* is also a wild *durian* variety which has thinner and drier flesh compared to the cultivated species which has thicker and creamier flesh. The taste is similar to other *durian*, although some have described it as sweetish sour. *Sukang*'s main attraction is its red-coloured flesh (Yumoto 2000).

This study was conducted to determine the proximate composition of the various underutilised fruits described above. This information is useful for development of a Malaysian underutilised food database.

Materials and methods

Preparation of samples

All fruits were obtained from Strategic Resources Research Centre, MARDI. The arils and seeds of all the fruit samples were manually removed. The flesh were then ground using a food processor (Model: FP1200, The Black & Decker Corp., Towson, Md., USA) and 500 g of each sample was put into a container for freeze-drying. The freeze-dried samples were kept at –18 °C until further analysis.

Proximate analysis

The moisture content of samples was determined in triplicate using the method of AOAC (1990). The homogenised sample (5 g) was placed in a 105 °C hot air convection oven (Mermet ULM 800, Germany) until the sample reached a constant weight.

Protein, fat and ash were determined according to methods of AOAC (1984). Protein content was determined by weighing 0.2 g of homogenised sample into a Kjeldahl digestion flask of capacity 30 – 35 ml. Potassium sulphate (1.2 g), mercuric solution (1 ml) and concentrated sulphuric acid (2.5 ml) were added. The mixture was then heated on a top pan heater in a fume cupboard. After heating, 10 ml of alkali mixture was added and the steam was passed through the apparatus until the volume of liquid was 50 – 100 ml. Finally, the liquid was titrated with 0.02 N HCl.

In the method described by Tee et al. (1986), fat content was determined by directly extracting 10 – 40 g of dried ground sample with 150 ml petroleum ether in a Soxhlet extraction apparatus. The residue in the extraction flask after solvent removal represented the fat content of the sample.

The ash content was determined by drying the homogenised sample in a dish in an oven at 130 °C for 24 h. The dried sample was charred until it ceased smoking. The dish was placed in a cold muffle oven until the temperature reached 550 °C. Total ash content was obtained after the weight of the sample was constant.

The carbohydrate content was calculated by difference [100 – (moisture + protein + fat + ash)]. The energy was calculated as follows:

Energy, kcal/100 g = [Fat] x 9 + [Protein] x 4 + [Carbohydrate] x 4

All samples were analysed in three replicates and data were presented in percentage in wet basis.

Results and discussion

The moisture content of the fruits ranged from 0.24% to 56.68% *(Table 1)*. *Asam gelugur* Taiping had the lowest moisture content, while *ceri terengganu* PK24 had the highest. The ash content ranged 1.36 – 4.44%. *Asam gelugur* Kampung Layang-layang also had the lowest

Table 1. Proximate composition of *ceri terengganu, bambangan, dabai, asam gelugur, durian, isu, nyekak* and *sukang* fruits

	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (Kcal)
Ceri terengganu						
Terengganu	23.03 ± 0.02	2.17 ± 0.02	0.80 ± 0.11	2.19 ± 0.02	71.81	303.18
Terengganu PK42	6.19 ± 0.11	4.44 ± 0.12	0.85 ± 0.04	7.30 ± 0.07	81.22	361.70
Terengganu PK44	4.58 ± 0.00	3.59 ± 0.01	0.94 ± 0.07	6.60 ± 0.03	84.30	372.00
Terengganu PK24	8.51 ± 0.21	4.31 ± 0.30	0.71 ± 0.04	6.91 ± 0.08	79.56	352.25
Terengganu PK4	56.68 ± 0.32	2.18 ± 0.00	0.46 ± 0.04	2.83 ± 0.02	37.86	166.85
Bambangan						
Bulat Bekenu	15.97 ± 0.14	2.40 ± 0.02	0.39 ± 0.02	3.33± 0.04	77.90	328.45
Bujur Bekenu	13.63 ± 0.22	2.32 ± 0.04	0.24 ± 0.03	3.10± 0.18	80.70	337.42
Ovoid	13.79 ± 0.13	2.42 ± 0.10	0.20 ± 0.02	3.27 ± 0.01	80.32	336.16
Dabai						
Bekenu	6.56 ± 0.02	3.33 ± 0.10	30.40 ± 0.02	8.53 ± 0.22	51.17	512.43
Bekenu (soaked)	7.17 ± 0.00	3.40 ± 0.05	29.58 ± 0.40	8.66 ± 0.05	51.20	505.62
Kapit	8.88 ± 0.21	3.99 ± 0.04	31.11± 0.10	6.70 ± 0.19	49.31	504.12
Kampung Keluru Tengah	5.38 ± 0.08	3.74 ± 0.02	35.62 ± 0.10	6.28 ± 0.31	48.99	541.61
Niah	6.69 ± 0.14	3.52 ± 0.05	36.82 ± 0.39	5.65 ± 0.26	47.32	543.26
Niah (soaked)	1.03 ± 0.04	3.52 ± 0.10	37.07 ± 0.66	7.38 ± 0.31	51.00	567.12
Asam gelugur						
Taiping (flatten/unripe)	17.84 ± 0.03	1.41 ± 0.05	0.51 ± 0.20	1.75 ± 0.03	78.50	325.57
Taiping (flatten/ripe)	9.76 ± 0.02	1.38 ± 0.03	0.64 ± 0.05	1.47 ± 0.00	86.75	358.64
Taiping (oval/ripe)	0.24 ± 0.00	1.50 ± 0.02	0.81 ± 0.02	1.42 ± 0.07	96.03	397.11
Taiping (oval/unripe)	6.95 ± 0.23	1.80 ± 0.03	0.69 ± 0.04	2.42 ± 0.01	88.15	368.45
Taiping (round/ripe)	16.20 ± 0.04	1.52 ± 0.02	0.52 ± 0.12	1.49 ± 0.06	80.26	331.72
Bota Kanan	0.77 ± 0.04	2.06 ± 0.04	0.58 ± 0.00	1.34 ± 0.01	95.26	391.59

(cont.)

Table 1. (*cont.*)

	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (Kcal)
Kampung Lak Lok	14.12 ± 0.09	1.78 ± 0.15	0.75 ± 0.20	2.04 ± 0.04	81.30	340.15
Kampung Layang-layang	23.21 ± 0.03	1.36 ± 0.06	0.35 ± 0.00	1.55 ± 0.07	73.53	303.44
Kuala Kangsar	20.05 ± 0.00	1.57 ± 0.05	0.37 ± 0.07	1.14 ± 0.01	76.86	315.37
Kampung Biong	15.33 ± 0.21	1.81 ± 0.17	0.56 ± 0.01	1.06 ± 0.03	81.24	334.26
Kampung Tok Kambing	14.12 ± 0.03	1.57 ±0.03	0.37 ± 0.02	1.57 ± 0.02	82.37	339.13
Durian						
PK1	9.06 ± 0.00	2.12 ± 0.07	17.89 ± 0.33	5.80 ± 0.36	65.12	444.73
Batu Kurau 3	7.45 ± 0.03	1.89 ± 0.04	5.49 ± 0.04	5.82 ± 0.02	79.35	390.09
1-89	7.80 ± 0.04	2.88 ± 0.00	40.14 ± 0.21	8.81 ± 0.02	40.37	557.98
B4 P5	8.70 ± 0.11	4.16 ± 0.16	6.34 ± 0.17	8.20 ± 0.30	72.62	380.15
Lenggeng	3.09 ± 0.17	2.98 ± 0.34	12.90 ± 0.08	6.05 ± 0.07	74.97	440.25
Isu						
Miri (oren)	8.98 ± 0.04	3.34 ± 0.04	10.39 ± 0.06	7.82 ± 0.17	69.47	402.63
Kelulit 1	6.03 ± 0.03	2.36 ± 0.06	16.18 ± 0.02	6.72 ± 0.10	68.70	447.40
Kelulit 2	8.15 ± 0.00	2.59 ± 0.01	11.37 ± 0.74	5.86 ± 0.00	72.03	413.86
Kampung Tiris 2	9.37 ± 0.21	2.08 ± 0.09	12.22 ± 0.12	6.18 ± 0.15	70.15	415.31
Miri Merudi 1	12.51 ± 0.07	2.03 ± 0.02	8.87 ± 0.10	5.42 ± 0.05	71.20	386.02
Nyekak						
10/1	3.31 ± 0.00	3.08 ± 0.19	8.64 ± 0.06	6.65 ± 0.11	78.32	417.65
10/2	4.19 ± 0.21	2.84 ± 0.02	4.88 ± 0.03	5.35 ± 0.10	82.74	396.28
Yellow 10/3	3.97 ± 0.06	3.34 ± 0.18	4.68 ± 0.12	5.19 ± 0.03	82.82	394.14
1	6.15 ± 0.07	3.99 ± 0.16	5.67 ± 0.49	7.55 ± 0.09	76.64	387.80

(*cont.*)

Table 1. *(cont.)*

	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Energy (Kcal)
Sukang						
1	5.84 ± 0.12	2.36 ± 0.18	7.53 ± 0.15	6.21 ± 0.07	78.06	404.84
2	4.02 ± 0.03	2.47 ± 0.08	11.15 ± 0.17	6.19 ± 0.03	76.17	429.80
Tengah	7.69 ± 0.08	2.48 ± 0.05	9.10 ± 0.04	5.20 ± 0.27	75.54	404.81

The carbohydrate content was calculated by difference [100 – (moisture + protein+ fat + ash)]. The energy was calculated as below:
Energy, kcal/100 g = [Fat] x 9 + [Protein] x 4 + [Carbohydrate] x 4
Values are mean ± SD, n = 3

ash content while *ceri terengganu* PK42 had the highest. The fat content ranged 0.20 – 40.14% with the lowest fat content in *bambangan* ovoid fruit, while the highest was in *durian* 1-89 variety. The protein content ranged 1.06 – 8.81%. The lowest protein content was in *asam gelugur* Kampung Biong fruit, while the highest was in *durian* 1-89 variety. The carbohydrate content ranged from 37.86% (*ceri terengganu* PK4) to 95.26% (*asam gelugur* Bota Kanan). The energy content of the fruits ranged from 166.85 Kcal in *ceri terengganu* PK4 to 567.12 Kcal in *dabai niah (soaked)*.

Ceri terengganu PK4 had the highest moisture content and it was associated with lowest energy content. *Bambangan*, a juicy fruit has 13 – 15% moisture content. The *dabai* varieties have low moisture but high in fat. The fat content contributes to the high energy content in this variety. The high fat content is associated with the oily texture that had been reported by Dayang et al. (2012). In addition, this fruit was also a good source of unsaturated fatty acids and thus has the potential to be developed as healthy cooking oil (Dayang et al. 2012).

The *asam gelugur* varieties have low fat content, 0.35 – 0.81%. *Asam gelugur* had been reported to contain 10 – 30% (–)-hydroxycitric acid (Jayaprakasha and Sakariah 2002) which helps in reducing weight and excess body fat by halting the glycogen process (Anthony 2012).

Most of the *durian* varieties (*durian, isu, nyekak* and *sukang*) had moisture contents below 10% except for *isu* Miri Merudi 1 which had 12.51%. The energy content ranged between 380.15 Kcal (*durian* B4 P5) and 557.98 Kcal (*durian* 1-89).

Moisture content is one of the most commonly measured properties in food. It is important to be used for legal and labelling requirements. There are legal limits to the maximum or minimum amount of water that must be present in certain types of food. The cost of many foods depends on the amount of water content. Water is an inexpensive ingredient and manufacturers often try to incorporate as much as possible in a food, without exceeding some maximum legal requirement.

The microbial stability also depends on the moisture content. The propensity of microorganisms to grow in foods depends on their water content. For this reason many foods were dried below some critical moisture content. Food quality such as texture, taste, appearance and stability are depending on the amount of water content. The processing operation also need moisture content information to predict the behaviour of foods during processing, such as mixing, drying, flow through a pipe or packaging (McClements and Decker 2009). From the moisture content of underutilised fruits, we can plan and design to develop new products based on legal requirement.

The ash content is a measure of the total amount of minerals present, whereas the mineral content is a measure of the amount of specific inorganic components such as calcium, sodium, potassium and chloride. Determination of the ash and mineral contents of foods is important for nutritional labelling, quality assessment, microbiological stability and food processing (McClements and Decker 2009). The higher ash content indicated higher minerals in the fruits. *Ceri terengganu* PK42 has highest ash among all fruits analysed. This result showed that *ceri terengganu* has highest mineral contents.

Lipid is one of the major constituents in foods and it plays an important role in the diet. Lipids are major sources of energy and provide essential lipid nutrients. Nevertheless, over-consumption of certain lipid components can be detrimental to our health, such as cholesterol and saturated fats. Lipid component in most food plays a major role in determining the overall physical characteristics of the food such as flavour, texture, mouth feel and appearance. Thus it may be difficult to develop low-fat alternatives of many foods because once the fat is removed, some of the most important physical characteristics are lost (Hu et al. 2003). The fat content ranged from 0.20% to 40.14% with the lowest fat content in *bambangan* ovoid fruit, while the highest was in *durian* 1-89 variety. The results on fat content can be utilised by entrepreneurs to develop products with either low or high fat content based on requirements.

Proteins are polymers of amino acids. There are 20 essential amino acids found naturally in proteins. Proteins differ from each other according to the type, number and sequence of amino acids that make up the polypeptide backbone. As a result they have different molecular structures, nutritional attributes and physiochemical properties. Proteins are important constituents of foods for a number of different reasons. They are a major source of energy, as well as containing essential amino-acids, such as lysine, tryptophan, methionine, leucine, isoleucine and valine, which are essential to human health (Nelson and Cox 2005).

Proteins are also the major structural components of many natural foods, often determining their overall texture, such as tenderness of meat or fish products. Isolated proteins are often used in foods as ingredients because of their unique functional properties, such as their ability to provide desirable appearance, texture or stability. Typically, proteins are used as gelling agents, emulsifiers, foaming agents and thickeners. Many food proteins are enzymes which are capable of enhancing the rate of certain biochemical reactions. These reactions can have either a favourable or detrimental effect on the overall properties of foods. Food analysts are interested in knowing the total concentration, type, molecular structure and functional properties of the proteins in foods (Hu et al. 2002). Analyses by Sandhyarani (2001) showed that high protein fruits contained 1 – 1.5 g of protein per 100 g. The protein content of all underutilised fruits studied ranged from 1.06% to 8.81%. Therefore, we can conclude that the underutilised samples had high protein content.

Carbohydrates are important components in many foods. They may be present as isolated molecules, physically associated or chemically bound to other molecules (Westman 2002). Individual molecules can be classified according to the number of monomers that they contain as monosaccharides, oligosaccharides or polysaccharides. Molecules in which the carbohydrates are covalently attached to proteins are known as glycoproteins, whereas those that are covalently attached to lipids are known as glycolipids (McClements and Decker 2009).

Some carbohydrates are digestible by humans and therefore provide an important source of energy, whereas others are indigestible and therefore do not provide energy. Indigestible carbohydrates form part of a group of substances known as dietary fibre, which also includes lignin. Consumption of significant quantities of dietary fibre has been shown to be beneficial to human nutrition, helping reduce the risk of certain types of cancer, coronary heart disease, diabetes and constipation (Friedman 1989). Carbohydrates also contribute to the sweetness, appearance and textural characteristics of many foods (McClements and Decker 2009). The carbohydrate content of samples ranged from 37.86% (*ceri terengganu* PK4) to 95.26% (*asam gelugur* Bota Kanan). The formulation of new products could be developed based on the carbohydrate content of these fruits.

The contribution of energy content in fruits comes from fat, protein and carbohydrate. Water and fibre in foods increase volume and thereby reduce energy density. In their natural state, fruits and vegetables have high water and fibre content and low in calories and energy density (Bell et al. 1998). The result had been proven that *ceri terengganu* has high moisture content but low in calories. So that if we want to choose a low calorie fruits, the moisture content must be high.

Conclusion

All the underutilised fruits studied were quite different in their proximate composition. Food quality such as texture, taste, appearance and stability depend on the amount of water content. The *ceri terengganu* had the highest ash content which indicated that this fruit had the highest mineral content. All samples also had high protein content which can be useful as food ingredients because of their unique functional properties such as their ability to provide desirable appearance, texture or stability. *Asam gelugur* Bota Kanan had the highest carbohydrate content. This fruit can be used as an ingredient for high source of carbohydrate product. These results were useful for future selection of varieties for improvement of nutritional and nutraceutical product characteristics. These findings were also beneficial for compiling a Malaysian underutilised food database. The developed database will be useful to those who are interested to explore the potential of underutilised fruits.

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Abstrak
Analisis proksimat terhadap 42 varieti buah nadir terpilih telah dilakukan pada buah *ceri terengganu* (5 varieti), *bambangan* (*Mangifera pajang)* (3 varieti), *dabai* (6 varieti), *asam gelugur (Garcinia atroviridis)* (11 varieti), *durian* (5 varieti), *isu* (5 varieti), *nyekak* (4 varieti) dan *sukang* (3 varieti). Kandungan lembapan ialah 0.24 – 56.68% dengan *asam gelugur* Taiping paling rendah dan *ceri terengganu* PK24 paling tinggi. *Asam gelugur* Kampung Layang-layang juga mempunyai kandungan abu paling rendah (1.36%) sementara *ceri terengganu* PK42 paling tinggi (4.44%). Kandungan lemak paling rendah didapati dalam buah *bambangan* ovoid (0.2%) dan paling tinggi dalam *durian* 1-89 (40.14%). Kandungan protein paling tinggi juga didapati dalam *durian* 1-89 (8.81%) sementara *asam gelugur* Kampung Biong paling rendah (1.06%). Julat kandungan karbohidrat antara 37.86% (*ceri terengganu* PK4) hingga 95.26% (*asam gelugur* Bota Kanan). Julat kandungan tenaga antara 166.85 Kcal (*ceri terengganu* PK4) hingga 567.12 Kcal [*dabai niah (soaked*)]. Komposisi proksimat buah-buahan ini berguna untuk membangunkan pangkalan data bagi buah-buahan nadir Malaysia.

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