

# Application of Data Mining with Apriori Algorithm and FP Growth on Cafe Bread Sales to Support Business Intelligence

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## Article Info

### Article history:

Received December 26, 2026

Revised February 24, 2026

Accepted May 05, 2026

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### Keywords:

Apriori Algorithm

FP Growth

Business Intelligence

Market Basket Analysis

Support Vector

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## ABSTRACT

This study aims to apply the Apriori and FP-Growth algorithms in analyzing sales transaction patterns in a bakery Cafe, with a focus on developing a business intelligence strategy. The data used includes 20,507 transactions from January 11, 2016 to December 3, 2017. The results of the analysis show that items (coffee and bread) are the most frequently purchased, with the highest support values of 26.67% and 32.72%, respectively. In addition, several significant association rules were found, such as a positive relationship between (hot chocolate and coffee). This study provides insights that can be used to design more effective marketing strategies, including bundling promotions and more efficient stock management, so as to increase sales and customer satisfaction.

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## 1. INTRODUCTION

Nowadays, cafes have become an important part of modern society. In addition to being a place to eat and drink, cafes also function as a space for social interaction. However, with increasing competition in this industry, many cafe managers face challenges, one of which is the mismatch between the number of menu stocks and customer demand. This problem often causes customers to be unable to order the desired menu because the stock has run out [1]. One solution to overcome this problem is to utilize data mining, especially the Apriori and FP-Growth algorithms, to analyze transaction patterns and provide data-based recommendations.

Previous research conducted [1] used the FP-Growth algorithm at Jingga Coffee to recommend drink menus based on customer purchasing patterns. As a result, they found rules such as (If you buy Lemon Tea, then buy Coffee Milk) with a support level of 96% and 100% confidence. This helps cafes develop more appropriate recommendation strategies. However, this study only focuses on drink menu recommendations without integrating the analysis results into a broader business strategy.

Another study conducted [2] used the Apriori algorithm to increase sales of Oriental Cafe through a product package system. With a minimum support of 30% and confidence of 70%, they successfully identified patterns such as (Mineral and Fish) and (Tea and Mineral) to be arranged into product packages. However, the application of the algorithm only focuses on simple pattern analysis without considering the potential for expansion to an integrated business intelligence support system.

On the other hand, [3] applied the Apriori algorithm to find sales transaction patterns at Cafe Sakuyan Side. This study is more comprehensive by involving the Knowledge Discovery in Database (KDD) stage, including the evaluation of the lift ratio. As a result, 158 valid association rules were found that can be used to develop sales strategies such as menu packages and cross-selling. However, this study is still exploratory without

direct integration into the business operational process. In addition, [4] at Habitat Coffee revealed the benefits of the Apriori algorithm in identifying menu combinations that are often purchased together, such as (special lontong with sweet iced tea). The results of this analysis provide important insights for Cafe managers to improve stock management efficiency.

Furthermore, research at Hidden Toast and Float Cafe [5] showed that the Apriori algorithm can be used to provide automatic menu recommendations based on transaction data. As a result, popular combinations such as (dark choco jam and cappuccino) were found, providing additional benefits in the form of operational efficiency through the development of a web-based system. In addition, research by [6] at Ukokopi highlighted the importance of the Apriori algorithm in stock management and menu placement strategies. Purchase patterns such as (if buying Ginger milk, then most likely buying sausage) with 100% confidence showed the potential of transaction data to support operational decisions.

These studies show that Apriori and FP-Growth algorithms are not only relevant for menu recommendations but also contribute to other aspects such as stock management and marketing. For example, [7] at Gunthem Coffee identified consumer interest patterns such as (if buying black pink, then most likely buying sanger milk coffee) with 86% confidence. The results provide strategic insights for managers to improve marketing effectiveness based on customer transaction patterns. For example, [8] at DL Cafe & Resto found patterns such as (fried noodles and lemon tea) which can be used to formulate more effective marketing strategies. In addition, [9] at Gelora Fantasi Coffee Shop identified the relationship between (cappuccino and palm sugar coffee), which helped reduce stock waste.

Several other studies such as [10] at Cafe The L.Co Coffee, [11] at Millennials Cafe, and [12] at Vin's Cafe further strengthen the argument that the Apriori algorithm can help Cafes formulate data-based strategies. Their findings, including association rules such as (thai tea and milo dinosaur and pizza millennials) or ISO 9126-based system recommendations, demonstrate the benefits of this algorithm in various aspects.

However, some studies still have limitations. Most of them only focus on data analysis without integrating the results into a comprehensive business intelligence strategy. For example, research by [13] at Penang Corner Cafe and [14] at Kafe Aksara only highlighted product combinations without expanding their analysis to broader marketing strategies. Similarly, research at Cafe Bimo [15] used the Apriori algorithm to find menu combination patterns, but did not explain the integration of the analysis results into a more strategic operational system.

Based on these studies, there is a gap in the application of the Apriori and FP-Growth algorithms in small to medium-scale cafes. Most studies only focus on analyzing transaction data to find purchasing patterns without paying more attention to the results of the analysis into business intelligence strategies. In addition, other studies tend to focus on a single aspect, such as menu recommendations or package arrangement, without utilizing more comprehensive data.

Therefore, this study aims to fill the gap by applying the Apriori and FP-Growth algorithms simultaneously to the sales data of bakery cafes. The Apriori algorithm is used to assist in selecting candidate item combinations, then it will be seen whether the combination has met the support, confidence and lift ratio parameters [3]. While the FP-Growth algorithm is used to generate the value of the information index that appears frequently (Frequent itemset) [1]. With this approach, this study not only produces transaction patterns that can support decision making, but also integrates the analysis results into business intelligence strategies to provide more strategic and applicable insights for cafe managers.

## 2. METHOD

This research was conducted using a quantitative approach that includes four main stages, namely data collection, data exploration and visualization, data processing using the Apriori and FP-Growth algorithms, and evaluation and integration of analysis results. The stages of the research steps can be seen in Figure 1

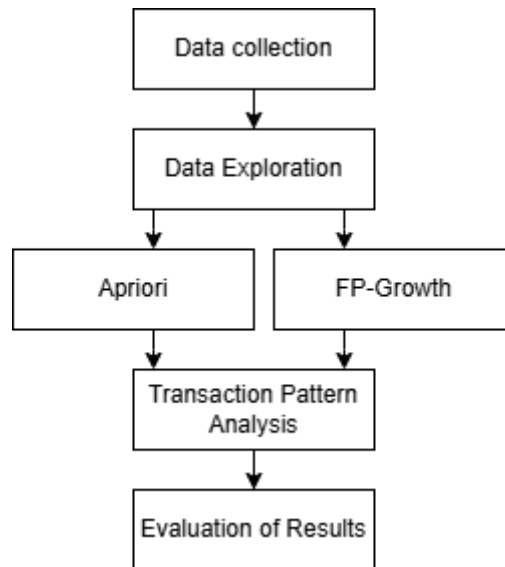


Figure 1. Research steps

The first stage is data collection, where the bakery cafe sales dataset is obtained from the Kaggle platform. This dataset includes important information such as transaction number, type of item purchased, transaction time, time category (daypart), and day type (weekend or weekday). The data is used as a basis for analyzing transaction patterns using data mining algorithms.

In the exploration and data visualization stage, the collected dataset is analyzed descriptively to identify initial patterns and data characteristics. The visualization process is carried out using a histogram to provide an overview of the distribution of transactions, times with the highest sales, and the most purchased items. This stage aims to understand the basic patterns of transactions that can provide initial insights before the data is processed further.

The next step is to process the data using the Apriori and FP-Growth algorithms to identify significant transaction patterns. The Apriori algorithm functions to generate a combination of candidate items based on minimum support and confidence values. The basic formulas used in the Apriori algorithm include:

$$Support(x) = \frac{Number\ of\ Transactions\ Containing\ X}{Total\ Transactions} \quad (1)$$

Support is used to measure how often an item or combination of items appears in the overall transaction. [2]

$$Confidence = P(X|Y) = \frac{\sum Number\ of\ Transactions\ Containing\ X\ and\ Y}{\sum Transactions\ Containing\ X} \quad (2)$$

Confidence is used to measure how much confidence there is that item YG will be purchased when item X has been purchased. [2]

$$Lift\ Ratio(x) = \frac{Confidence\ Support(X \cap Y)}{Support(X) * Support(Y)} \quad (3)$$

Lift ratio is used to measure the extent to which two items X and Y are related to each other or is used to determine the validity of association rules. [2]

After the Apriori algorithm generates combinations, the FP-Growth algorithm is used to efficiently find frequent itemsets through the formation of an FP-tree. This algorithm utilizes a tree structure to store transaction data, thereby reducing the need for recalculation of frequently occurring item combinations. Both algorithms are evaluated using support, confidence, and lift ratio parameters to determine the most relevant association rules.

The final stage is the evaluation and integration of the analysis results, where the resulting transaction patterns are evaluated based on their validity and relevance to the Cafe's business needs. The results of this analysis are then integrated into the business intelligence strategy to provide recommendations in the form of menu packages, promotional strategies, and more efficient stock management. With this process, Cafe managers are expected to be able to utilize data-based insights to support more effective decision making.

### 3. RESULTS AND DISCUSSION

The sales data from the bakery cafe in this study included 20,507 transactions from January 11, 2016 to December 3, 2017. The analysis was conducted with the aim of gaining an understanding of purchasing patterns, the most frequently purchased items, and seasonal patterns in transactions. Here are the results of the most frequently purchased items:

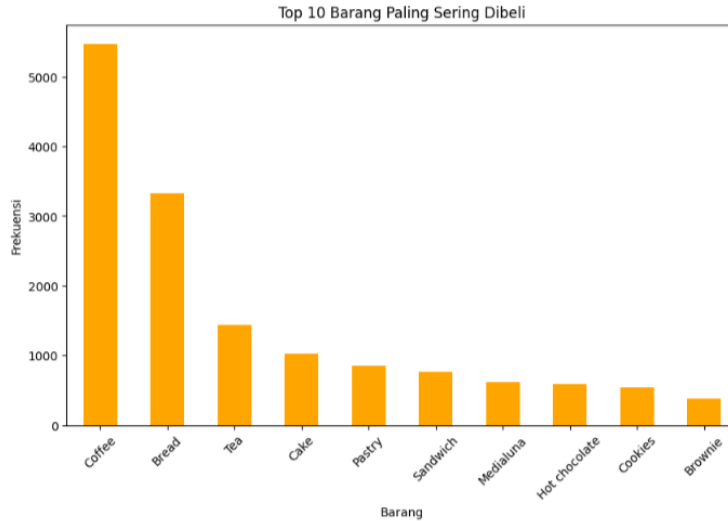


Figure 2. Histogram data analysis

Based on the analysis, there are several types of unique items available in the dataset. Here is a list of the 10 items with the highest transactions:

Table 1. Most frequently purchased items

Item	Transaction Amount
Coffe	5471
Bread	3325
Tea	1435
Cake	1025
Pastry	856
Sandwich	771
Medialuna	616
Hot chocolate	590
Cookies	540
Brownie	379

After the data analysis is complete, the next step is to analyze the seasonal pattern of sales transactions at the Bakery Cafe. Here are the results of the monthly sales transactions:

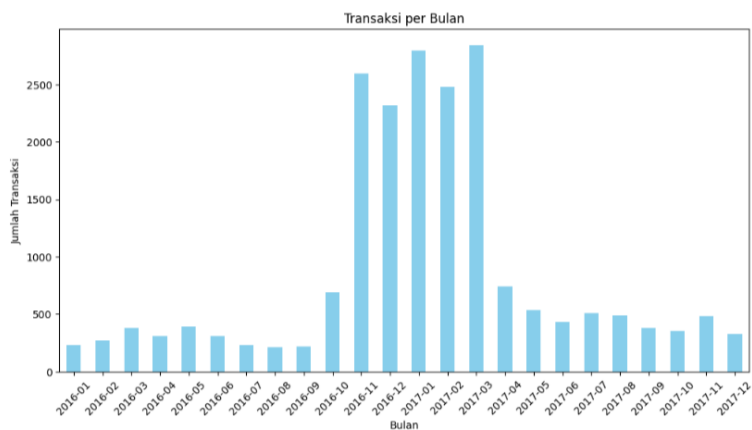


Figure 3. Number of transactions per month

Based on the analysis, the number of transactions per month shows that the most transactions occurred in March 2017 with 2,840 transactions, while August 2016 was the month with the lowest sales, only 212 transactions. This analysis was conducted to understand seasonal patterns in sales, so that Cafe managers can plan more efficient promotions and stock management. After getting an overview of the transactions, the next step is to apply the Apriori algorithm to find more specific purchasing patterns.

After data analysis, the apriori algorithm is used to perform manual calculation processes to find sales transaction patterns.

$$\text{Support}(x) = \frac{\text{Number of Transactions Containing } x}{\text{Total Transactions}} \quad (4)$$

$$\text{Support}(x) = \frac{5471}{20.507} = 0,2667 \text{ (26,67\%)} \quad (5)$$

For example, the calculation of the support value for sales (coffee) shows that the support is 26.67%, which means that this item appears in 26.67% of the total transactions. This is an important step in the analysis using the Apriori algorithm, because it helps managers understand how often this item appears in transactions, which in turn helps in formulating more targeted sales and promotion strategies. Furthermore, the results of this calculation will provide further insight into purchasing patterns.

```

===== Apriori =====
Frequent Itemsets (Apriori):
      support      itemsets
0      0.036344      (Alfajores)
1      0.016059      (Baguette)
2      0.005071      (Bakewell)
3      0.327205      (Bread)
4      0.040042      (Brownie)
..      ...      ...
109    0.007184      (Coffee, Bread, Sandwich)
110    0.007396      (Tea, Coffee, Bread)
111    0.006867      (Cake, Hot chocolate, Coffee)
112    0.010037      (Tea, Coffee, Cake)
113    0.005388      (Tea, Coffee, Sandwich)

[114 rows x 2 columns]
    
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Figure 4. Results of Apriori purchasing pattern analysis

Figure 4 shows the results of the purchase pattern analysis generated by the Apriori algorithm. The results of the purchase pattern analysis show frequent itemsets identified by the Apriori algorithm, providing insight into items that are frequently purchased together. From the analysis, it was found that the Bread item had the highest support value of 32.72%, indicating its popularity among customers. In this way, the information obtained can be used to design more effective marketing strategies.

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===== FP-Growth =====
Frequent Itemsets (FP-Growth):
      support      itemsets
0      0.327205      (Bread)
1      0.029054      (Scandinavian)
2      0.058320      (Hot chocolate)
3      0.054411      (Cookies)
4      0.015003      (Jam)
..      ...      ...
109    0.018067      (Coffee, Scone)
110    0.008347      (Tea, Scone)
111    0.006550      (Salad, Coffee)
112    0.005177      (Chicken Stew, Coffee)
113    0.010882      (Coffee, Spanish Brunch)
    
```

[114 rows x 2 columns]

Figure 5. FP-Growth purchasing pattern analysis results

Meanwhile, the results of the FP-Growth algorithm also confirm the popularity of bread with the same support, which is 0.327205. In addition, other items that stand out are Hot chocolate with support of 0.058320 and cookies with support of 0.054411. The combination of items such as (coffee, scone) with support of 0.018067 shows that customers tend to buy these items together, which can be used for marketing strategies.

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Aturan Asosiasi (Apriori):
      antecedents consequents support confidence lift
0      (Alfajores) (Bread) 0.010354 0.284884 0.870657
1      (Alfajores) (Coffee) 0.019651 0.540698 1.130235
2      (Alfajores) (Tea) 0.006762 0.186047 1.304393
3      (Brownie) (Bread) 0.010777 0.269129 0.822508
4      (Cake) (Bread) 0.023349 0.224822 0.687097
..      ...      ...      ...      ...
98      (Tea, Cake) (Coffee) 0.010037 0.422222 0.882582
99      (Cake, Coffee) (Tea) 0.010037 0.183398 1.285822
100     (Tea, Coffee) (Sandwich) 0.005388 0.108051 1.503972
101     (Tea, Sandwich) (Coffee) 0.005388 0.375000 0.783873
102     (Coffee, Sandwich) (Tea) 0.005388 0.140884 0.987753
    
```

[103 rows x 5 columns]

Figure 6. Association rules of Apriori

Figure 6 above provides the results of the apriori association rules with support, confidence, and lift values, which can help in evaluating the strength of the relationship between items. From the Apriori results, for example, the association rule between Alfajores and Bread has a support of 0.010354, with a confidence of 0.284884 and a lift of 0.870657, indicating that although there is a relationship, this association is not very strong.

This can provide additional insights for Cafe managers to design more effective marketing strategies. Furthermore, sales data visualization can also provide a clearer picture of existing trends.

Aturan Asosiasi (FP-Growth):

	antecedents	consequents	support	confidence	lift
0	(Coffee)	(Bread)	0.090016	0.188163	0.575059
1	(Bread)	(Coffee)	0.090016	0.275105	0.575059
2	(Scandinavian)	(Bread)	0.006550	0.225455	0.689030
3	(Hot chocolate)	(Coffee)	0.029583	0.507246	1.060311
4	(Hot chocolate)	(Tea)	0.008030	0.137681	0.965298
...	...	...	...	...	...
98	(Scone)	(Coffee)	0.018067	0.522936	1.093107
99	(Scone)	(Tea)	0.008347	0.241590	1.693816
100	(Salad)	(Coffee)	0.006550	0.626263	1.309094
101	(Chicken Stew)	(Coffee)	0.005177	0.398374	0.832732
102	(Spanish Brunch)	(Coffee)	0.010882	0.598837	1.251766

[103 rows x 5 columns]

Figure 7. Association rules of FP Growth

Rather, the association rule between (Hot chocolate) and (Coffee) from the FP-Growth results shows support of 0.029583, confidence of 0.507246, and lift of 1.060311, which indicates a fairly strong positive association between the two items.

These results show that data processing using the Apriori and FP-Growth algorithms not only helps in identifying frequently purchased items, but also in understanding the relationships between items through the evaluation of support, confidence, and lift values. With this information, business managers can design more effective marketing strategies, such as bundling promotions or strategic product placement, to increase sales and customer satisfaction.

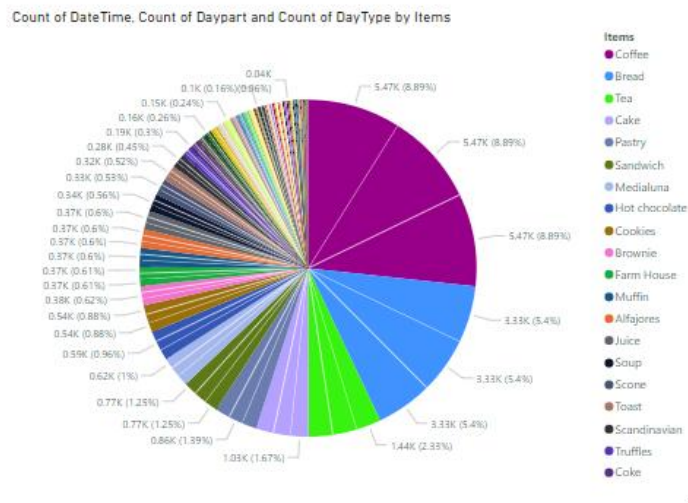


Figure 8. Sales visualization

This visualization provides a comprehensive overview of sales trends and patterns, helping cafe managers understand sales dynamics and make better decisions regarding stock management. With this information, managers can design more effective marketing strategies, such as bundling promotions or strategic product placement, to increase sales and customer satisfaction.

#### 4. CONCLUSION

Based on the results of the analysis conducted, it can be concluded that the application of the Apriori and FP-Growth algorithms simultaneously provides valuable insights in understanding sales transaction patterns at the bakery cafe. This study successfully identified the most frequently purchased items and the relationships between items, which can be utilized to formulate more effective marketing strategies. With high support values for items (coffee and bread), cafe managers can focus on promoting and managing the stock of both items. In addition, the association rules found, such as the relationship between (hot chocolate and coffee), indicate the potential for developing attractive product packages for customers. Overall, the results of this study not only provide a better understanding of customer purchasing behavior, but also support more strategic decision making in managing the cafe business.

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