Khazanah Journal of Religion and Technology
Sunan Gunung Djati State Islamic University, Bandung, Indonesia
https://journal.azkia.id/index.php/kjrt
Online ISSN: 2987-6060
Volume 4 Issue 1 (2026)
DOI: https://doi.org/10.66948/kjrt.v4i1.54

Tajweed Pattern Analysis in the 30th Juz of Qur'an Using the Apriori Algorithm

Nazwa Revalina Azzahra Djuarsah
Department of Informatics
UIN Sunan Gunung Djati Bandung
Bandung, Indonesia
revalnzw2024@gmail.com

Marisah Lofiana
Department of Informatics
UIN Sunan Gunung Djati Bandung
Bandung, Indonesia
marisahloviana334@gmail.com

Mochammad Khaerul Ilman
Department of Informatics
UIN Sunan Gunung Djati Bandung
Bandung, Indonesia
khaerulilman10@gmail.com

Rizki Surya Gani
Department of Informatics
UIN Sunan Gunung Djati Bandung
Bandung, Indonesia
rizkisurya047@gmail.com

Gallung Marwan Haqiqi Hafidz
Department of Informatics
UIN Sunan Gunung Djati Bandung
Bandung, Indonesia
gallungmarwan147@gmail.com

Abstract — Tajweed knowledge plays an important role in maintaining the integrity and beauty of the recitation of the Qur'an. However, tajweed learning is often conventional and less data-driven. This study aims to analyze the pattern of the emergence of tajweed rules in the 30th Juz of the Qur'an using the Apriori algorithm, a data mining method capable of efficiently identifying associations between items. The dataset used consists of 564 verses, which are classified into 22 categories of tajweed rules based on manual analysis from trusted sources. Through the process of data transformation and the application of Apriori, several significant patterns of the emergence of tajweed rules were obtained. The Mad Thobii rule is the most dominant with the highest support value of 79.96%. The combination of patterns with the highest confidence value was found in the (Ghunnah) → (Mad Thobii) rule at 83.11%, indicating a strong relationship between the two rules. These findings are expected to provide new insights in data-based tajweed learning and become a reference in the development of interactive media for learning the Qur'an. In the future, this research can be expanded to encompass the entire Quran and other association algorithms, such as FP-Growth, can be applied to evaluate the effectiveness and efficiency of tajweed pattern analysis. This research represents an initial step toward utilizing data to strengthen adaptive and relevant religious learning.

Keywords - Apriori, Association Rules, Data Mining, Tajweed

I. INTRODUCTION

Tajwid, according to the term, is a science that provides all understanding about letters, both the rights of letters (haqqul harf) and new rules that arise after the rights of letters (mustahaqqul harf) are fulfilled, which consists of the properties of letters, mad rules, and so on [1]. Tajwid emphasizes the correct articulation of letters (makhraj), which is very important for maintaining the integrity of the Qur'anic text [2]. Mastery of tajwid allows for more fluent and rhythmic reading, making it easier for listeners to engage with the text [3]. Correct reading fosters a deeper spiritual connection because it reflects the beauty and holiness of the Qur'an, increasing the reader's faith and moral character [4].

The role of technology, especially data mining, in analyzing the text of the Qur'an is very important because it

can increase accessibility and understanding of the verses of the Qur'an. There have been many studies discussing the use of data mining or text mining using Qur'an data sources, whether in the form of text, images, or audio. There are studies that propose several text mining approaches, namely most frequent words, K-means clustering, and association rules, to analyze the interpretation and translation of the Indonesian Qur'an and provide insight into hidden knowledge and relationships based on statistical information obtained from it [5]. Then, a study has been conducted that created a tajweed detection design using the YOLO algorithm which was optimized to find and analyze text mining detection in the tajweed reading of the Qur'an [6]. The study conducted by M.A. Ahmed, et al. [7] adapted the K-Means clustering algorithm to describe and find relationships between keywords called features or concepts for five different translators in 286 verses in Surah Al-Baqarah.

Of the various studies on the analysis of the Quran using a data mining approach, no research has been found that discusses the analysis of the emergence patterns of tajweed rules using the Apriori algorithm. A 2020 study on the emergence patterns of tajweed rules, however, used the image method with Gower and Legendre [12]. The Apriori algorithm is a data mining technique used to analyze sales transaction data and identify frequent itemsets and association rules [8][9]. This algorithm has been applied in various contexts, including retail stores, coffee shops, and e-commerce platforms, to uncover patterns of consumer purchasing behavior [8][9][10]. This algorithm operates by setting minimum support and confidence thresholds to determine significant associations between items [11]. The implementation of Apriori has proven effective in identifying items that frequently appear together in large data sets, helping businesses make informed decisions about product placement, inventory management, and marketing strategies [9][10]. For example, a study in a convenience store found a strong correlation between cigarettes and matches, while another study of building materials revealed a high correlation between Toba Panels and Starlight Plate Racks [8][11].

Therefore, this study attempts to identify patterns of tajweed rules that frequently appear together in Juz' 30 using an apriori algorithm. Furthermore, it aims to provide information and insights to facilitate data-based tajweed learning and enrich the literature in the field of data-based religious text analysis.

II. Related Works

Before conducting the research, the author searched for and collected several relevant research literature relevant to this study. The author conducted a literature search from various article databases such as IEEE, ScienceDirect, Elsevier, and Google Scholar. However, to facilitate the literature search, the author also used tools such as SciSpace and Elicit to obtain more detailed information about the identity and sources of the literature articles. Keywords used to conduct the literature search included "apriori algorithm," "association rules," and "data mining." Then, the literature was filtered based on criteria such as the year of publication of the article starting from 2022 to 2025, and the presence of a Digital Object Identifier in the article.

Research related to the application of the Apriori algorithm in purchasing pattern analysis has been conducted in various contexts. A study by Naveenkumar [15] aimed to analyze small transaction patterns using the Apriori algorithm. This study did not specify the number of data rows, with an unspecified minimum support value and a confidence of up to 80%. The results found itemsets such as {bread, butter} and {milk, cheese}. Meanwhile, Amanda et al. [9] aimed to help coffee shops make recommendations for food and beverage package menus. With a dataset of 28 transactions, this study used a minimum support of 10% and a confidence of 60%, resulting in itemsets such as {ice coffee} with a minimum support of 0.5 and {Caramel Machiato, Ice Coffee} with a support of 0.1786 [9]. Turukay et al. [11] focuses on predicting product sales performance at the DEPO TEGUH Store using 10 transactions, with minimum support of 60% and confidence of 75%, resulting in itemsets such as {Starlight Dish Rack}, {Hit Anti Kecoa}, and {Toba Panel Cabinet, Stella Car Freshner}.

Lahuddin and Satra [13] aimed to provide product arrangement recommendations in minimarkets based on the relationship between items, using a dataset of 100 transactions, minimum support of 10%, and confidence of 62.5%, with the resulting itemset {Ultra Milk Slim Chocolate 200ml, LE MINERAL 600ml}. Mairani [14] correlated facial skin problems with products used at Queen Arabic, using 527 rows of data, minimum support of 80%, and confidence of 100%, resulting in 60 rules, including 2 rules with minimum support of 95% and confidence of 100% for a combination of 2 itemsets. Badaruddin and Rayendra [10] identified patterns of relationships between products in e-commerce sales with 10 transactions, minimum support of 60%, and confidence of 50%, resulting in rules such as A1 → A2 (support of 40%, confidence of 67%) and A1 → A5 (support of 50%, confidence of 83%).

Kuswanto et al. [16] identified consumer purchasing patterns in the West Java retail sector, with an unspecified number of transactions, minimum support of 10%, and confidence of 30%, resulting in the rule {drinks} → {cosmetics, household appliances} with confidence of 37.1%. Rosmayati et al. [17] aimed to provide discount and product recommendations for coffee shops, using 20 transactions, minimum support of 50%, and confidence of 50%, resulting in rules such as {Kopsu Friends, V60} → {Cappucino} (confidence of 83%, support of 25%, lift of 1,667). Situmorang et al. [18] analyzed the performance of the Apriori algorithm to find relationship patterns between items with 20 transactions, minimum support of 30%, and confidence of 50%, resulting in rules such as {Blush on} → {Lipstick} and {Blush on} → {Concealer}. Finally, Poli and Sikder [19] studied the application of the Apriori algorithm for sales forecasting in the retail industry with a dataset of 38,766 transactions, without mentioning minimum support and confidence, resulting in itemsets such as {Whole milk},

{other vegetables}, {rolls/buns}, and the rule {shopping bags} → {other vegetables}.

III. Research Methods

The method used in this research is Knowledge Discovery in Databases (KDD). The tools used to support this research include the Python programming language version 3.12, Google Colab, Visual Studio Code, Google Sheets, and several Python libraries such as Seaborn, Pandas, Matplotlib, and Mlxtend. The following are the research stages:

A. Data Selection

Tajweed rule data was collected through a process of analyzing the tajweed rule sourced from the Indonesian translation of the Quran and the tajweed study guide book by H. Dachlan Salim Zarkasyi. Then, the data was entered into a CSV format file consisting of 5 columns, including id, no_surah, name_surah, verse, and tajweed rule. The tajweed rule data collected only verses in juz 30 starting from Surah An-Naba verse 1 to Surah An-Nas verse 6. So the number of rows of data generated reached 564 data.

B. Preprocessing Data

The tajwid legal data that has been collected is carried out by a process of exploration, examination and data cleaning. Removing space characters in the values in the legal_tajwid column to make it easier to name identification per category of tajwid rule. Then, explore and analyze data such as column information, total value, average value, and comparison graph of the number of verses between surahs.

C. Data Transformation

Carry out data transformation stages before implementing using an a priori algorithm. The initial data has 5 columns in Table 1; only 1 column is used for the data mining process, namely the legal_tajwid column. All values in the rule_tajwid column will be converted into column names using the code 'apply(lambda x:x.split(","))'.

AlQomariyah	AsySyamsiyah	Ghunnah	IdhghomBighunnah	IdhghomBilaghunnah	I
False	False	True	False	False	
True	True	True	False	False	
False	True	False	False	False	
False	False	False	False	False	
False	False	True	False	False	
...	...	...	...	...	
False	True	True	False	False	
False	True	True	False	False	
True	False	True	False	False	
False	True	True	False	False	
True	True	True	False	False	

Fig 1. Changes become Boolean

Then, using 'TransactionEncoder' to convert transaction data in the form of a list of lists (a list of items in each transaction) into a one-hot encoded format, namely a boolean array (True/False) which shows the existence of each item in each transaction [20][21]. The number of columns obtained after carrying out data transformation is 22 columns for the Tajwid rule category.

D. Data Mining

At this stage, enter into the implementation of the a priori algorithm using the Python programming language library a priori association rules, which comes from Machine Learning Extensions (MLxtend). Then, carry out a trial with the parameters of the minimum support value and confidence value to find the tajwid rule itemset that appears in the tajwid rule data in Al-Quran juz 30.

E. Evaluation

This stage examines the apriori algorithm model. This stage involves determining the minimum support value and confidence value, as well as calculating evaluation metrics such as support, confidence, and lift for each itemset or combination of itemsets.

F. Knowledge

In this final stage, conclusions are drawn regarding the final results of this research. The questions are: What items emerged after the apriori algorithm was applied to the research process, and whether there is a relationship between the items that emerged according to the minimum support and confidence values set. Scientifically, there is no specific connection between each of the rules of tajwid and a specific rule. However, this research only provides insight or knowledge into the unique patterns of tajwid rules, as outlined in the conclusion section of this article.

IV. Results and Discussion

A. Number of Appearances of Tajweed

Table 1 shows the total number of Tajweed rules in each category in the 30th volume of the Quran, based on the collected data. The total number for each Tajweed rule category is taken from the 'True' value in the data transformation table using TransactionEncoder.

Table 1. Details of the number of Tajweed per category

No.	Tajweed Category	Amount *True*
1.	Al-Qomariyah	195
2.	AsySyamsiyah	130
3.	Ghunnah	148
4.	IdhghomBighunnah	73
5.	IdhghomBilaghunnah	29
6.	IdhghomMitsli	6
7.	IdhghomMutajanisain	1
8.	Idzhar	65
9.	Idzhar Syafawi	78
10.	IdzharWajib	1
11.	Ikhfa	108
12.	Ikhfa Syafawi	8
13.	Iqlab	12
14.	MadBadal	30
15.	Madiwadh	67
16.	MadJaizMunfasil	59
17.	MadLazimMutsaqqolKalimi	5

No.	Tajweed Category	Amount *True*
18.	MadShilahQoshiroh	46
19.	MadShilahThowilah	7
20.	MadThobii	451
21.	MadWajibMuttasil	57
22.	Qolqolah	161

Based on the graph in Figure 2, the highest number of occurrences of the Tajwid rule in the Al-Quran Juz 30 is found in the 'MadThobii' rule with a total frequency of occurrence of 451 data. Followed by 'AlQomariyah ', which has 195 data on the emergence of Tajweed rule, 'Qolqolah' with 161 data, and 'Ghunnah' with 148 data.

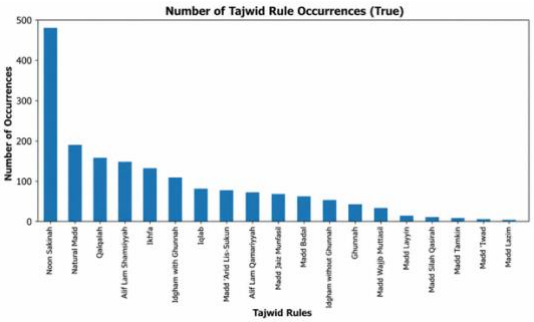

Fig 2. Graph emergence Tajweed

Previous research generally sets a minimum support value of 0.5 and a confidence value of 0.6. The determination of these two values depends on the needs of the itemset to be displayed. For this study, the itemset that appeared at the minimum support value was set at 0.2, or 20%. The confidence value was also set at 0.2, or 20%.

B. Itemset Appearance with Implementation Apriori

The results of the itemset that appear by setting the minimum support value to 0.2 are shown in Table 2

Table 2. Details of the number of Tajweed rules per category

No.	Support	Itemsets
1.	0.345745	(Al-Qomariyah)
2.	0.230496	(AsySyamsiyah)
3.	0.262411	(Ghunnah)
4.	0.799645	(MadThobii)
5.	0.285461	(Qolqolah)
6.	0.265957	(MadThobii, AlQomariyah)
7.	0.218085	(Ghunnah, MadThobii)
8.	0.221631	(Qolqolah, MadThobii)

Based on the results in Table 2, the highest support value was obtained for the Tajweed rule itemset (Madthobii) with a value of 0.799645 or 79.96%, while the lowest support value above the predetermined minimum support value was obtained for the combination itemset (Ghunnah, MadThobii) with a support value of 0.218085 or 21.81%.

Table 3. Antecedents and Consequents

No.	antecedents	consequents	antecedent support	consequent support
1.	(MadThobii)	(Al-Qomariyah)	0.799645	0.345745
2.	(Al-Qomariyah)	(MadThobii)	0.345745	0.799645
3.	(Ghunnah)	(MadThobii)	0.262411	0.799645
4.	(MadThobii)	(Ghunnah)	0.799645	0.262411
5.	(Qolqolah)	(MadThobii)	0.285461	0.799645
6.	(MadThobii)	(Qolqolah)	0.799645	0.285461

Antecedents are the initial conditions for an item to appear, and their support values are the percentage of antecedents appearing in the dataset. Likewise, consequents are the conditions for the resulting itemset to appear, and their support values are the percentage of antecedents appearing in the dataset. Based on Table 3, the highest values for the causes and effects of an item appearing are (Mad Thobii) and (AlQomariyah), and vice versa.

Table 4. Evaluation of support, confidence, and lift

antecedents	consequents	support	confidence	elevator
(MadThobii)	(Al-Qomariyah)	0.265957	0.332594	0.961965
(Al-Qomariyah)	(MadThobii)	0.265957	0.769231	0.961965
(Ghunnah)	(MadThobii)	0.218085	0.831081	1.039312
(MadThobii)	(Ghunnah)	0.218085	0.272727	1.039312
(Qolqolah)	(MadThobii)	0.221631	0.776398	0.970927
(MadThobii)	(Qolqolah)	0.221631	0.277162	0.970927

In the results of Table 4, the rules (Ghunnah) → (MadThobii) and (MadThobii) → (Ghunnah) have the best rules. These rules respectively produce confidence values of 83.11% and 27.27%. These two rules produce the same lift value, namely 1.039312, which shows that the relationship between the two items supports each other and is very strong because the lift value is more than 1. The results from Table 3 show that the relationship between the rule items (AlQomariyah) → (MadThobii) and vice versa, for the item 'MadThobii' the rule has the same antecedent support and consequent support values as the item 'MadThobii' in the rule (Ghunnah) → (MadThobii) and vice versa. However, if you look at Table 4 through the support, confidence, and lift side of the rule (AlQomariyah) → (MadThobii) and vice versa, the resulting lift value is less than 1, namely 0.961965.

Based on an in-depth analysis of confidence, lift, and support metrics, this research identifies tajwid legal patterns that can be an insight or reference for learning tajwid rules based on data on the existence of tajwid rules or legal categories in verses of the Al-Quran, Juz 30. For the appearance of items based on a minimum support value of 0.2 and a confidence value of 0.2, including 'MadThobii' with a support value of 0.799645 and a total of 451 data, 'Al-Qomariyah' with the result is a support value of 0.345745 and a total of 195 data, 'Qolqolah' with a supporting value of 0.285461 and a total of 161 data, 'Ghunnah' with a supporting value of 0.262411 and a total of 148 data, and 'AsySyamsiyah' with a supporting value of 0.230496 and a total of 130 data.

Three combinations of recitation rule items in Al-Quran juz 30 based on the results of the highest confidence values include (Ghunnah) → (MadThobii) with a confidence value of 0.831081, (Qolqolah) → (MadThobii) with a confidence value of 0.776398, and (AlQomariyah) → (MadThobii) with a confidence value 0.769231. Meanwhile, for the item

'AsySyamsiyah', in this study there was no combination of items with 'AsySyamsiyah' due to the influence of determining the minimum support value and confidence value that had been determined.

V. CONCLUSION

This study successfully identified the pattern of Tajweed rules in the 30th volume of the Quran using the Apriori algorithm. Based on the analysis, the most frequently occurring Tajweed rules were Mad Thobii, followed by Al-Qomariyah, Qolqolah, and Ghunnah. Furthermore, frequently occurring patterns were also found, such as (Ghunnah) → (Mad Thobii) with the highest confidence level of 83.11%, as well as other combinations such as (Qolqolah) → (Mad Thobii) and (Al-Qomariyah → (Mad Thobii).

These findings provide valuable insights into the field of tajweed learning, particularly in understanding the patterns of tajweed rules that frequently occur in the verses of the Quran. This data-based analysis model can be an effective tool in supporting the learning process and gaining knowledge about the unique patterns of tajweed rules in the 30th chapter of the Quran.

This research has considerable scope for development. In the future, research can be expanded beyond just juz 30 to include other chapters or even the entire Quran. With a larger and more diverse data set, the patterns of tajweed rules discovered will certainly be more comprehensive and accurate.

Furthermore, the exploration of data mining methods Other methods also present significant opportunities for development, such as using the FP-Growth algorithm, Eclat, or other association algorithms that are more efficient in searching for frequent itemsets than Apriori. A comparison between these methods can provide new insights into the effectiveness and efficiency of algorithms in the context of analyzing tajweed legal patterns.

With these developments, the results of this research are expected to not only provide academic contributions but also be implemented in a more interactive and adaptive digital learning system to meet the needs of the wider community in understanding and studying Quranic tajweed in greater depth.

REFERENCES

[1] M. Damier, W. Damier, H. Wahab, "Pembelajaran Ilmu Tajwid untuk Meningkatkan Kualitas Qira'atul Qur'an Pesantren NU Polewali Mandar," *Journal of Indonesian Scholars for Social Research*, vol. 2, no. 2, pp. 147-154, 2022.

[2] V. Prabaningtyas, I. Tabroni, "Improving the Ability of Tajwid Science in Reading the Qur'an," *Jurnal Pengabdian Masyarakat Bestari (JPMB)*, vol. 1, no. 8, pp. 835-846, 2022, doi: 10.55927/jpmb.v1i8.1822.

[3] T. Sutrisno, dkk., "Pelatihan Ilmu Tajwid Dalam Tahsin Al-Qur'an Bagi Anak Usia SD/MI di Surau Bulangan Barat Kabupaten Pamekasan," *Kifah,* vol. 1, no. 2, pp. 119-129, 2022, doi: 10.35878/kifah.v1i2.483.

[4] N. Sakinah, R. Kurniawati, I.Z. Nasution, "Pelatihan Ilmu Tajwid Dalam Tahsin Al-Qur'an Bagi Anak Usia SD/MI di Surau Bulangan Barat Kabupaten Pamekasan," *Maslahah*, vol. 3, no. 2, 2022, doi: 10.56114/maslahah.v3i2.359.

[5] M.A. Ayu, E. Irawan, T. Mantoro, "Text mining approaches for analyzing an Indonesian tafseer and translation of the Holy Quran," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 25, no. 3, pp. 1469-1490, doi: 10.11591/ijeecs.v25.i3.pp1469-1480.

[6] D.I. Mulyana, M.A.I. Rowis, "Optimization of Text Mining Detection of Tajweed Reading Laws using the YOLOV8 Method on the Qur'an," *Qalamuna - Jurnal Pendidikan, Sosial, dan Agama*, vol. 14, no. 2, pp. 1089-1110, 2022, doi: 10.37680/qalamuna.v14i2.3866.

[7] M.A. Ahmed, H. Baharin, and P.N.E. Nohuddin, "Text Clustering of Tafseer Translations by Using k-means Algorithm: An Al-Baqarah Chapter View" *Annals of Emerging Technologies in Computing (AETiC)*, vol. 7, no. 4, pp. 27-34, 2023, doi: 10.33166/AETiC.2023.04.003.

[8] Suardi, "Implementasi Algoritma Apriori Untuk Analisis Data Transaksi Penjualan Pada Toko Berbasis Desktop," *Teknokompak*, vol. 17, no. 1, 2023, doi: 10.33365/jtk.v17i1.2148.

[9] S.M. Amanda, D. Setiawan, L. Trisnawati, "Penerapan Algoritma Apriori Dalam Menganalisis Pola Minat Beli Konsumen di Coffee Shop," *JEKIN (Jurnal Teknik Informatika)*, vol. 1, no. 2, pp. 25-32, 2023, doi: 10.58794/jekin.v3i1.483.

[10] M. Badaruddin, R. Rayendra, "Penerapan Algoritma Apriori Pada Analisa Data Penjualan Ecommerce," *Jurnal Media Informatika Budidarma*, vol. 6, no. 2, 2022, doi: 10.30865/mib.v6i2.3976.

[11] Y.Y.Y. Turukay, et al., "Implementasi Algoritma Apriori Untuk Meningkatkan Pola Penjualan Barang (Studi Kasus: Toko DEPO TEGUH)," *G-Tech : Jurnal Teknologi Terapan*, vol. 7, no. 2, pp. 450-455, 2023, doi: 10.33379/gtech.v7i2.2007.

[12] D. Abdullah, M. Dewi, Fadlisyah, "Sistem Pendeteksi Pola Tajwid Al-Qur'an Hukum Idgham Mutaqaribain Pada Al-Qur'an Menggunakan Metode Gower & Legendre," *Jurnal Teknologi Terapan & Sains*, vol. 1, no. 2, pp. 193-205, 2020, doi: 10.29103/tts.v1i2.3260.

[13] H. Lahuddin, R. Satra, "Data Mining Approach to Improve Minimarket Sales using Association Rule Method," *Jurnal Informatika,* vol. 12, no. 1, pp. 10-14, 2025, doi: 10.31294/inf.v12i1.20835.

[14] Mairani, "Korelasi Permasalahan Kulit Wajah terhadap Jenis Produk yang Digunakan Menggunakan Metode Apriori (Studi Kasus : Queen Arabic)," *BRIDGE : Jurnal publikasi Sistem Informasi dan Telekomunikasi*, vol. 2, no. 4, pp. 288-294, 2024, doi: 10.62951/bridge.v2i4.256.

[15] Dr R.Naveenkumar, Md Aisaifi, "Deciphering Patterns in a small scale Case Analysis Study of the Apriori Algorithm in Market Basket Analysis using machine learning tools," *International Scientific Journal of Engineering and Management*, vol. 3 no. 5, pp. 1-11, 2024, doi: 10.55041/ISJEM01603.

[16] A.D. Kuswanto, et al., "Penerapan Algoritma Apriori Dalam Analisis Keranjang Belanja Retail Di Wilayah Jawa Barat,"Saturnus : Jurnal Teknologi dan Sistem Informasi, vol. 2, no. 3, pp. 139-150, 2024, doi: 10.61132/saturnus.v2i3.208.

[17] I. Rosmayati, et al., "Implementasi Data Mining pada Penjualan Kopi Menggunakan Algoritma Apriori," *Jurnal Algoritma,* vol. 20, no. 1, pp. 99-107, 2023, doi: 10.33364/algoritma/v.20-1.1259.

[18] B.H. Situmorang, et al., "Apriori Algorithm Application for Consumer Purchase Patterns Analysis," *Komputasi: Jurnal Ilmiah Ilmu Komputer dan Matematika*, vol. 21, no. 1, pp. 15-20, 2024, doi: 10.33751/komputasi.v21i1.9260.

[19] N.S. Poli, A.S. Sikder, "Predictive Analysis of Sales Using the Apriori Algorithm: A Comprehensive Study on Sales Forecasting and Business Strategies in the Retail Industry," *International Journal of Imminent Science & Technology*, vol. 1, no. 1, pp. 1-15, 2023, doi: 10.70774/ijist.v1i1.1.

[20] S. Raschka"TransactionEncoder: Convert item lists into transaction data for frequent itemset mining," Mlxtend. [Online]. Available: https://rasbt.github.io/mlxtend/user_guide/preprocessing/TransactionEncoder/.

[21] Data Camp, "One-hot encoding transaction data,". [Online]. Available: https://campus.datacamp.com/courses/market-basket-analysis-in-python/introduction-to-market-basket-analysis-1?ex=9.