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# Contents

# Multiple Correspondence Analysis on Public Service in Sabang Tourism Area

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**Abstract.** Sabang area is being developed to be e tourism destination in Indonesia. There are several tourism spots in Sabang. The research purposes are to identify the most interesting tourism location, similarly of the tourism spots, and correlation of public service variables. Data were gathered with using questioners. Respondents were domestic tourists, trader, and hotel manager. A number of tourism sites included 20 sites. Both Multiple Correspondence Analysis and Spearman Correlation are used to analyze the data. The research results show that each site clusters on one or great than one variable. Hospitally, cleanness, publication, and beauty gather with gender variable. The results are strengthened by Spearman correlation which is approximate one.

**Keywords** : Multiple Correspondence Analysis, Spearman Correlation.

## 1 INTRODUCTION

### Background

In everyday life, often we find relation between one variable and another variable. This relation can be studied by various statistical methods both parametric and non parametric. In practice, assumptions related to parametric statistic are difficult to satisfy, therefore non parametric statistic are appropriate to be used to solve the problems mentioned above. For instance, correspondence analysis can be used to solve the problem, if data are found in the form of contingency table and qualitative variables.

Correspondent analysis is a plot between rows and columns of matrix in the form of data categories and the accuracy rates are not lost either by statistical analysis using the assumption (Irlandia, 2006). This analysis is used for public service resort in Kota Sabang since the data consists of rows and columns, so it can be simplified from n-dimension into simple dimension that can describe any information from this data.

Kota Sabang which familiar call of Weh Island, as objects of maritime tourism in Aceh Province is famous for its beautiful natural panoramas to overseas. Many tourists come to this island to enjoy its beauty. These conditions create separate duties for the City Government of Sabang as

implementers of public services in order to fulfil their needs. Therefore, the public service in tourism sector needs to be reviewed further.

**Research Objective**

This study aimed to determine whether there is any relation between variables, the similarity between variables and to find out the association between one variable and another variable by presenting each variable of tourist attraction, gender and public service together in an optima small dimensional vector space.

**Research Benefit**

Benefit of this paper is to obtain mapping using correspondence analysis and to obtain information from the mapping so they can be used as inputs in formulating policies and actions by the government of Sabang.

## 2 Research Method

**Data**

In this research uses secondary data taken from previous research, funded by a research institute in Aceh Institute. In such research, the data used are generally quantitative. Source of data is taken from primary data sources and secondary data sources. The primary data source was obtained directly from the field through interviews and questionnaires, while secondary data sources obtained from government agencies, media, and also the results of research.

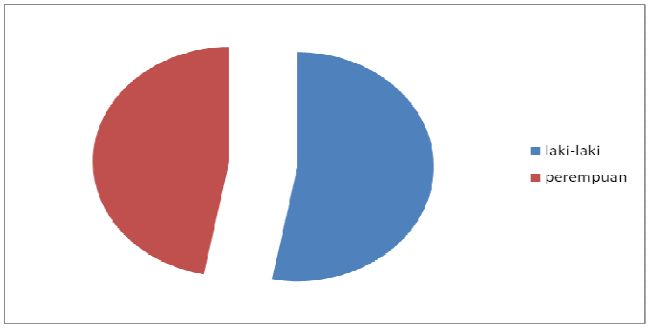
Data collection technique used was quota sampling, where five respondents were selected for each tourist attraction which frequently visited. The research was conducted in the city of Sabang, precisely at 20 locations of Sabang attractions, namely; Pasir Putih, Teupin Sirkui, Danau Aneuk Laot, Pantai Kasih, Teluk Sabang, Air Terjun, Air Panas Keuneukai, Tugu Kilometer Nol, Balohan, Pantai Reuteuk, Pantai Arun, Pantai Anoi Itam, Pantai Paradiso, Pantai Sumur Tiga, Pulau Rubiah, Lueng Angina, Pantai Iboih, Teupin Layee, Pantai Pria Laot Dan Pantai Gapang. Total respondents were 100 visitors and the variables are as follows:

1. Tourist attraction: Pasir Putih, Teupin Sirkui, Danau Aneuk Laot, Pantai Kasih, Teluk Sabang, Air Terjun, Air Panas, Keunuekai, Tugu Km Nol, Balohan, Pantai Reuteuk, Pantai Aroun, Pantai Anoi Itam, Pantai Paradiso, Pantai Sumur Tiga, Pantai Rubiah, Lueng Angin, Pantai Iboih, Teupin Layee, Pantai Pria laot dan Pantai Gapang (20 categories).
2. Gender: Male and Female (2 categories).
3. Public Service: (7 categories). Cleanliness, friendliness, beauty, transportation, publications, facilities, and prices.

## 3 Result And Discussion

### Result

For multiple correspondence analysis, the variables used are tourist attractions, gender and public service. Visitor attractions divided into 20 different locations with the total of respondent is 100 visitors. Therefore, there are five respondents for each tourist attractions. Furthermore, the second variable is gender that divided into male and female categories (male: 53 respondents, female: 47 respondents). The following pie chat display respondent categories.




**Picture 1.** Pie Chart for Gender category

Pie chat above shows that the number of male respondents is more than female. Nevertheless, this difference is significantly small, so that multiple correspondence analysis method can be used.

The third variable is public service that consists of 7 categories; cleanliness, friendliness, beauty, transportation, publication, facility, and price. Scale used is 1 = Disagree, 2 = doubtful, 3 = Agree, 4 = Strongly Agree.

***Table1.*** *Singular Value, Main inertia, Chi Square, Proportion of Explained, and Proportion Cumulative*

| No. | Category | Total | Mean |
|---|---|---|---|
| 1 | Cleanliness | 226.3 | 2.3 |
| 2 | Friendliness | 305.5 | 3.1 |
| 3 | Beauty | 297.0 | 3.0 |
| 4 | Transportation | 213.5 | 2.1 |
| 5 | Publication | 233.5 | 2.3 |
| 6 | Facility | 189.0 | 1.9 |
| 7 | Price | 261.0 | 2.6 |

According to table above, friendliness and beauty categories were 3.1 and 3.0 in value means the level of friendliness and the beauty is relatively good for the 20 major tourist attractions in Sabang. Followed by cleanliness, transportation, and publication that were ranked at number-two means that tourists were hesitate to the public service for this category. Likewise facility which figures was approaching at 1.9. Base on this result, we suggest that the improvement of public services in this category should be increased to satisfy the tourists.
The analysis of three variables above will be continued with multiple correspondences. Below is the output using SPSS.

***Table 2.*** *Singular Value, Main Inertia, Proportion of Explained, and Proportion Cumulative*

| Dimension | Singular Value | Main Inertia | Proportion of Explained | Proportion Cumulative |
|---|---|---|---|---|
| 1 | 0.64704 | 0.41867 | 4.83 | 4.83 |
| 2 | 0.60341 | 0.36410 | 4.20 | 9.03 |
| 3 | 0.60110 | 0.36132 | 4.17 | 13.20 |
| 4 | 0.59345 | 0.35218 | 4.06 | 17.26 |
| … | … | … | … | … |
| … | … | … | … | … |
| Total | | 8.66667 | 100.00 | - |

The table above shows that the percentage of the cumulative proportion of the first two characteristic roots is 9.03%, which means that two vector rows and columns can explain the variability origin data for 9.03% of total inertia. Means that the output picture only explain 9.03% of actual data. Each dimension can be described as the following proportions:
1. Dimension 1 explained the data variability of 4.83%
2. Dimension 2 explains the data variability of 4:20%

## Discussion

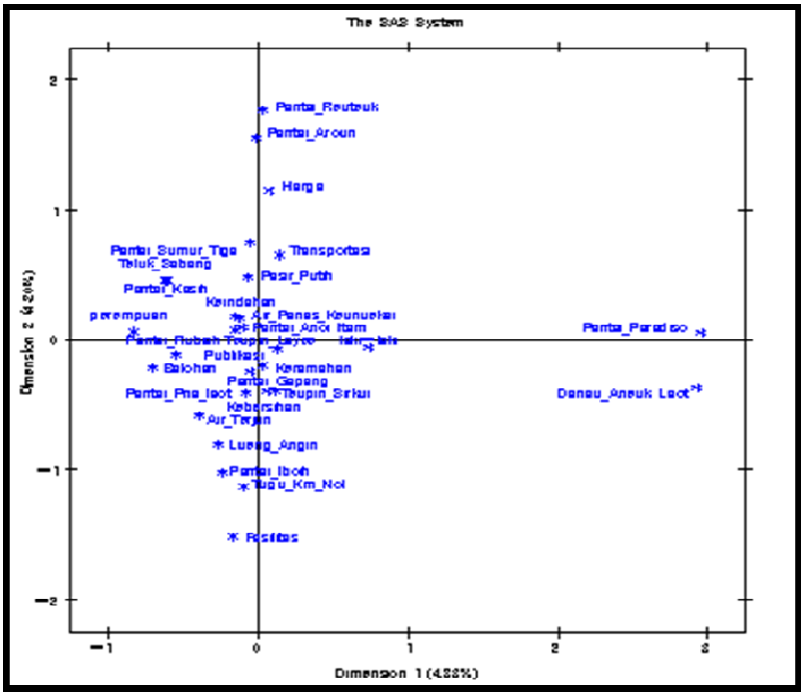
### *Multiple Correspondence Analysis*

In multiple correspondence analysis, the output will be displayed in the form of one-dimensional and two dimensional. In this case, both dimensions will be drawn into a Cartesian graph. To illustrate the Cartesians in the chart, locations of the dots is required. The Dots can be obtained using SAS software. Here are the results obtained by SAS:

***Table 3.*** *Coordinate for each categories for 1- dimensional and 2- dimensional*

| Variable | Category | 1-dimentional | 2-dimentional |
|---|---|---|---|
| Tourist Attraction | Air Panas Keuneukai | -0.1542 | 0.1793 |
| | Air Terjun | -0.3881 | -0.5781 |
| | Balohan | -0.7021 | -0.2168 |
| | Danau Aneuk Laot | 2.9323 | -0.3660 |
| | Lueng Angin | -0.2665 | -0.8041 |
| | Pantai Anoi Itam | -0.0999 | 0.1026 |
| | Pantai Aroun | -0.0056 | 1.5508 |
| | Pantai Gapang | 0.1266 | -0.0658 |
| | Pantai Iboih | -0.2311 | -1.0196 |
| | Pantai Kasih | -0.6123 | 0.4586 |
| | Pantai Paradiso | 2.9625 | 0.0521 |
| | Pantai Pria laot | -0.0821 | -0.4134 |
| | Pantai Reuteuk | 0.0343 | 1.7677 |
| | Pantai Rubiah | -0.5510 | -0.1118 |
| | Pantai Sumur Tiga | -0.0568 | 0.7476 |
| | Pasir Putih | -0.0612 | 0.4768 |
| | Teluk Sabang | -0.6123 | 0.4586 |
| | Teupin Layee | -0.1554 | 0.0785 |
| | Teupin Sirkui | 0.1165 | -0.3916 |
| | Tugu Km Nol | -0.0958 | -1.1244 |
| | Facility | -0.1645 | -1.5065 |
| | Price | 0.0818 | 1.1513 |
| Public Service | Cleanliness | 0.0679 | -0.3979 |
| | Beauty | -0.1226 | 0.1663 |
| | Friendliness | 0.0350 | -0.1914 |
| | Publication | -0.0464 | -0.2439 |
| | Transportation | 0.1484 | 0.6572 |
| Gender | Male | 0.7459 | -0.0585 |
| | Female | -0.8325 | 0.0653 |

According to the table above, the coordinate dots of both dimensions are depicted in a picture resulting from SAS. Below is the multiple correspondence analysis appearance from SAS




**Picture 2.** Multiple Correspondence Analysis Output

Base on the result display:

1. The majority of tourist attractions are clustered in publication, cleanliness, friendliness and beauty attributes.
2. Pantai Reuteuk and Pantai Aroun are clustered in price attribute. Means that the prices at these locations are relatively cheap and achievable.
3. Pasir Putih and Pantai Sumur Tiga are clustered in transportation attribute. In these locations have good road facilities for vehicles. Thereby, we can conclude that in transportation facilities in these places are better than the others.
4. Tugu Km Nol is clustered in facility attribute that serves variety food and beverage, rental and toilet that relatively good that others places.
5. Pantai Iboih is clustered in cleanliness attribute which means the hygiene standard in this place is high compare to other attractive places.

6. Pantai Anoi Itam and Teupin Layee are clustered in transportation attribute. It Means that at these places transportation facilities are relatively good that other locations.
7. Both male and female are clustered in publication, cleanliness, friendliness, and beauty. It means that they expect better public service at these attributes.

***Spearman Correlation***

Spearman correlation is used to support the multiple correlation analysis outcomes to investigate the strength and relation among variables. The latter to observe closeness among 7 public service variables: cleanliness, friendliness, beauty, transportation, publication, facility, and price.

***Table 4.4*** *Spearman Correlation Output*

| - | | Cleanliness | Friendliness | Beauty | Transportation | Publication | Facility | Price |
|---|---|---|---|---|---|---|---|---|
| **Cleanliness** | | 1.00000 | 0.81949 | 0.72357 | 0.12420 | 0.82031 | 1.70147 | 0.43385 |
| | **P value** | | < 0.0001 | 0.00030 | 0.60190 | <0.0001 | 0.00060 | 0.05600 |
| **Friendliness** | | | 1.00000 | 0.72336 | 0.03967 | 0.75482 | 0.75255 | 0.47378 |
| | **P value** | | | 0.00030 | 0.86810 | 0.00010 | 0.00010 | 0.03480 |
| **Beauty** | | | | 1.00000 | 0.30185 | 0.77748 | 0.49189 | 0.43946 |
| | **P value** | | | | 0.19590 | <0.00010 | 0.02760 | 0.05250 |
| **Transportation** | | | | | 1.00000 | 0.46790 | 0.20928 | -0.00339 |
| | **P value** | | | | | 0.03570 | 0.37590 | 0.98870 |
| **Publication** | | | | | | 1.00000 | 0.66516 | 0.21078 |
| | **P value** | | | | | | 0.00140 | 0.37240 |
| **Facility** | | | | | | | 1.00000 | 0.23645 |
| | **P value** | | | | | | | 0.31550 |
| **Price** | | | | | | | | 1.00000 |
| | **P value** | | | | | | | |

Base on the table above, we can conclude:

1. Cleanliness is significantly associates with friendliness, beauty, publication, and facility. Means that is cleanliness increases, it affects friendliness attribute, beauty, publication and facility. On the contrast, cleanliness does not relate to transportation and price since p value is more than 0.05.
2. Friendliness is significantly associates with beauty, publication, facility and price but not with transportation.
3. Beauty does not correlate with price because p value is more than 0.05. According to the result of spearman correlation above, it can be concluded that the result has support the output accuracy of correspondent analysis (Picture 2).

## 4 Conclusion and Suggestion

### Conclusion

Regarding to research outcome and discussion , we can conclude that:

1. The majority of tourist attractions are clustered in publication, cleanliness, friendliness and beauty attributes.
2. Pantai Reuteuk and Pantai Aroun are clustered in price attribute. This explains that the price offered in this area is relatively cheap and very affordable for tourists.
3. Pasir Putih and Pantai Sumur Tiga clustered in the transport attribute. Thus, the conclusion of transport in both places is better than other places.
4. Tugu Km Nol clustered in attribute Facility.
5. Pantai Iboih clustered with cleanliness attribute that indicates where this tour has a high level of cleanliness of the other attractions.
6. Transportation attributes clustered with beach resorts and Teupin Layee Anoi Itam. This is the best means of transport from other regions.
7. Spearman correlation test results confirming the accuracy of the results of correspondence analysis display.

### Suggestion

City Government of Sabang should level the public service in every area of tourism in order to further enhance the development of tourism revenue in Sabang.

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# Linear Programming and Sensitivity Analysis for Optimizing Nutrient Sufficiency

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**Abstract.** The application of Linear Programming and Sensitivity Analysis in this research is to optimize the nutrition sufficiency of adult female in Aceh Besar regency. The objectives of this research are to identify the amount of money to fulfill the food needed and food quantity combination that must be prepared in a week, so that the nutrition can be satisfied. Data consist of 43 decision variables as well as 248 females as the object. Data Analysis results count of money that should be prepared by the community in Aceh Besar for food consumption is Rp. 3,398.21 per kilogram body weight per week, also food consumption combination in the unit of gram and URT per week. The research also results output of Sensitivity Analysis.

**Keywords :** *Linear Programming, Sensitivity Analysis, Nutrient Sufficiency.*

## 1 Introduction

### 1.1 Background

In developing or disaster area like Aceh Besar regency, people or families are often difficult or they do not notice nutrient of themselves. These happenings because knowledge about nutrient is little, purchasing power which is thought is not able to buy foods which have high nutrient, or knowledge about nutrient is not suitable with community habit.

Foods which will be consumed ought to satisfy 100% of nutrient elements in the body, their prices can be reached with purchasing power of the community, and food kinds are suitable with consumption habit. Therefore, optimalization of person or family nutrient sufficiency with notice purchasing power and consumption habit is important for community, and the other people or institution which has interest.

This research is held to apply linear programming model and sensitifity analysis for optimalizing of nutrient sufficiency in Aceh Besar regency, Aceh province.

### 1.2 Objectives

Purpose of the research is :
1. To apply linear programming model in identifying the amount of expenditure budget for foods which should be prepared per week so that necessity of nutrient elements can be satisfied.
2. To apply sensitifity analysis in identifying change of objective function score which is caused by food price change or nutrient element necessity change in body.

## 2 Materials And Methods

### 2.1 Sampling Method

Data used in the research are both primer and secondary data. The former data are family food consumption data with factors which their influence. Respondents were housewives in Aceh Besar regency, Aceh Province, Indonesia. The number of samples taken was 250 households held with two steps, they were :
1. The first step
The first step was applied stratified random sampling, stratification was based on region locations in Aceh Besar regency. There were five regions which become layers.
2. The Second Step
Cluster sampling was used after the first step, the cluster was subdistrict. 2 subdistricts were chosen from every regions randomly, the subdistricts can be seen in Table 1, then households were taken from the subdistricts. Respondents in the households were housewives who have obtained cash direct aid ( Bantuan Langsung Tunai [BLT] ) from central government. Households receiver BLT have low economics or poor families.

**Table 1.** Subdistricts which selected as location of sampling in every region

| Region 1 | Region 2 | Region 3 | Region 4 | Region 5 |
|---|---|---|---|---|
| Montasik | Peukan Bada | Mesjid Raya | Kutabaru | Darul Imarah |
| Indrapuri | Lhoknga | Baitussalam | Krueng Barona Jaya | Darul Kamal |

Housewives are chosen as respondents because they know about food consumed in family. 50 households were chosen from every regions, where each subdistricts were represented by 25 households. Respondents were taken from all villages in the subdistricts, each of villages consists of 1 or 2 housholds.

Respondens were interviewed with using questionary. Data taken from questionary included the number of family expenditure budgets for non food, frequency and the number of foods which is usually consumed by family member. Respondens were interviewed not only about their consumed food habit but also about their family consumed food habit. Respondens and their families are also counted their body weight and height.

Secondary data source is nutrition sufficiency rate table ( Tabel Angka Kecukupan Gizi [ AKG ] ) and Indonesian Food Composition Table ( Daftar Komposisi Bahan Makanan [ DKBM ] ). AKG table is needed to identify requirement nutrient elements of family members daily and DKBM is required to identify nutrient element of every foods which are usually eaten in 100 gram foods.

### 2.2 Research Steps

Research steps of this research are :

- Gather data with using food frequency questionary
- Build linear programming model.
- Find values of decision variables and objective function
- Apply sensitifity analysis
- Make conclusion.

## 3 Results And Discussions

### 3.1 Data Characteristics

Survey was held to 250 households. 968 people from 250 households had been gathered, or 1 family was around 4 people. The number of males was 483 whereas females was 485, see Figure 1. 237 people of 483 male people which were obtained have age between 20 and 59 years old. 279 people of 485 female people which were got have age between 20 and 59 year and 31 people were giving suck. Object of this linear programming research was female which have age between 20 and 59 years old without both fregnant and giving suck. The number of them was 248 people, see Figure 2.

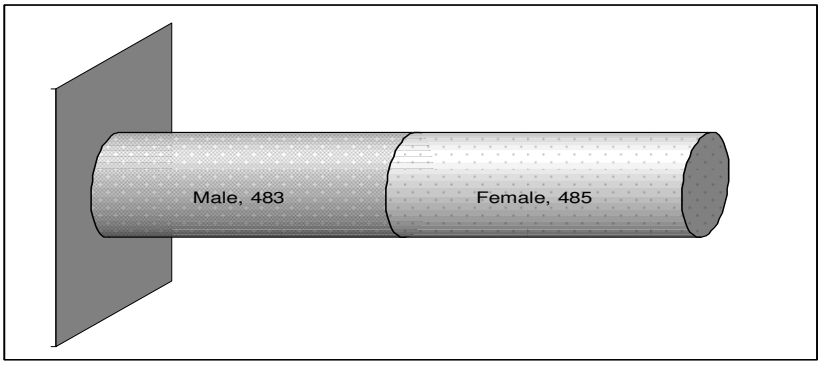


**Figure 1.** Distribution of data according to gender

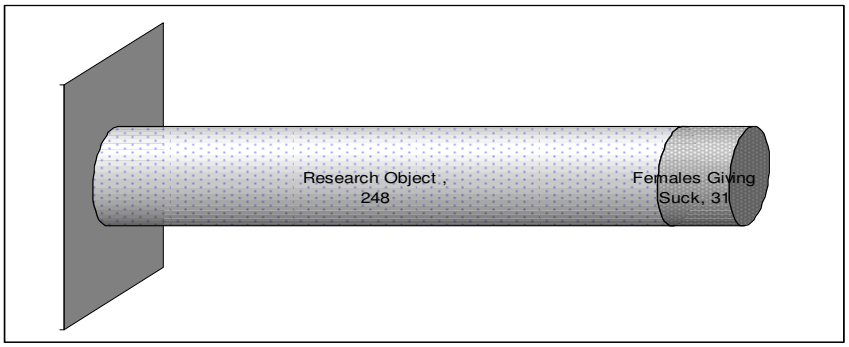


**Figure 2.** Distribution females age between 19 and 59 years old

Foods which are consumed by family members in Aceh Besar in the research have many kinds, let rice, nasi gurih, nasi goreng, roti, to tahu goreng. Each of foods has measurement unit ( satuan ukuran rumah tangga [URT] ) which is different, such as rice its URT is plate, noodle its URT is pack, bread its URT is piece, etc. URT of each food is converted to gram unit with measure directly foods which are usually consumed.

Food prices are obtained from interview directly with respondens. URT of food was converted to gram, then it was converted to food prices, for instance one plate of rice is 250 gram and its price Rp 3000 ( see Table 2 ). The food prices are used in linear programming objective function as decision variable coefficients, so purpose of minimize expenditure budget can be reached. The amount of food nutrient usually consumed is taken from DKBM. The data is used as constraints in linear programming model.

**Table 2.** Conversion of food URT usually consumed by Aceh Besar society to gram unit and food prices

| No. | Name of Foods | Food Codes | URT | Convert result from URT to Gram | Food Prices per URT ( Rp ) |
|---|---|---|---|---|---|
| I. Cereals | | | | | |
| 1 | Rice | X1 | Plate | 250 | 3000 |
| 2 | Nasi gurih | X2 | Plate | 350 | 3500 |
| 3 | Fried Rice | X3 | Plate | 350 | 3500 |
| 4 | Instant noodle | X4 | Pack | 100 | 1000 |
| 5 | Bread | X5 | Piece | 50 | 500 |
| II. Meats, Fishes, Eggs | | | | | |
| 6 | Chicken | X6 | Piece | 50 | 4000 |
| 7 | Beef/ mutton | X7 | Piece | 60 | 4000 |
| 8 | Sea Fish | X8 | Piece | 50 | 3000 |
| 9 | Freshwater fish | X9 | Piece | 60 | 4000 |
| 10 | Salted fish | X10 | Piece | 10 | 600 |
| 11 | Crab | X11 | Piece | 200 | 5000 |
| 12 | Egg | X12 | Unit | 45 | 600 |
| 13 | Salted egg | X13 | Unit | 60 | 1200 |
| 14 | Milk | X14 | Glass | 230 | 4000 |
| 15 | Shrimp | X15 | Piece | 10 | 250 |
| 16 | Clam | X16 | Tablespoon | 10 | 1000 |
| III. Beans | | | | | |
| 17 | Tempe | X17 | Piece | 38 | 250 |
| 18 | Tahu | X18 | Piece | 100 | 350 |
| 19 | Long bean | X19 | Tablespoon | 4 | 16 |
| 20 | Green bean | X20 | Tablespoon | 1,5 | 22 |
| IV. Leaves | | | | | |
| 21 | Spinach | X21 | Tablespoon | 20 | 150 |
| 21 | Water spinach | X22 | Tablespoon | 20 | 100 |
| 23 | Mustard Green | X23 | Tablespoon | 20 | 200 |
| 24 | Sup ( Carrot, Cabbage ) | X24 | Tablespoon | 40 | 400 |
| V. Fruit Vegetables | | | | | |
| 25 | Squash | X25 | Tablespoon | 20 | 150 |
| 26 | Tomato | X26 | Unit | 100 | 300 |
| 27 | Cucumber | X27 | Unit | 340 | 1000 |
| 28 | Jackfruit | X28 | Tablespoon | 25 | 300 |
| 29 | Eggplant | X29 | Piece | 30 | 100 |
| VI. Fruits | | | | | |
| 30 | Papaya | X30 | Piece | 125 | 500 |
| 31 | Pineapple | X31 | Piece | 100 | 500 |
| 32 | Banana | X32 | Unit | 150 | 400 |
| 33 | Orange | X33 | Un | 100 | 800 |

| | | | | | |
|---|---|---|---|---|---|
| 34 | Apple | X34 | Unit | 200 | 4000 |
| 35 | Bark | X35 | Unit | 75 | 600 |
| 36 | Melon | X36 | Piece | 100 | 1000 |
| 37 | Watermelon | X37 | Piece | 150 | 500 |
| VII. Others | | | | | |
| 38 | Meatball | X38 | Bowl | 750 | 5000 |
| 39 | Siomay | X39 | Plate | 500 | 5000 |
| 40 | Fried banana | X40 | Piece | 100 | 500 |
| 41 | Chicken noodle | X41 | Plate | 500 | 5000 |
| 42 | Bakwan | X42 | Piece | 50 | 500 |
| 43 | Fried Tahu | X43 | Piece | 50 | 500 |

### 3.2 Build Linear Programming Model

Values which want to be resulted are the number of foods which should be consumed per week in Aceh Besar area. Each of foods is coded, let $X_1$ is rice code, $X_2$ is nasi gurih, to $X_{43}$ is fried tahu. Decision variables, $X_j$ ( $j$ =1,2,3,...,43) represent 43 of food kinds ( see Table 2 ).

Objective of the linear programming model is minimization of total cost which should be prepared for food expenditure per person per week. Model of linear programming for this problem becomes :

$$\text{Minimum } Z = 12\,X_1 + 10\,X_2 + 10\,X_3 + ... + 10\,X_{43}$$

For each food price ( $C_j$ ) can be counted from data in Table 2 . Let $C_1$ = 3000/ 250 = 12.

Constraints of this model are :

a. The first constraint ( energy )

Constraints of the models need both AKG and DKBM data. Coeficients of decision variables use DKBM data. Values of right hand sides ( rhs ) are taken from AKG. Rhs values for energy constraint for 1 kilogram body weight per week are

$$\frac{\text{Necessity of energy per person per day ( from AKG table)}}{\text{Body Weight ( from AKG table)}} x\ many\ days\ per\ week =$$

$$\frac{2250}{54} x\ 7 = 291.67$$

Coefficients of decision variables in constraints use DKBM data. Let coefficient of $X_1$ is energy in 1 gram rice is

$$\frac{\text{energy in 100 gram rice ( from DKBM table)}}{100} = \frac{178}{100} = 1.78$$

Coefficient of $X_2$ is energy nasi gurih in 1 gram nasi gurih is

$$\frac{\text{energy in 100 gram nasi gurih ( from DKBM table)}}{100} = \frac{253}{100} = 2.53$$

Hence, model of energy constraint is

$$1.78X_1 + 2.53X_2 + 2.76X_3 + \ ... \ + 3.28X_{43} = 291.67$$

b. The second constraint ( protein )
Rhs of the protein constraint is 6.22 gram for 1 kilogram body weight per week. Coefficient of $X_1$ which is protein of rice in 1 gram is 0.021, coefficient of $X_2$ which is protein of nasi gurih in 1 gram is 0.043.

Hence, model of the protein constraint is

$$0.021X_1 + 0.043X_2 + 0.032X_3 + \ ... \ + 1.84X_{43} = 6.22$$

c. The third constraint (calcium), the forth constraint (phosfor), the fifth constraint ( iron ), the sixth constraint (vitamine A), the seventh constraint (vitamine C) are each

$$0.05X_1 + 0X_2 + 0X_3 + \ ... \ + 0X_{43} = 64.81$$
$$0.22X_1 + 0X_2 + 0.028X_3 + \ ... \ + 1.496X_{43} = 58.33$$
$$0.005X_1 + 0.0035X_2 + 0.0066X_3 + \ ... \ + 0.1048X_{43} = 3.37$$
$$0X_1 + 0X_2 + 0X_3 + \ ... \ + 0X_{43} = 64.81$$
$$0X_1 + 0X_2 + 0X_3 + \ ... \ + 0X_{43} = 7.78$$

with limits of each food are:

$$X_1 = 97.22; 0 \le X_2 \le 6.48; \cdots; 0 \le X_{43} \le 1.85$$

Lower bound and upper bound of foods are determined from the twentieth percentile and the eightieth percentile of respondent food consumption data. Lower bound means respondent usually consumes foods great than the lower bound, whereas upper bound means that respondent generally consumes foods less than the upper bound. Let percentile 20 ( lower bound ) of instant noodle is 0.92 gram per kilogram body weight per week and

percentile 80 ( upper bound ) is 5.56 gram per kilogram body weight per week ( Table 3 ), it is the mean that adult women in Aceh Besar regency generally consumed great than 0.92 gram per kilogram body weight per week and less than 5.56 gram per kilogram body weight per week. Both of the limits are used so that result of the research can be accepted highly because consumption suitable with habit of society in the place.

**Table 3.** Lower bound and upper bound of foods ( gram per kilogram body weight per week )

| No | Names of foods | Codes of foods | Lower bound | Upper bound |
|---|---|---|---|---|
| I. Cereals | | | | |
| 1 | Rice | X1 | 97,22 | 97,22 |
| 2 | Nasi gurih | X2 | 0 | 6,48 |
| 3 | Fried Rice | X3 | 1,62 | 12,96 |
| 4 | Instant noodle | X4 | 0,92 | 5,56 |
| 5 | Bread | X5 | 0,46 | 2,77 |
| II. Meats, Fishes, Eggs | | | | |
| 6 | Chicken | X6 | 0,04 | 0,46 |
| 7 | Beef/ mutton | X7 | 0,05 | 0,14 |
| 8 | Sea Fish | X8 | 6,48 | 19,44 |
| 9 | Freshwater fish | X9 | 0,005 | 1,11 |
| 10 | Salted fish | X10 | 0,09 | 0,74 |
| 11 | Crab | X11 | 0,06 | 1,85 |
| 12 | Egg | X12 | 1,25 | 5,83 |
| 13 | Salted egg | X13 | 0,14 | 1,11 |
| 14 | Milk | X14 | 0,08 | 1,06 |
| 15 | Shrimp | X15 | 0,1 | 0,74 |
| 16 | Clam | X16 | 0,004 | infinity |
| III. Beans | | | | |
| 17 | Tempe | X17 | 1,41 | 5,63 |
| 18 | Tahu | X18 | 1,85 | 11,11 |
| 19 | Long bean | X19 | 0,07 | 0,44 |
| 20 | Green bean | X20 | 0,02 | 0,11 |
| IV. Leaves | | | | |
| 21 | Spinach | X21 | 0,37 | 2,22 |
| 22 | Water spinach | X22 | 0,55 | 2,22 |
| 23 | Mustard Green | X23 | 0,007 | 0,74 |
| 24 | Sup ( Carrot, Cabbage ) | X24 | 0,15 | 2,22 |
| V. Fruit Vegetables | | | | |
| 25 | Squash | X25 | 0,01 | 0,37 |
| 26 | Tomato | X26 | 1,85 | 6,48 |
| 27 | Cucumber | X27 | 0,79 | 6,3 |
| 28 | Jackfruit | X28 | 0,12 | 0,58 |

| | | | | |
|---|---|---|---|---|
| 29 | Eggplant | X29 | 0,14 | 1,11 |
| VI. Fruits | | | | |
| 30 | Papaya | X30 | 1,16 | 4,63 |
| 31 | Pineapple | X31 | 0,04 | 0,93 |
| 32 | Banana | X32 | 2,08 | 11,11 |
| 33 | Orange | X33 | 0,46 | 3,7 |
| 34 | Apple | X34 | 0,08 | 0,93 |
| 35 | Bark | X35 | 0,35 | 2,78 |
| 36 | Melon | X36 | 0,02 | 0,04 |
| 37 | Watermelon | X37 | 0,23 | 2,78 |
| VII. Others | | | | |
| 38 | Meatball | X38 | 0,58 | 10,42 |
| 39 | Siomay | X39 | 0,1 | 2,32 |
| 40 | Fried banana | X40 | 1,85 | 7,41 |
| 41 | Chicken noodle | X41 | 0,19 | infinity |
| 42 | Bakwan | X42 | 0,46 | 1,85 |
| 43 | Fried Tahu | X43 | 0 | 1,85 |

### 3.3 Results of Linear Programming

Output of the linear programming model is

The LP Procedure

Problem Summary

| | |
|---|---|
| Objective Function | Min Biaya |
| Rhs Variable | _RHS_ |
| Type Variable | _TYPE_ |
| Problem Density (%) | 80.52 |

| Variables | Number |
|---|---|
| Lower Bounded | 2 |
| Upper and Lower Bounded | 40 |
| Fixed | 1 |
| Slack | 1 |
| Total | 44 |

| Constraints | Number |
|---|---|
| LE | 1 |
| EQ | 6 |
| Objective | 1 |
| Total | 8 |

Solution Summary

Terminated Successfully

| | |
|---|---|
| Objective Value | 3398.2139624 |
| Phase 1 Iterations | 20 |
| Phase 2 Iterations | 21 |
| Phase 3 Iterations | 0 |
| Integer Iterations | 0 |
| Integer Solutions | 0 |
| Initial Basic Feasible Variables | 8 |
| Time Used (seconds) | 0 |
| Number of Inversions | 3 |
| Epsilon | 1E-8 |
| Infinity | 1.797693E308 |
| Maximum Phase 1 Iterations | 100 |
| Maximum Phase 2 Iterations | 100 |
| Maximum Phase 3 Iterations | 99999999 |
| Maximum Integer Iterations | 100 |
| Time Limit (seconds) | 120 |

Variable Summary

| Col | Variable Name | Status | Type | Price | Activity | Reduced Cost |
|---|---|---|---|---|---|---|
| 1 | x1 | | FIXED | 12 | 97.22 | 13.136867 |
| 2 | x2 | LOWBD | UPLOWBD | 10 | 0 | 20.617881 |
| 3 | x3 | LOWBD | UPLOWBD | 10 | 1.62 | 13.576142 |
| 4 | x4 | LOWBD | UPLOWBD | 10 | 0.92 | 0 |
| 5 | x5 | UPPBD | UPLOWBD | 10 | 2.77 | -6.367372 |
| 6 | x6 | LOWBD | UPLOWBD | 80 | 0.04 | 76.040831 |
| 7 | x7 | LOWBD | UPLOWBD | 66.67 | 0.05 | 15.327515 |
| 8 | x8 | LOWBD | UPLOWBD | 60 | 6.48 | 78.556453 |
| 9 | x9 | UPPBD | UPLOWBD | 66.67 | 1.11 | -135.7448 |
| 10 | x10 | UPPBD | UPLOWBD | 60 | 0.74 | -8.928443 |
| 11 | x11 | UPPBD | UPLOWBD | 25 | 1.85 | -13.84044 |
| 12 | x12 | UPPBD | UPLOWBD | 13.33 | 5.83 | -28.47958 |
| 13 | x13 | UPPBD | UPLOWBD | 20 | 1.11 | -48.92844 |
| 14 | x14 | BASIC | UPLOWBD | 17.39 | 0.7717433 | 0 |
| 15 | x15 | UPPBD | UPLOWBD | 25 | 0.74 | -216.5969 |
| 16 | x16 | BASIC | LOWERBD | 100 | 23.674607 | 0 |
| 17 | x17 | UPPBD | UPLOWBD | 6.58 | 5.63 | -263.2249 |
| 18 | x18 | LOWBD | UPLOWBD | 3.5 | 1.85 | 7.3871856 |
| 19 | x19 | UPPBD | UPLOWBD | 4 | 0.44 | -16.49369 |
| 20 | x20 | UPPBD | UPLOWBD | 14.67 | 0.11 | -6.983705 |
| 21 | x21 | UPPBD | UPLOWBD | 7.5 | 2.22 | -33.26171 |
| 22 | x22 | UPPBD | UPLOWBD | 5 | 2.22 | -37.51481 |
| 23 | x23 | UPPBD | UPLOWBD | 10 | 0.74 | -79.488 |
| 24 | x24 | BASIC | UPLOWBD | 10 | 1.8702092 | 0 |
| 25 | x25 | LOWBD | UPLOWBD | 7.5 | 0.01 | 5.4046496 |
| 26 | x26 | LOWBD | UPLOWBD | 3 | 1.85 | 10.051054 |
| 27 | x27 | BASIC | UPLOWBD | 2.94 | 5.121166 | 0 |
| 28 | x28 | LOWBD | UPLOWBD | 12 | 0.12 | 0.461313 |
| 29 | x29 | UPPBD | UPLOWBD | 3.33 | 1.11 | -2.926571 |
| 30 | x30 | BASIC | UPLOWBD | 4 | 3.4691777 | 0 |
| 31 | x31 | LOWBD | UPLOWBD | 5 | 0.04 | 12.405158 |
| 32 | x32 | UPPBD | UPLOWBD | 2.67 | 11.11 | -1.488667 |
| 33 | x33 | LOWBD | UPLOWBD | 8 | 0.46 | 24.668219 |
| 34 | x34 | LOWBD | UPLOWBD | 20 | 0.08 | 18.419547 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 35 | x35 | UPPBD | UPLOWBD | 8 | 2.78 | -113.5474 | |
| 36 | x36 | LOWBD | UPLOWBD | 10 | 0.02 | 10.45073 | |
| 37 | x37 | LOWBD | UPLOWBD | 3.33 | 0.23 | 0.7390287 | |
| 38 | x38 | UPPBD | UPLOWBD | 6.67 | 10.42 | -64.97344 | |
| 39 | x39 | UPPBD | UPLOWBD | 10 | 2.32 | -18.85536 | |
| 40 | x40 | LOWBD | UPLOWBD | 50 | 1.85 | 68.05485 | |
| 41 | x41 | BASIC | LOWERBD | 10 | 63.670007 | 0 | |
| 42 | x42 | UPPBD | UPLOWBD | 10 | 1.85 | -182.0639 | |
| 43 | x43 | LOWBD | UPLOWBD | 10 | 0 | 13.887186 | |
| 44 | Protein | BASIC | SLACK | 0 | 1.8288826 | 0 | |

Constraint Summary

| Row | Constraint Name | Type | S/S Col | Rhs | Activity | Dual Activity |
|---|---|---|---|---|---|---|
| 1 | Cost | OBJECTVE | . | 0 | 3398.214 | . |
| 2 | Energy | EQ | . | 291.67 | 291.67 | -8.322215 |
| 3 | Protein | LE | 44 | 6.22 | 4.3911174 | 0 |
| 4 | Calcium | EQ | . | 64.81 | 64.81 | 20.681794 |
| 5 | Phosfor | EQ | . | 58.33 | 58.33 | -10.30853 |
| 6 | Fe | EQ | . | 3.37 | 3.37 | 2982.0924 |
| 7 | Vit.A | EQ | . | 64.81 | 64.81 | 2.6698401 |
| 8 | Vit.C | EQ | . | 7.78 | 7.78 | -61.3875 |

Result of the model is Z value Rp.3398,21 per kg body weight per week and $X_j$ value is quantity of foods with unit gram per kilogram body weight per week.

Food combination is determined according to ideal body height and weight. Each of the body hights can be looked for ideal body weight, the number of foods which should be consumed 1 week in gram and URT, and the number of costs which should be prepared in 1 week for the foods. For instance, necessity of rice to adult female which has body height 1.5 metres.

Ideal body weight can be conted with formula :

$$\text{Body Weight ( BW )} = \text{Body Mass Index ( BMI )} \times (\text{ Body Hight ( BH ) })^2$$

In this formula, body weight in kilogram, body height in metre, and IMT is taken from normal BMI median ( 22 ), so the formula becomes :

$$\text{Ideal BW} = 22 \times (\text{BH})^2$$

After each of ideal body hights is obtained, then food consumption with gram per week for every body hight can be counted with :

$$Food\ Consumption\ jth = X_j \times ideal\ BW$$

Therefore, quantity of rice consumption for 1.5 metre can be counted with:

$$BW = 22 \times (BH)^2 = 22 \times (1.5)^2 = 49.5$$

Consumption of rice (gram per week) = 97,22 x 49,5 = 4812,390 gram

Quantity of every foods can be converted to URT unit, the formula can be used :

$$Food\ consumption\ (URT) = \frac{Food\ consumption\ j\ (gram)}{Food\ weight\ URT\ (gram)}$$

Hence, quantity of rice consumption for females which have body height 1.5 metre is:

$$\text{Rice (plate)} = \frac{4812.390\ (gram\ per\ week)}{250\ (gram)} = 19.250 \approx 19 \text{ plate per week}$$

Cost of every food consumption for every body height can be counted with formula :

*Food consumption cost = Food consumption (URT) x Food prices (Rp/ URT)*

Cost of rice for a body height is :

*Rice consumption cost = Rice consumption (Plate) x Price of nasi (Rp/ plate)*

Price of every food can be seen in Table 2. Hence, cost of rice consumption for females which have body height 1.5 metre is:

Rice consumption cost = 19 x Rp. 3,000,- = Rp. 57,000,- per week

Total cost of foods which should be prepared for every person in one week is multply Rp. 3398,214 ( result of linear programing ) with ideal body weight, mathematically it can be written:

*Cost per week = Rp. 3398.214 x Ideal body weight (kilogram)*

Therefore, cost which should be prepared per week for body height 1.5 metres can be counted :

Cost per week = Rp. 3398.214 x 49.5 kg = Rp. 168211.159

### 3.4 Result of Sensitifity Analysis

a. Sensitivity Analysis for change of cost ( $C_{ij}$ )

Result which is obtained from the model is minimum score Z Rp.3398.21 per kg body weight per week. According to sensitifity result, if cost of chicken meat ( X6 ) change from Rp 80 per gram becomes batween 3.959 and infinity with the other cost is fixed, then total cost (Z) will change from Rp. 3398.21 becomes between Rp. 3395.17 and *infinity*. The less cost of foods changes, the less total cost is gotten. Changes the other foods can be noticed in the Output.

The LP Procedure

Price Range Analysis

| | Variable | Minimum Phi | | | Maximum Phi | | |
|---|---|---|---|---|---|---|---|
| Col | Name | Price | Entering | Objective | Price | Entering | Objective |
| 1 | x1 | -1.136867 | x1 | 2121.0478 | INFINITY | . | INFINITY |
| 2 | x2 | -10.61788 | x2 | 4305.4007 | INFINITY | . | -INFINITY |
| 3 | x3 | -3.576142 | x3 | 3376.2206 | INFINITY | . | INFINITY |
| 4 | x4 | 10 | x4 | 3398.214 | INFINITY | . | INFINITY |
| 5 | x5 | -INFINITY | . | -INFINITY | 16.367372 | x5 | 3415.8516 |
| 6 | x6 | 3.9591693 | x6 | 3395.1723 | INFINITY | . | INFINITY |
| 7 | x7 | 51.342485 | x7 | 3397.4476 | INFINITY | . | INFINITY |
| 8 | x8 | -18.55645 | x8 | 2889.1681 | INFINITY | . | INFINITY |
| 9 | x9 | -INFINITY | . | -INFINITY | 202.41484 | x9 | 3548.8907 |
| 10 | x10 | -INFINITY | . | -INFINITY | 68.928443 | x10 | 3404.821 |
| 11 | x11 | -INFINITY | . | -INFINITY | 38.840444 | x11 | 3423.8188 |
| 12 | x12 | -INFINITY | . | -INFINITY | 41.80958 | x12 | 3564.2499 |
| 13 | x13 | -INFINITY | . | -INFINITY | 68.928443 | x13 | 3452.5245 |
| 14 | x14 | -9.44497 | x11 | 3377.5043 | 21.205305 | x28 | 3401.1584 |
| 15 | x15 | -INFINITY | . | -INFINITY | 241.59692 | x15 | 3558.4957 |
| 16 | x16 | 85.097651 | x37 | 3045.4067 | 103.35871 | x28 | 3477.7302 |
| 17 | x17 | -INFINITY | . | -INFINITY | 269.80486 | x17 | 4880.1699 |
| 18 | x18 | -3.887186 | x18 | 3384.5477 | INFINITY | . | INFINITY |
| 19 | x19 | -INFINITY | . | -INFINITY | 20.493685 | x19 | 3405.4712 |
| 20 | x20 | -INFINITY | . | -INFINITY | 21.653705 | x20 | 3398.9822 |
| 21 | x21 | -INFINITY | . | -INFINITY | 40.761714 | x21 | 3472.055 |
| 22 | x22 | -INFINITY | . | -INFINITY | 42.514811 | x22 | 3481.4968 |
| 23 | x23 | -INFINITY | . | -INFINITY | 89.487997 | x23 | 3457.0351 |
| 24 | x24 | 8.3727058 | x28 | 3395.1706 | 11.210056 | x37 | 3400.477 |
| 25 | x25 | 2.0953504 | x25 | 3398.1599 | INFINITY | . | INFINITY |
| 26 | x26 | -7.051054 | x26 | 3379.6195 | INFINITY | . | INFINITY |
| 27 | x27 | 2.4199419 | x28 | 3395.5507 | 4.0336905 | x18 | 3403.8149 |
| 28 | x28 | 11.538687 | x28 | 3398.1586 | INFINITY | . | INFINITY |
| 29 | x29 | -INFINITY | . | -INFINITY | 6.2565707 | x29 | 3401.4625 |
| 30 | x30 | -5.267114 | x37 | 3366.0647 | 5.7909212 | x28 | 3404.427 |
| 31 | x31 | -7.405158 | x31 | 3397.7178 | INFINITY | . | INFINITY |
| 32 | x32 | -INFINITY | . | -INFINITY | 4.1586665 | x32 | 3414.753 |
| 33 | x33 | -16.66822 | x33 | 3386.8666 | INFINITY | . | INFINITY |
| 34 | x34 | 1.5804532 | x34 | 3396.7404 | INFINITY | . | INFINITY |
| 35 | x35 | -INFINITY | . | -INFINITY | 121.54739 | x35 | 3713.8757 |
| 36 | x36 | -0.45073 | x36 | 3398.0049 | INFINITY | . | INFINITY |
| 37 | x37 | 2.5909713 | x37 | 3398.044 | INFINITY | . | INFINITY |
| 38 | x38 | -INFINITY | . | -INFINITY | 71.643443 | x38 | 4075.2372 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 39 | x39 | -INFINITY | . | -INFINITY | 28.855363 | x39 | 3441.9584 |
| 40 | x40 | -18.05485 | x40 | 3272.3125 | INFINITY | . | INFINITY |
| 41 | x41 | 2.1663635 | x32 | 2899.4463 | 10 | x4 | 3398.214 |
| 42 | x42 | -INFINITY | . | -INFINITY | 192.06392 | x42 | 3735.0322 |
| 43 | x43 | -3.887186 | x43 | 5453.5174 | INFINITY | . | -INFINITY |
| 44 | Protein | -29.23559 | x10 | 3344.7455 | 94.997241 | x28 | 3571.9528 |

b. Sensitivity Analysis for change nutrient elements ( $g_i$ )

Sensitifity Analisis for change right hand side ( RHS ) in constraints can be seen in Output. Result which is gotten from the model is minimum score ( Z ) Rp.3398.21 per kilogram body weight per week. According to Output, if necessity of energy changes becomes between 277.86 and 295.965 with the other necessity is fixed, then total cost (Z) change between 3362.47 and 3513.13. Change of the other nutrient element can be seen in the Output.

The LP Procedure

RHS Range Analysis

| | Minimum Phi | | | Maximum Phi | | |
|---|---|---|---|---|---|---|
| Row | Rhs | Leaving | Objective | Rhs | Leaving | Objective |
| Energy | 277.86107 | x14 | 3513.1348 | 295.96548 | x27 | 3362.4661 |
| Protein | 4.3911174 | Protein | 3398.214 | INFINITY | . | . |
| Calcium | 64.634782 | x27 | 3394.5901 | 65.453771 | x27 | 3411.5283 |
| Phosfor | 57.832799 | x27 | 3403.3394 | 58.465326 | x27 | 3396.819 |
| Fe | 3.3637699 | x27 | 3379.6352 | 3.3928902 | x27 | 3466.4746 |
| Vit.A | 62.290275 | x24 | 3391.4867 | 65.322366 | x24 | 3399.5819 |
| Vit.C | 6.8637479 | x27 | 3454.4604 | 8.0293807 | x27 | 3382.9051 |

Change of Xj food nutrient element content ($a_{ij}$) in this cases is not learned because aij value is fixed.

## 4 Conclusions

Conclusions from the research are:

1. Adult females in Aceh Besar regency which have 19 to 59 old should prepare cost for food minimum Rp. 3398.21 per kilogram body weight per week, and combination of food consumption in URT which have been counted can be become as guidance.
2. Sensitifity analysis in this research can be applied to see change minimum cost ( Z ) which is caused by either food cost or nutrient necesity in body change.

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