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Vinesh Thiruchelvam · Rayner Alfred · Zamhar Iswandono Bin Awang Ismail · Haviluddin Haviluddin · Aslina Baharum *Editors*

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Analyzing Purchasing Patterns of Agri-Food Commodities for Every State in Malaysia Using Association Rules

Bonaventure Boniface, Geoffrey Harvey Tanakinjal, Rayner Alfred, Mori Kogid, Stephen L. Sondoh, Assis Kamu, Alesia Sigang Gugkang, Anath Rau Krishnan, Nalini Arumugam, Nolila Mohd Nawi, Venus Khim Sen Liew, and Harry Entebang

Abstract Malaysia relies heavily on food imports, making it vulnerable to global market fluctuations and supply chain disruptions. Knowing which agri-food commodities are often consumed together or have complementary markets can inform export strategies and boost the agricultural sector's economic contribution. Market basket analysis can be used to provide valuable insights into the relationships between

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different items in a dataset and can be used for decision-making, recommendation systems, and optimizing business processes. The aim of this paper is to investigate the relationships between agri-food commodities in Malaysia for 13 states and 2 districts using Association rules, as it provides insights into consumer preferences and behavior. The datasets were collected from February 2022 through January 2023 from 13 states and 3 federal territories, which consists of 56,878 number of transactions recorded with 324 number of unique items. Based on the findings of this paper, it can be observed that the extracted rules for every state focuses on different types of agri-food commodities. These extracted rules can be applied for crop planning and production optimization, diversification of agricultural products, supply chain effficiency and local and sustainable agriculture activities. For future works, a more comprehensive validation works is recommended to be conducted to validate these extracted rules so that they can be applied by retailers in each state in Malaysia.

Keywords Purchasing behavior · Agri-food commodities · Apriori algorithm · Food security · Association rules

1 Introduction

Food security is a critical concern for Malaysia, a nation with rich cultural tapestry and a robust economy. Despite its economic strength, Malaysia faces challenges in ensuring a stable and sustainable food supply. Malaysia relies heavily on food imports, making it vulnerable to global market fluctuations and supply chain disruptions. The overreliance on imports poses a risk to the country's ability to meet domestic demand consistently [1]. Therefore, there is a need to understand what customers need, want, and prefer. Analyzing customer purchasing behavior in the agri-food industry for every state in Malaysia is crucial for aligning production with market demand, optimizing resources, improving product quality, and implementing effective marketing strategies. It contributes to the overall sustainability and success of agricultural businesses in a rapidly changing market [2].

Knowing which commodities are often consumed together or have complementary markets can inform export strategies and boost the agricultural sector's economic

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contribution [3]. When the information related to the supply and demand for any agri-food commodities, farmers, distributors, and retailers will be able to understand the relationships of different products at different states in Malaysia and this will enable more efficient production, storage, distribution practices [4–7] and also diversification of agricultural products [7, 8].

The aim of this paper is to analyze the purchasing behaviour of agri-food in every state in Malaysia using Association rules. The paper presents the findings obtained related to the application of Apriori algorithm to investigate the relationship between agri-food commodities bought in Malaysia for the whole year 2022, based on individual states. Datasets were collected from February 2022 through January 2023 which consists of 56,878 number of transactions recorded with 324 number of unique items. This will expose the purchase pattern behavior for all the households, according to states in Malaysia.

The rest of this paper is organized as follows. In Sect. 2, Related Work on recent works related to association rules are described. In Sect. 3, the method and materials used in this paper are outlined and described. Then, in Sect. 4, the results of the experiment conducted, and the discussion are presented. Finally, this paper is concluded in Sect. 5.

2 Related Works

Association rules have been used in various domains, including retail (market basket analysis) [9–11], healthcare (patient diagnosis patterns) [12–14], and web usage mining (user navigation patterns). For instance, association rules that may be utilised to create discounts and package deals are extracted using market basket analysis [9]. These rules can be used as a summary of the patterns that exist in a specific dataset [15, 16].

One may also understand the characteristics of customer preferences after locating trends of purchased items [17]. Besides using market basket analysis, one may also improve recommendation accuracy by using a wide variety of agri-food related data, including SNS opinion mining, consumer's purchase data, climate data, and wholesale price data [18]. Analysis of purchasing behavior allows farmers to identify opportunities for diversifying their product offerings. This diversification can be based on customer demand, leading to the cultivation of a variety of crops that align with market preferences [19].

Understanding customer preferences helps farmers and producers plan their crops more effectively [20]. By growing the crops that are in demand, they can optimize production, reduce waste, and ensure a more sustainable use of resources.

There was also a study conducted that focuses on identifying and analyzing spending trend profiles and developing the per capita consumption models to forecast the fresh agro-food per capita consumption in Malaysia [21]. However, not many works have been conducted to analyze the purchasing behaviour of agri-food in every state in Malaysia in order to understanding customer preferences that helps farmers and producers plan their crops more effectively.

3 Methods and Materials

3.1 Datasets

The KPASM dataset was obtained from consumer from 13 states (Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Perak, Perlis, Sabah, Sarawak, Selangor, Terengganu) or 2 districts (Putrajaya, Federal Territory of Kuala Lumpur and Labuan). There are 56,878 number of transactions recorded with 324 number of unique items. These datasets are stored in a sparse database. Market basket analysis normally requires sparse database. Unlike relational database, sparse database may not have a fixed schema, and they often store data in a more flexible or dynamic way. All transaction databases are in the form of sparse database. In contrast, in relational database summarization, the goal is to create summaries that capture the essential information from the tables and relationships between them [23–27]. On the other hand, sparse databases are often associated with mining association rules.

3.2 Apriori Algorithm

The Apriori algorithm is a popular algorithm for mining frequent itemsets and generating association rules [28, 29]. It uses a level-wise search strategy, starting with frequent itemsets of size 1 and gradually increasing the size until no more frequent itemsets can be found.

Association rules can be defined as an implication expression of the form $X \Rightarrow Y$, where X and Y are itemsets. An itemset is a collection of one or more items. In the context of market basket analysis, an item could be a product in a transaction. For instance, Milk, Diaper $\Rightarrow$ Beer implies that when Milk and Diaper occur together, it is likely or observed that Beer is also present. In other words, An association rule is an implication of the form $X \Rightarrow Y$, where X and Y are itemsets. The rule suggests that if X is present, then Y is also likely to be present.

3.3 Measurements

The quality of the association rules extracted using the Apriori algorithm can be measured using the support, confidence, coverage, List and count [22]. Let have the following symbols and its representation.

1. $X \cap Y$: Total Number of transactions containing both X and Y
2. N: Total Number of transactions
3. X: Total Number of transactions that contain X
4. Y: Total Number of transactions that contain Y
5. R: Total Number of instances covered by the rule.

$$Support(X \Rightarrow Y) = \frac{X \cap Y}{N} \tag{1}$$

$$Confidence(X \Rightarrow Y) = \frac{X \cap Y}{X} \tag{2}$$

$$Coverage = \frac{N}{R} \times 100 \tag{3}$$

$$Lift(X \Rightarrow Y) = \frac{X \cap Y}{Y} \tag{4}$$

$$Lift(X \Rightarrow Y) = \frac{X \cap Y}{N} \tag{5}$$

$$Count(R) = \frac{X \cap Y}{N} \tag{6}$$

Support measures how frequently an itemset appears in the dataset. Confidence measures the reliability of the inference made by a rule. For a rule $X \Rightarrow Y$, where X and Y are itemsets, confidence is calculated as the support of the union of X and Y divided by the support of X. High confidence indicates that the presence of X is likely to be associated with the presence of Y. Lift is a measure of how much more likely item Y is purchased when item X is purchased, compared to when item Y is purchased without item X. A lift value greater than 1 suggests a positive association. Coverage refers to the proportion of instances in the dataset that are covered by a particular rule. It is a measure of how well a rule captures or represents the data. Coverage is an important metric because it helps assess the generalizability or applicability of a rule. Finally, count refers to the number of transactions where both the antecedent X and consequent Y of the rule are present.

4 Results and Discussion

4.1 Johor

In Johor, the top five association rules indicate rules related to vegetables that include Long Bean (Kacang buncis), Lady's Finger (Kacang bendi), Orange sweet potato (Ubi keledek oren), Potato (Ubi kentang), Chili padi (Cili padi), Green chili (Cili hijau) (See Fig. 1).

Based on Table 1, the top rule could imply that when Long Bean (Kacang buncis) occurs, it is likely or observed that Lady's Finger (Kacang bendi) is also present. This rule has the highest LIFT's value of 60.42 for these Long Bean (Kacang buncis) and Lady's Finger (Kacang bendi) commodities.

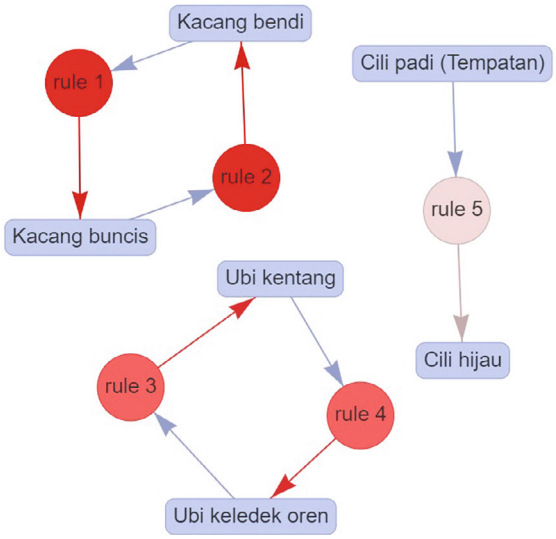

Fig. 1 Top 5 association rules of purchasing patterns extracted for Johor state

Table 1 Quality of Johor's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Kacang buncis ⇒ Kacang bendi	0.01	0.85	0.01	60.42	35
Kacang bendi ⇒ Kacang buncis	0.01	0.51	0.01	60.42	35
Ubi keledek oren ⇒ Ubi kentang	0.01	0.60	0.01	53.28	30
Ubi kentang ⇒ Ubi keledek oren	0.01	0.55	0.01	53.28	30
Cili padi (Tempatan) ⇒ Cili hijau	0.01	0.56	0.01	35.35	35

4.2 Kedah

In Kedah, the top five association rules indicate rules related to chicken (ayam), fruits (buahan), vegetables (sayuran), fish (ikan) and egg (Telur ayam) (See Fig. 2).

Based on Table 2, the top rule could imply that when chicken (Ayam) and vegetables (Sayuran) occur, it is likely or observed that egg (Telur ayam) is also present. This rule has the highest LIFT's value of 61.65 for these chicken (Ayam), vegetables (Sayuran) and egg (Telur ayam) commodities.

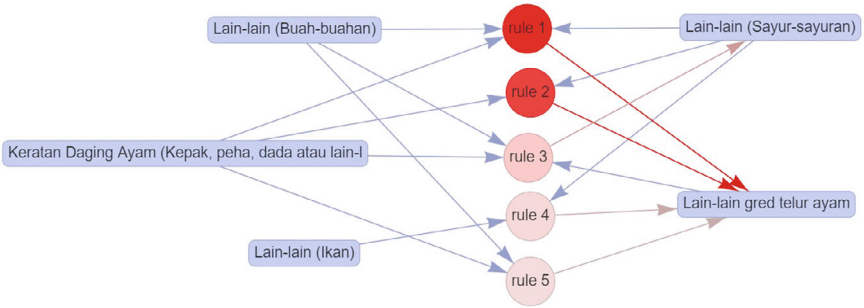

Fig. 2 Top 5 association rules of purchasing patterns extracted for Kedah state

Table 2 Quality of Kedah's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Ayam, Buahan, Sayuran ⇒ Telur ayam	0.01	0.66	0.01	61.65	19
Ayam, Sayuran ⇒ Telur ayam	0.01	0.65	0.01	61.04	24
Ayam, Buahan, Telur ayam ⇒ Sayuran	0.01	0.95	0.01	57.61	19
Ikan, Sayuran ⇒ Telur ayam	0.01	0.61	0.01	57.13	17
Ayam, Buahan ⇒ Telur ayam	0.01	0.61	0.01	57.03	20

4.3 Kelantan

In Kelantan, the top five association rules indicate rules related to chicken (Ayam), fruits (Buahan), vegetables (Sayuran), eggs (Telur ayam), rice (Beras) and fish (Ikan) (See Fig. 3).

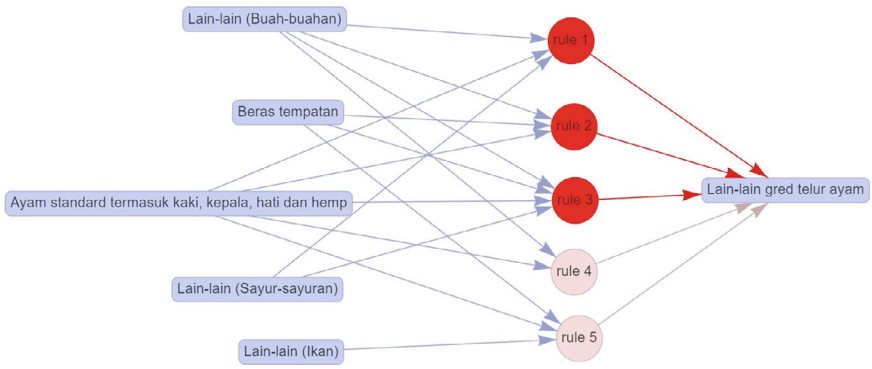

Fig. 3 Top 5 association rules of purchasing patterns extracted for Kelantan state

Table 3 Quality of Kelantan's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Ayam, Buahan, Sayuran ⇒ Telur ayam	0.01	1.00	0.01	39.54	14.00
Ayam, Buahan ⇒ Telur ayam	0.01	1.00	0.01	39.54	14.00
Ayam, Beras, Buahan, Sayuran ⇒ Telur ayam	0.01	1.00	0.01	39.54	14.00
Ayam, Buahan ⇒ Telur ayam	0.01	0.93	0.01	36.90	14.00
Ayam, Beras, Ikan ⇒ Telur ayam	0.01	0.93	0.01	36.90	14.00

Based on Table 3, the top rule could imply that when chicken (Ayam), fruits (Buahan) and vegetables (Sayuran) occur together, it is likely or observed that eggs (Telur ayam) is also present. This rule has the highest LIFT's value of 39.54 for these chicken (Ayam), fruits (Buahan), vegetables (Sayuran) and eggs (Telur ayam) commodities.

4.4 Kuala Lumpur

In Kuala Lumpur, the top five association rules indicate rules related to imported big red onion (Bawang besar merah), rice (Beras), eggs (Telur ayam), Holland Onion (Bawang Holland), fish (Ikan), vegetables (Sayuran) and fruits (Buahan) (See Fig. 4).

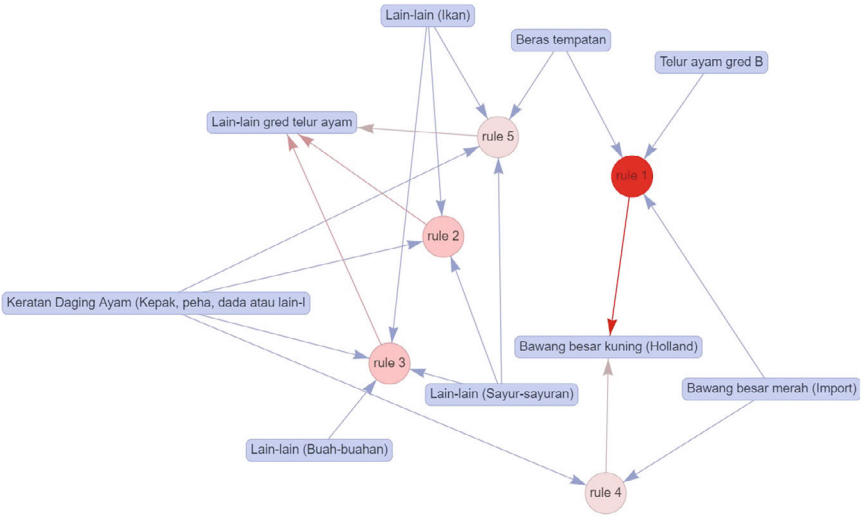

Fig. 4 Top 5 association rules of purchasing patterns extracted for Kuala Lumpur

Table 4 Quality of Kuala Lumpur's rules based on Sup, Conf, Cov, Lift and Count. (BBM = Bawang besar merah, BH = Bawang Holland)

Rules	Supp	Conf	Cov	Lift	Count
BBM (Import), Beras, Telur ayam (B)⇒ BH	0.01	1.00	0.01	33.65	12
Ayam, Ikan, Sayuran) ⇒ Telur ayam	0.01	0.94	0.01	31.54	15
Ayam, Buahan, Ikan, Sayuran ⇒ Telur ayam	0.01	0.94	0.01	31.54	15
Bawang besar merah (Import), Ayam ⇒ BH	0.01	0.92	0.01	31.06	12
Beras, Ayam , Ikan, Sayuran ⇒ Telur ayam	0.01	0.92	0.01	31.06	12

Based on Table 4, the top rule could imply that when imported big red onion (Bawang besar merah), rice (Beras) and eggs (Telur ayam) occur together, it is likely or observed that Holland Onion (Bawang Holland) is also present. This rule has the highest LIFT's value of 33.65 for these commodities.

4.5 Labuan

In Labuan, the top five association rules indicate rules related to imported red Chili (Cili merah (Import)), fish (Ikan Sebelah), potato (Ubi kentang), imported tomato and mustard (Sawi) (See Fig. 5).

Based on Table 5, the top rule could imply that when red Chili (Cili merah (Import)), fish (Ikan Sebelah) and potato (Ubi kentang) occur together, it is likely or observed that imported tomato is also present. This rule has the highest LIFT's value of 45.34 for these commodities.

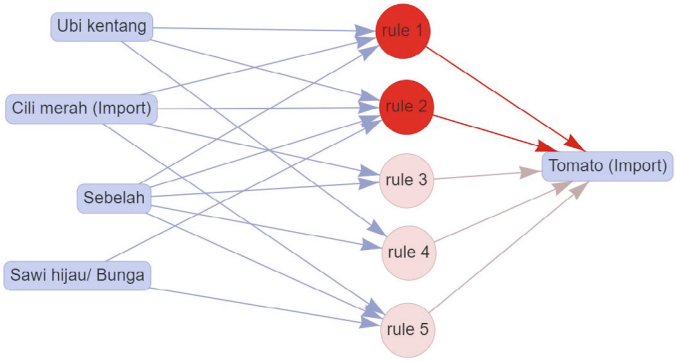

Fig. 5 Top 5 association rules of purchasing patterns extracted for Labuan

Table 5 Quality of Labuan's rules based on Sup, Conf, Cov, Lift and Count. (CM = Cili merah, UK = Ubi kentang, TI = Tomato (Import))

Rules	Supp	Conf	Cov	Lift	Count
CM (Import), Ikan Sebelah, UK ⇒ TI	0.02	1.00	0.02	45.34	170
CM (Import), Sawi, Ikan Sebelah, UK ⇒ TI	0.02	1.00	0.02	45.34	168
CM (Import), Ikan Sebelah⇒ TI	0.02	0.99	0.02	44.82	171
Ikan Sebelah, UK => TI	0.02	0.99	0.02	44.81	170
CM (Import), Sawi, Ikan Sebelah =⇒ TI	0.02	0.99	0.02	44.81	169

4.6 Melaka

In Melaka, the top five association rules indicate rules related to white onion (Bawang putih), Puyuh eggs (Telur burung puyuh), white potato (Ubi keledek putih), dragon fruits (Buah naga), white prawn (white prawn), green apple (epal hijau), stingray (pari), brinjal (terung) and catfish (Ikan Patin) (See Fig. 6).

Based on Table 6, the top rule could imply that when white onion (Bawang putih), Puyuh eggs (Telur burung puyuh) and white prawn (white prawn) occur together, it is likely or observed that white potato (Ubi keledek putih) is also present. This rule has the highest LIFT's value of 47.42 for these commodities.

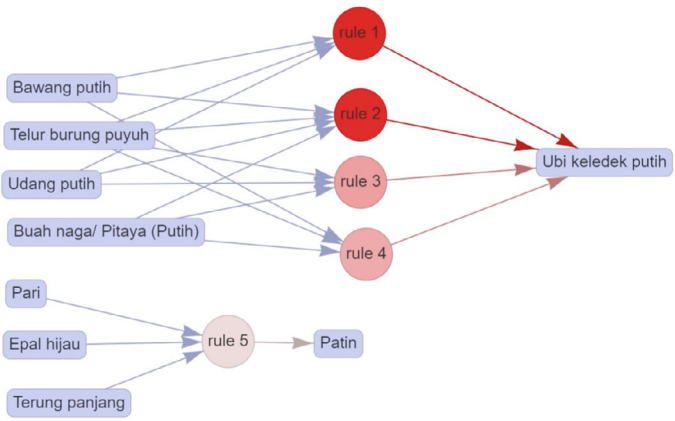

Fig. 6 Top 5 association rules of purchasing patterns extracted for Melaka state

Table 6 Quality of Melaka's rules based on Sup, Conf, Cov, Lift and Count. (BP = Bawang putih, TBP = Telur burung puyuh, UKP = Ubi keledek putih)

Rules	Supp	Conf	Cov	Lift	Count
BP, Telur burung puyuh, Udang putih => UKP	0.01	0.96	0.01	47.42	25
BP, Buah naga, TBP, Udang putih => UKP	0.01	0.96	0.01	47.26	23
Buah naga, TBP, Udang putih => UKPh	0.01	0.89	0.01	44.03	25
BP, Buah naga, TBP => UKP	0.01	0.88	0.01	43.63	23
Epal hijau, Pari, Terung => Patin	0.01	1.00	0.01	41.43	19

4.7 Negeri Sembilan

In Negeri Sembilan, the top five association rules indicate rules related to fruits (Buahan), vegetables (Sayuran), Orange (oren), bamboo shoots (Rebung), snails (Siput retak seribu) and orange potato (Ubi keledek oren) (See Fig. 7).

Based on Table 7, the top rule could imply that when fruit (Buahan) occurs, it is likely or observed that vegetables (Sayuran) is also present. This rule has the highest LIFT's value of 110.30 for these commodities. Other noticeable agri-food commodities involved include bamboo shoots (Rebung) and snails (Siput retak seribu).

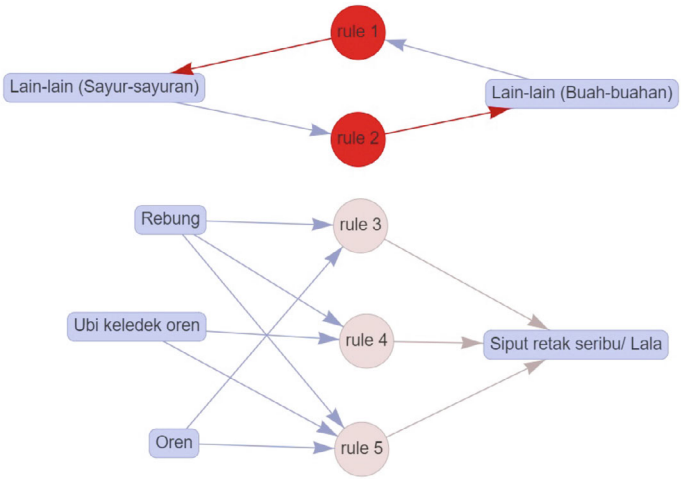

Fig. 7 Top 5 association rules of purchasing patterns extracted for Negeri Sembilan state

Table 7 Quality of Negeri Sembilan's rules based on Sup, Conf, Cov, Lift and Count. (UKO = Ubi keledek oren)

Rules	Supp	Conf	Cov	Lift	Count
Buahan => Sayuran	0.01	0.97	0.01	110.30	28
Sayuran) => Buahan)	0.01	0.74	0.01	110.30	28
Oren, Rebung => Siput retak seribu	0.01	1.00	0.01	52.94	38
Rebung, UKO => Siput retak seribu	0.01	1.00	0.01	52.94	38
Oren, Rebung, UKO => Siput retak seribu	0.01	1.00	0.01	52.94	38

4.8 Pahang

In Pahang, the top five association rules indicate rules related to stringray (Pari), brinjals (Terung), catfish (patin), rice (Beras), green apple (epal hijau) and chichen (Ayam) (See Fig. 8).

Based on Table 8, the top rule could imply that when stringray (Pari) and brinjals (Terung) occur together, it is likely or observed that catfish (patin) is also present. This rule has the highest LIFT's value of 81.61 for these commodities. Other noticeable agri-food commodities involved include rice (Beras), green apple (epal hijau) and chichen (Ayam).

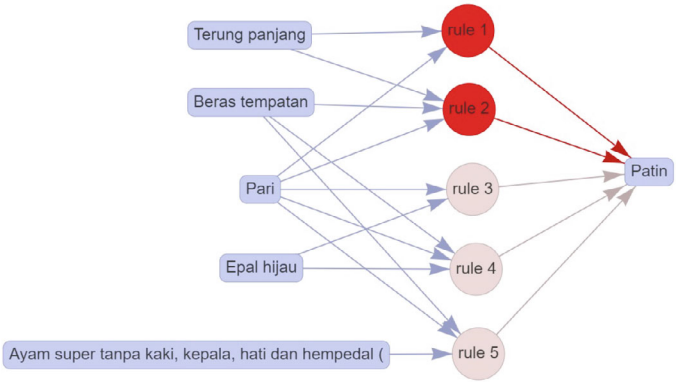

Fig. 8 Top 5 association rules of purchasing patterns extracted for Pahang state

Table 8 Quality of Pahang's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Pari, Terung => Patin	0.01	0.96	0.01	81.61	25
Beras tempatan,Pari,Terung panjang => Patin	0.01	0.96	0.01	81.61	25
Epal hijau, Pari => Patin	0.01	0.96	0.01	81.48	24
Beras tempatan, Epal hijau, Pari => Patin	0.01	0.96	0.01	81.48	24
Ayam, Beras tempatan, Pari => Patin	0.01	0.96	0.01	81.48	24

4.9 Perak

In Perak, the top five association rules indicate rules related to chicken (Ayam), vegetables (Sayuran), eggs (Telur ayam), fruits (Buahan), rice (Beras) and fish (Ikan) (See Fig. 9).

Based on Table 9, the top rule could imply that when chicken (Ayam), vegetables (Sayuran) and eggs (Telur ayam) occur together, it is likely or observed that fruits (Buahan) is also present. This rule has the highest LIFT's value of 81.82 for these commodities. Other noticeable agri-food commodities involved include rice (Beras) and fish (Ikan).

4.10 Perlis

In Perlis, the top five association rules indicate rules related to rice (Beras), anchovies (Ikan Bilis), Fish (Ikan Beliak Mata), parsley (Daun Sup), Onion (Daun Bawang), cencaru, Gelama fish (Ikan Gelama), eggs (Telur ayam) and wild chicken (Ayam Kampung) (See Fig. 10).

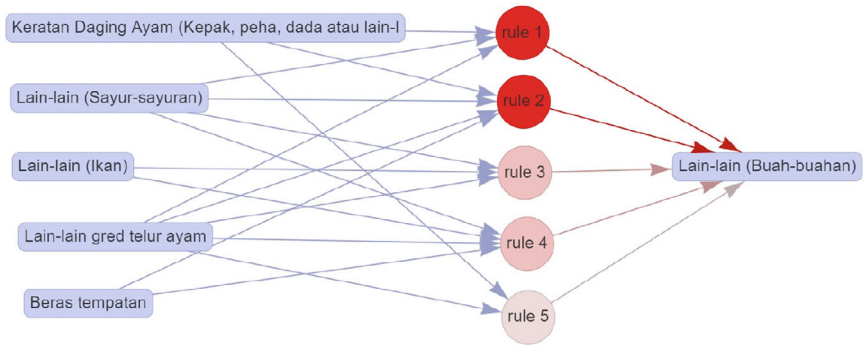

Fig. 9 Top 5 association rules of purchasing patterns extracted for Perak state

Table 9 Quality of Perak's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Ayam, Sayuran, Telur ayam => Buahan	0.01	1.00	0.01	81.82	26
Beras, Ayam, Sayuran, Telur ayam => Buahan	0.01	1.00	0.01	81.82	26
Ikan, Sayuran, Telur ayam => Buahan	0.01	0.97	0.01	79.48	34
Beras, Ikan, Sayuran, Telur ayam => Buahan	0.01	0.97	0.01	79.48	34
Ayam, Telur ayam => Buahan)	0.01	0.96	0.01	78.90	27

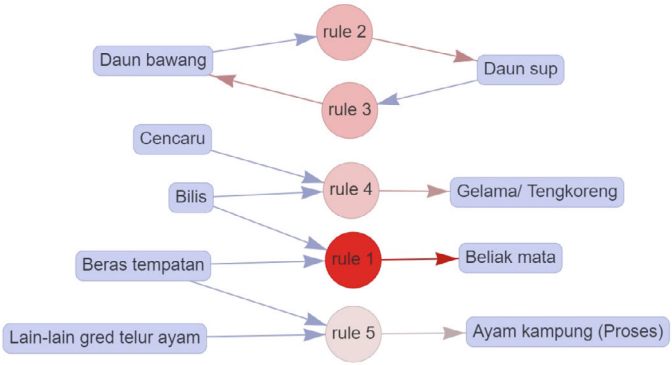

Fig. 10 Top 5 association rules of purchasing patterns extracted for Perlis state

Table 10 Quality of Perlis's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Beras, Bilis => Ikan Beliak Mata	0.01	0.42	0.02	23.05	31
Daun bawang => Daun sup	0.01	0.49	0.03	17.30	47
Daun sup => Daun bawang	0.01	0.45	0.03	17.30	47
Bilis, Cencaru => Ikan Gelama/Tengkoreng	0.01	0.40	0.02	16.53	24
Beras, Telur ayam => Ayam kampung (Proses)	0.01	0.58	0.02	15.19	38

Based on Table 10, the top rule could imply that when rice (Beras) and anchovies (Ikan Bilis) occur together, it is likely or observed that Fish (Ikan Beliak Mata) is also present. This rule has the highest LIFT's value of 23.05 for these commodities. Other noticeable agri-food commodities involved include parsley (Daun Sup), Onion (Daun Bawang), cencaru, Gelama fish (Ikan Gelama), eggs (Telur ayam) and wild chicken (Ayam Kampung).

4.11 Pulau Pinang

In Pulau Pinang, the top five association rules indicate rules related to chicken (Ayam), Fish (Ikan Sebelah), cow fresh milk (Susu segar tempatan (Lembu)), sweet turnip (Sengkuang), Sardine and lemongrass (Serai) (See Fig. 11).

Based on Table 11, the top rule could imply that when chicken (Ayam), Fish (Ikan Sebelah) and cow fresh milk (Susu segar tempatan (Lembu)) occur together, it is likely or observed that sweet turnip (Sengkuang) is also present. This rule has the highest LIFT's value of 74.01 for these commodities. Other noticeable agri-food commodities involved include Sardine and lemongrass (Serai).

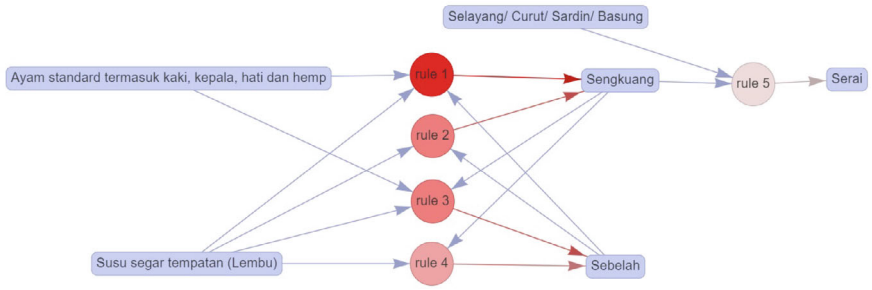

Fig. 11 Top 5 association rules of purchasing patterns extracted for Pulau Pinang state

Table 11 Quality of Pulau Pinang's rules based on Sup, Conf, Cov, Lift and Count (SST = Susu segar tempatan (Lembu))

Rules	Supp	Conf	Cov	Lift	Count
Ayam, SST => Sengkuang	0.01	0.97	0.01	74.01	29
Sebelah, SST => Sengkuang	0.01	0.91	0.01	69.38	29
Ayam, Sengkuang, SST => Sebelah	0.01	0.94	0.01	69.34	29
Sengkuang, SST => Sebelah	0.01	0.91	0.01	67.18	29
Sardin, Sengkuang => Serai	0.01	0.94	0.01	62.41	29

4.12 Putrajaya

In Putrajaya, the top five association rules indicate rules related to chicken (Ayam), Fish (Ikan), eggs (Telur Ayam), seaweed (Rumpai Laut), vegetables (Sayuran), meat (Daging), big red onion (imported) and lady's finger (Kacang Bendi) (See Fig. 12).

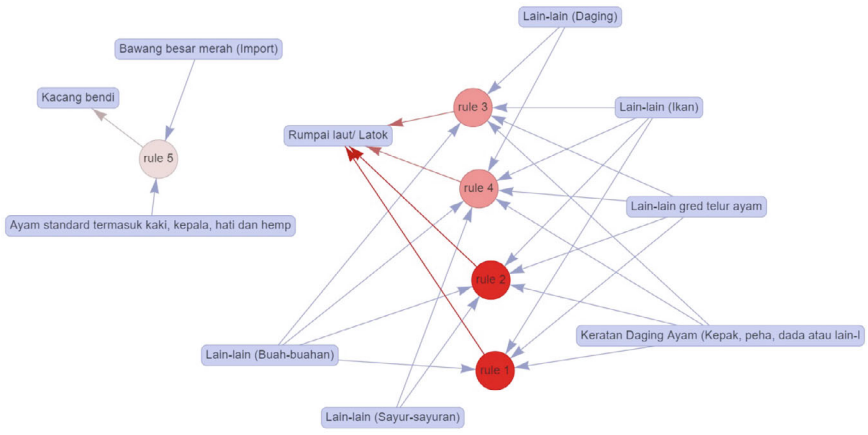

Fig. 12 Top 5 association rules of purchasing patterns extracted for Putrajaya

Table 12 Quality of Putrajaya's rules based on Sup, Conf, Cov, Lift and Count (TA = Telur Ayam, RL = Rumpai laut, KB = Kacang Bendi)

Rules	Supp	Conf	Cov	Lift	Count
Ayam, Buahan, Ikan, TA => RL	0.01	0.31	0.04	17.65	22
Ayam, Buahan, Ikan, Sayuran), TA => RL	0.01	0.31	0.04	17.65	22
Ayam, Buahan, Daging, Ikan, TA => RL	0.01	0.30	0.04	17.42	19
Ayam, Buahan, Daging, Ikan, Sayuran, TA => RL	0.01	0.30	0.04	17.42	19
Ayam, Bawang besar merah (Import) => KB	0.01	0.67	0.02	17.18	18

Based on Table 12, the top rule could imply that when chicken (Ayam), Fish (Ikan) and eggs (Telur Ayam) occur together, it is likely or observed that seaweed (Rumpai Laut) is also present. This rule has the highest LIFT's value of 17.65 for these commodities. Other noticeable agri-food commodities involved include vegetables (Sayuran), meat (Daging), big red onion (imported) and lady's finger (Kacang Bendi).

4.13 Sabah

In Sabah, the top five association rules indicate rules related to chicken (Ayam), Fish (Ikan), vegetables (Sayuran), fruits (Buahan) and eggs (Telur Ayam) (See Fig. 13).

Based on Table 13, the top rule could imply that when chicken (Ayam), Fish (Ikan) and eggs (Telur Ayam) occur together, it is likely or observed that seaweed (Rumpai

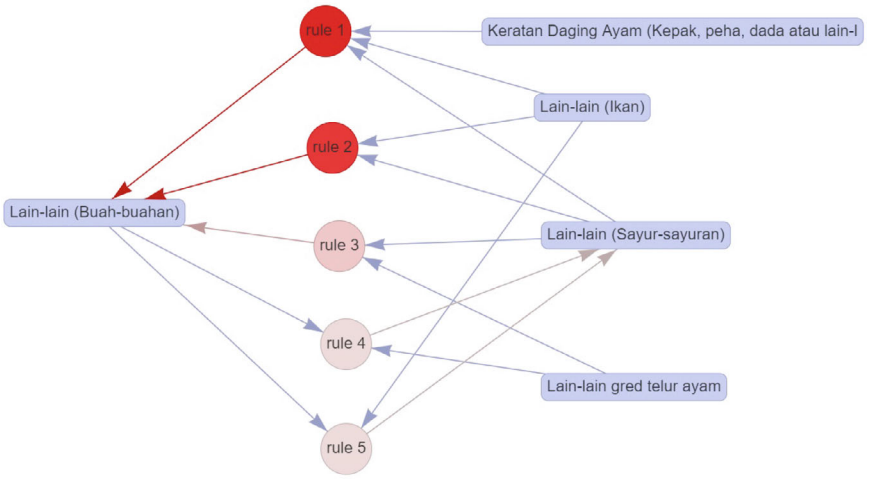

Fig. 13 Top 5 association rules of purchasing patterns extracted for Sabah state

Table 13 Quality of Sabah's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Ayam, Ikan, Sayuran => Buahan	0.01	0.77	0.01	70.60	20
Ikan, Sayuran => Buahan	0.01	0.76	0.01	69.63	22
Sayuran, Telur ayam => Buahan	0.01	0.67	0.01	61.19	22
Buahan, Telur ayam => Sayuran	0.01	0.96	0.01	59.77	22
Buahan, Ikan => Sayuran	0.01	0.96	0.01	59.77	22

Laut) is also present. This rule has the highest LIFT's value of 17.65 for these commodities. Other noticeable agri-food commodities involved include vegetables (Sayuran), meat (Daging), big red onion (imported) and lady's finger (Kacang Bendi).

4.14 Sarawak

In Sarawak, the top five association rules indicate rules related to pandan leaf (Daun pandan), curry leaf (Daun Kari), imported red chili (Cili merah (Import)), eggs grade A (Telur ayam gred A), Chili (Cili padi), Turmeric (Kunyit) and Pangkus (Lengkuas) (See Fig. 14).

Based on Table 14, the top rule could imply that when pandan leaf (Daun pandan) occurs, it is likely or observed that curry leaf (Daun Kari) is also present. This rule has the highest LIFT's value of 42.15 for these commodities. Other noticeable agri-food

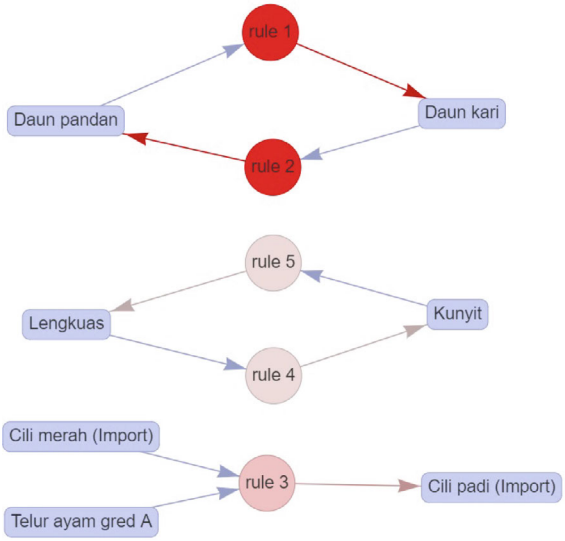

Fig. 14 Top 5 association rules of purchasing patterns extracted for Sarawak state

Table 14 Quality of Sarawak's rules based on Sup, Conf, Cov, Lift and Count (TAA = Telur ayam gred A)

Rules	Supp	Conf	Cov	Lift	Count
Daun pandan => Daun kari	0.01	0.73	0.01	42.15	24
Daun kari => Daun pandan	0.01	0.48	0.02	42.15	24
Cili merah (Import), TAA => Cili padi (Import)	0.01	0.51	0.01	27.52	20
Kunyit => Lengkuas	0.01	0.55	0.02	24.32	24
Lengkuas => Kunyit	0.01	0.37	0.02	24.32	24

commodities involved include imported red chili (Cili merah (Import)), eggs grade A (Telur ayam gred A), Chili (Cili padi), Turmeric (Kunyit) and Pangkus (Lengkuas).

4.15 Selangor

In Selangor, the top five association rules indicate rules related to abalone mushroom (Cendawan abalone), red chili (Import) (Cili merah (Import)), imported small red onion (Bawang merah kecil (Import)), chicken (Ayam) and eggs grade A (Telur ayam gred A) (See Fig. 15).

Based on Table 15, the top rule could imply that when abalone mushroom occurs, it is likely or observed that imported red chili is also present. This rule has the highest LIFT's value of 29.72 for these commodities. Other noticeable agri-food commodities involved include imported small red onion (Bawang merah kecil (Import)), chicken (Ayam) and eggs grade A (Telur ayam gred A).

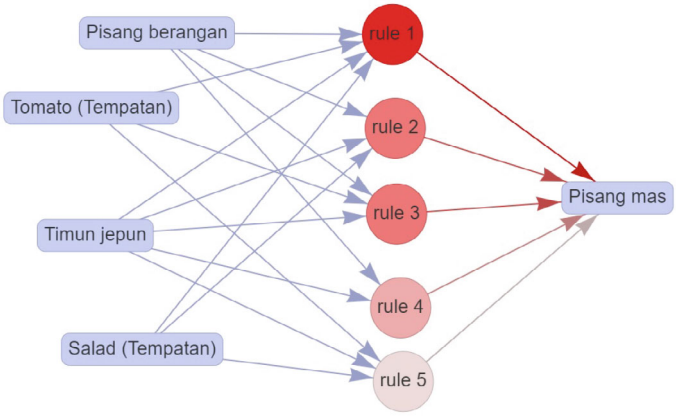

Fig. 15 Top 5 association rules of purchasing patterns extracted for Selangor state

Table 15 Quality of Selangor's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Cendawan abalone => Cili merah (Import)	0.01	0.62	0.01	29.72	16
Cili merah (Import) => Cendawan abalone	0.01	0.30	0.02	29.72	16
Cendawan abalone => Bawang merah kecil (Import)	0.01	0.62	0.01	23.95	16
Cendawan abalone => Ayam	0.01	0.62	0.01	8.87	16
Ayam tua (Proses) => Telur ayam gred A	0.01	0.74	0.01	9.74	17

4.16 Terengganu

In Terengganu, the top five association rules indicate rules related to parsley (Daun Sup), Onion leaf (Daun Bawang), green apple (Epal hijau), red apple (Epal merah), Round Cabbage (Kobis bulat), chicken (Ayam) and Cauliflower (See Fig. 16).

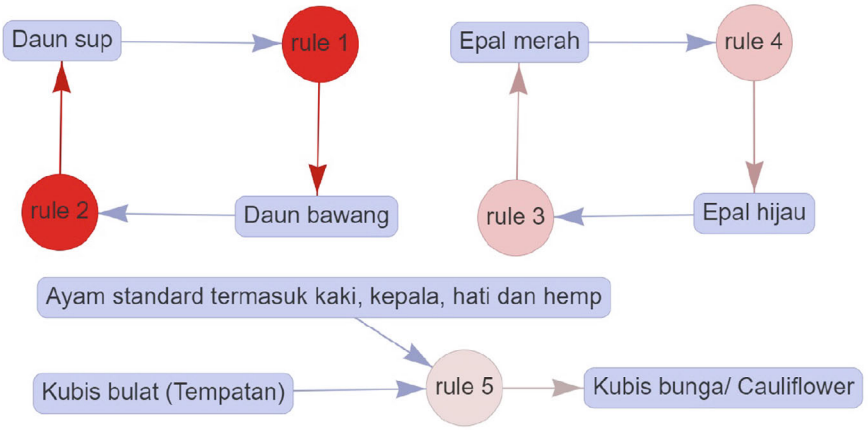

Fig. 16 Top 5 association rules of purchasing patterns extracted for Terengganu state

Table 16 Quality of Terengganu's rules based on Sup, Conf, Cov, Lift and Count

Rules	Supp	Conf	Cov	Lift	Count
Daun sup => Daun bawang	0.01	0.59	0.01	50.59	20
Daun bawang => Daun sup	0.01	0.56	0.01	50.59	20
Epal hijau => Epal merah	0.01	0.48	0.02	20.70	26
Epal merah => Epal hijau	0.01	0.36	0.02	20.70	26
Ayam, Kubis bulat (Tempatan) => Cauliflower	0.01	0.49	0.02	14.27	36

Based on Table 16, the top rule could imply that when parsley (Daun Sup) occurs, it is likely or observed that Onion leaf (Daun Bawang) is also present. This rule has the highest LIFT's value of 50.59 for these commodities. Other noticeable agri-food commodities involved include green apple (Epal hijau), red apple (Epal merah), Round Cabbage (Kobis bulat), chicken (Ayam) and Cauliflower.

5 Conclusion

The aim of this paper is to analyze the purchasing behaviour of agri-ffod in every state in Malaysia using Association rules. Based on the findings of this paper, it can be observed that the extracted rules for every state focuses on different types of agri-food commodities. The association rules concentrate on the following commodities for every states or districts in Malaysia.

1. **Johor**: Long Bean (Kacang buncis), Lady's Finger (Kacang bendi), Orange sweet potato (Ubi keledek oren), Potato (Ubi kentang), Chili padi (Cili padi), Green chili (Cili hijau).
2. **Kedah**: Chicken (ayam), fruits (buahan), vegetables (sayuran), fish (ikan) and egg (Telur ayam).
3. **Kelantan**: Chicken (Ayam), fruits (Buahan), vegetables (Sayuran), eggs (Telur ayam), rice (Beras) and fish (Ikan).
4. **Kuala Lumpur**: Imported big red onion (Bawang besar merah), rice (Beras), eggs (Telur ayam), Holland Onion (Bawang Holland), fish (Ikan), vegetables (Sayuran) and fruits (Buahan).
5. **Labuan**: Red Chili (Cili merah (Import)), fish (Ikan Sebelah), potato (Ubi kentang), imported tomato and mustard (Sawi).
6. **Melaka**: White onion (Bawang putih), Puyuh eggs (Telur burung puyuh), white potato (Ubi keledek putih), dragon fruits (Buah naga), white prawn (white prawn), green apple (epal hijau), stingray (pari), brinjal (terung) and catfish (Ikan Patin).
7. **Negeri Sembilan**: Fruits (Buahan), vegetables (Sayuran), Orange (oren), bamboo shoots (Rebung), snails (Siput retak seribu) and orange potato (Ubi keledek oren)
8. **Pahang**: Stringray (Pari), brinjals (Terung), catfish (patin), rice (Beras), green apple (epal hijau) and chichen (Ayam).
9. **Perak**: Chicken (Ayam), vegetables (Sayuran), eggs (Telur ayam), fruits (Buahan), rice (Beras) and fish (Ikan)
10. **Perlis**: Rice (Beras), anchovies (Ikan Bilis), Fish (Ikan Beliak Mata), parsley (Daun Sup), Onion (Daun Bawang), cencaru, Gelama fish (Ikan Gelama), eggs (Telur ayam) and wild chicken (Ayam Kampung)
11. **Pulau Pinang**: Chicken (Ayam), Fish (Ikan Sebelah), cow fresh milk (Susu segar tempatan (Lembu)), sweet turnip (Sengkuang), Sardine and lemongrass (Serai).

12. **Putrajaya**: Chicken (Ayam), Fish (Ikan), eggs (Telur Ayam), seaweed (Rumpai Laut), vegetables (Sayuran), meat (Daging), big red onion (imported) and lady's finger (Kacang Bendi)
13. **Sabah**: Chicken (Ayam), Fish (Ikan), vegetables (Sayuran), fruits (Buahan) and eggs (Telur Ayam)
14. **Sarawak**: Pandan leaf (Daun pandan), curry leaf (Daun Kari), imported red chili (Cili merah (Import)), eggs grade A (Telur ayam gred A), Chili (Cili padi), Turmeric (Kunyit) and Pangkus (Lengkuas)
15. **Selangor**: Abalone mushroom (Cendawan abalone), imported red chili (Cili merah (Import)), imported small red onion (Bawang merah kecil (Import)), chicken (Ayam) and eggs grade A (Telur ayam gred A).
16. **Terengganu**: Parsley (Daun Sup), Onion leaf (Daun Bawang), green apple (Epal hijau), red apple (Epal merah), Round Cabbage (Kobis bulat), chicken (Ayam) and Cauliflower

It is important to look at these patterns as it can be used an input to help retailers better plan pricing, promotions, product placement, product recommendations, and other aspects of their business, which will improve not only the customer shopping experience but also retailer profits and customer retention.

The patterns also provide important market information to players in Malaysia's fresh food supply chain. It enables them to produce and market fresh food in response to local demand.

Therefore, the outputs of this paper can be considered as guidelines for retailers in every stated in Malaysia and future works, a more comprehensive validation works is required in order to validate these extracted rules so that they can be applied by retailers in Malaysia.

Acknowledgements This work was supported by the Ministry of Agriculture and Food Security.

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