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Detection of Red Meat Consumption with Fuzzy Logic Method

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***Abstract*—This study provides a model that estimates amount of meat consumption using fuzzy logic based on criteria selected. In the study, total 235 data compiled from the survey belong to Bingöl province in Turkey in 2020 year were utilized. MATLAB package program was used for the implementation phase of this research. Research model included 3 inputs (income, food spending, frequent) and 1 output (amount consumption). Besides, study model used Mamdani Type Fuzzy Interference and made used of Mean of Maximum – MOM method.**
In the study, the results obtained point out the usability of fuzzy logic in estimating red meat consumption.

Keywords—Read meat, consumption, fuzzy logic, membership, income

I. INTRODUCTION

Breeding activities are usually carried out by small family-owned businesses with traditional methods devoid of economic awareness in a disorganized way in Turkey. This situation creates problems in forming statistical information about animal assets, balancing the supply and demand equilibrium of animal products, making the market price, and marketing [1].
Establishing and developing agriculture policies in the country will enable accessing basic foodstuff, which is important for human life, at the intended level and cost-effectively. The importance of a well-balanced diet for protecting and improving human health has been increasing [2].
People in countries where balanced and adequate nutrition is provided are healthy and able to maintain their physical and mental activities, and this is important for the economy of the country. Animal proteins such as red meat, which is an important outcome of animal production, are the main elements for adequate and balanced nutrition of individuals [3].
The quality of the protein intake is also important in order to mention balanced and adequate nutrition, and it is recommended that the amount of animal protein should constitute almost 40-50% of daily protein intake [4]. Meat is the most important protein source and contains many components necessary for growth, development, and fulfilling some physiological functions. Additionally, meat has such features as being delicious, being able to be consumed in many ways, and having a high degree of digestion. It is also highly priced compared to other foods across the world. This is an important factor that decreases adequate meat consumption [5].
Some studies included various statistical methods about red meat consumption. It is possible to conduct statistical studies with the fuzzy logic method.
With fuzzy logic, an inference structure with knowledge-based, applicable approximation capability is provided. Fuzzy set theory has provided mathematical power that includes uncertainties combined with human cognitive processes such as thinking [6].
MATLAB is a software that is widely used in many areas all over the world with numerical and symbolic calculations, data analysis, highly advanced drawing procedures, algorithm development, advanced programming, engineering and scientific applications [7].
Fuzzy logic has recently gained traction in many fields. To illustrate, it is used in geophysics [8, 9], creating a land valuation model [10], in the health sector [11] and egg consumption forecast [12].
The goal of this study is to estimate red meat consumption with fuzzy logic application by creating input functions and output functions using MATLAB program.

II. MATERIAL AND METHOD

Material

The population of the study included people who lived in Bingöl, Turkey and neighboring provinces. However, sampling was made as it was almost impossible to reach the entire population and obtain information about them in terms of time and cost. A study was conducted in February 2020 mostly in Bingöl, Turkey and the survey was implemented to 235 people. The survey was excluded and the remaining 235 surveys were analyzed.

Method

Fuzzy logic is a powerful problem-solving method for many auditing and information processes. It enables simply obtaining accurate results considering fuzzy information in indefinite situations containing uncertainties. Qualifications in the fuzzy logic enable using indefinite provisions [13].

Conventional set theory is a structure defined with quite certain rules. This structure consists of sets and elements are either a member of the set or not. This certainty creates a difference between the elements
and the membership of an element to a set is assessed as yes or no so it is certain. The membership feature is a binary function in conventional sets, in other words, it takes the value of 0 or 1. Linguistically, all colors are either black or white. A color is obliged to be included in one of the two sets [14].
Fuzzy Inference Systems are basically used to transform inputs to outputs. Firstly, numerical inputs are divided into conventional sets, in other words, they are blurred. Rules are added to the database according to the values and the rules suitable for the inputs are activated. An area sum forms for each input due to the
rules activated in the Mamdani style. These areas consist of the areas of fuzzy outputs which are equivalent to the areas in the blurred input [15]. Fuzzy outputs are transformed into numerical values via blur removal algorithms and form the outcome of the system as an output. The same process is repeated for all inputs. It is necessary to blur the inputs and outputs to form a well-functioning Fuzzy Inference System [16].
The inputs are defined with fuzzy sets for the Mamdani style fuzzy inference system. These set structures introducing the membership functions are multifarious. The most common fuzzification methods are those performed with triangle, trapezoid, gauss, and general bell membership functions. It is important to determine the most suitable membership functions based on the data distribution or model [17]. One of the most commonly used membership functions is the triangle membership function.
The triangular membership function is defined as follows [18].

$$f(x,a,b,c) = \begin{cases} \dfrac{x-a}{b-a}, & a \le x \le b \\ \dfrac{c-x}{c-b}, & b \le x \le c \\ 0, & x \le c \ \ or \ \ x \le a \end{cases}$$

In this model estimating red meat consumption based on fuzzy logic, inputs were defined as monthly income, monthly food spending, yearly consumption frequently and outputs were defined as the amount of consumption (Table 1). System structure is displayed in Figure 1.

Table 1. Input, output and membership functions (For red meat consumption amount)

	Variables	Values	Membership functions		
Input	Income	2000-10000 TRY	Low	Medium	High
	Food spending	500-3000 TRY	Low	Medium	High
	Consumption frequently	0-100	Low	Medium	High
Output	Consumption amount	0-5 kg	Low	Medium	High

Fuzzy sets and expressions were formed according to the data obtained. Fuzzy sets created for each of the input data were formed in the low, medium and high ranges. The income input variable was defined in the range of 2000-10000, the food spending variable was defined in the range of 500-3000 and consumption frequently variable was determined in the range of 0-100 in a year. The amount of red meat consumption was defined in the range of 0-5 kg in a month.

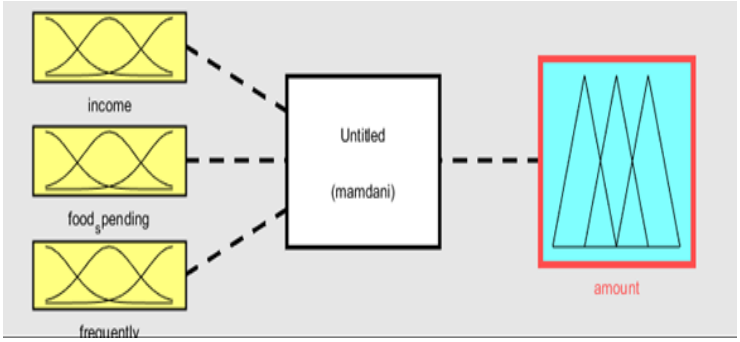

Figure 1. Fuzzy logic based red meat consumption amount determination

In the system, levels were defined according to value ranges in order to define membership functions. Three levels (low, medium, high) were defined for the income input data, three levels (low, medium, high) were defined for the food expenditure input data, and three levels (low, medium, high) were defined for the amount of consumption output data. Membership functions used in the system are shown in Figure 2.

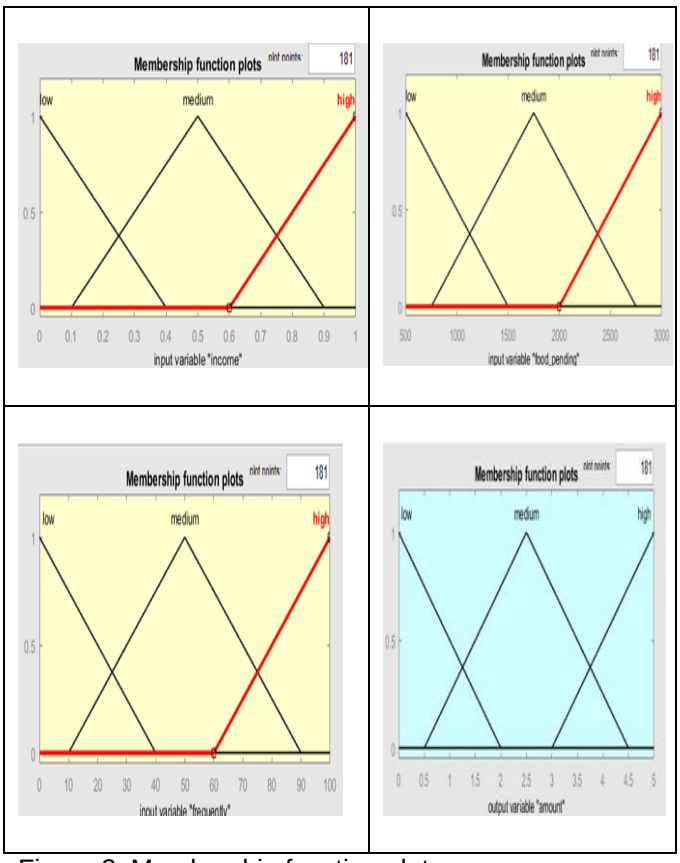

Figure 2. Membership function plots

The analysis of fuzzy logic application was carried out using Matlab Fuzzy toolbox.

III. RESULTS AND DISCUSSION

In the fuzzy logic application, input and output variables were defined to determine red meat consumption. The triangular membership function was selected for the membership function. Input variables were income, food spending and frequently, while output variable was amount of consumption. Figure 3 shows the parameters of the fuzzy model consisting of three input and one output parameter and the modeling of the system in MATLAB R2016b program.

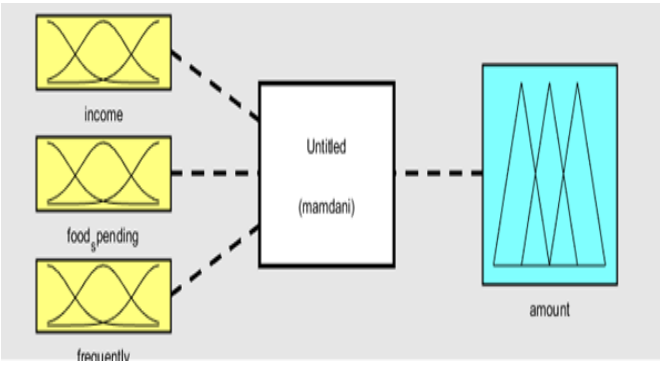

Figure 3. MATLAB view of modeling

Graphical representation of "income" input parameter in MATLAB is given in Figure 4.

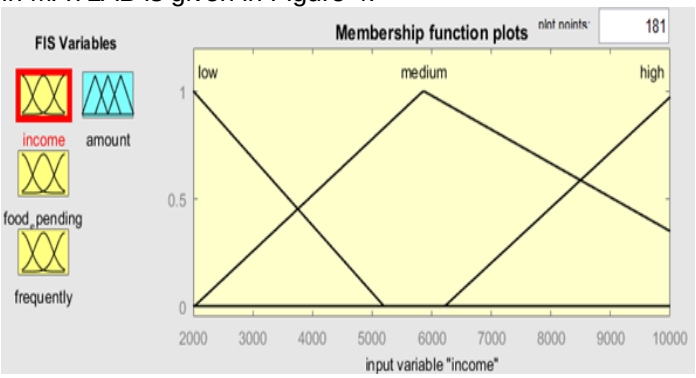

Figure 4. Income input parameter membership functions

Graphical representation of "food spending" input parameter in MATLAB is given in Figure 5.

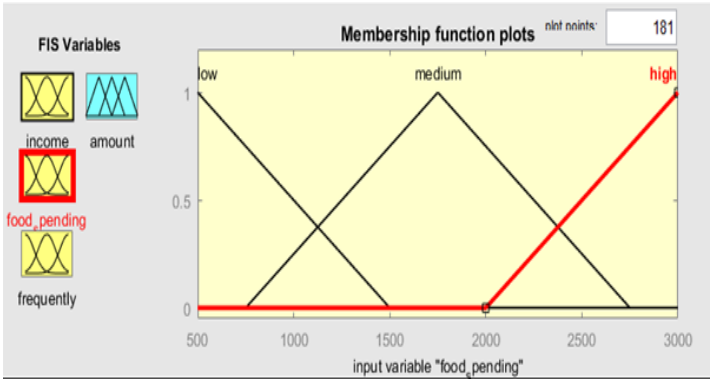

Figure 5. Food spending input parameter membership functions

Graphical representation of "frequently" input parameter in MATLAB is given in Figure 6.

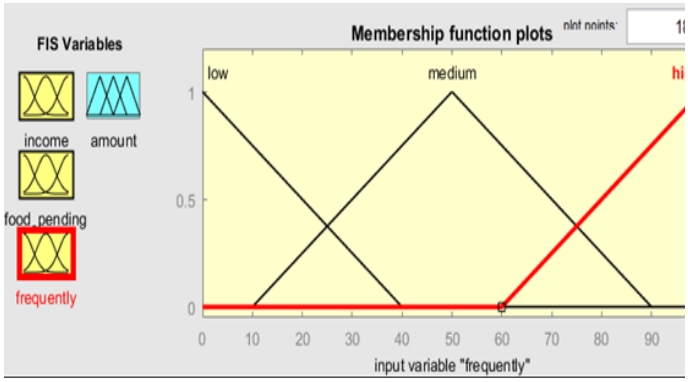

Figure 6. Frequently input parameter membership functions

Graphical representation of "amount" output parameter in MATLAB is given in Figure 7.

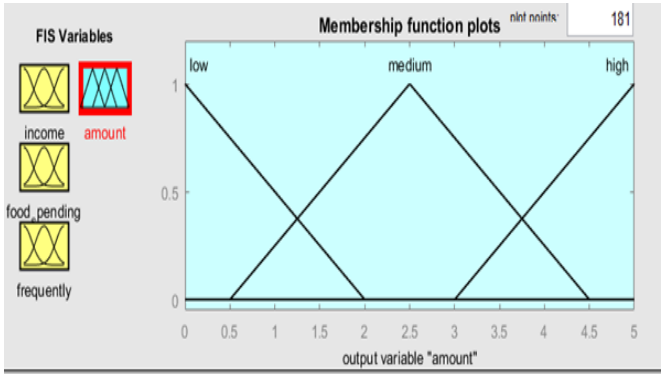

Figure 7. Membership functions of the output parameter of consumption amount

Rules were created with IF-THEN structure for the system to be designed according to the fuzzy rule base. To understand the relationship between the determined membership functions, a fuzzy rule base was created. Numerous rules were created that make the relationship between input and output parameters easy to understand. All possibilities are included in the knowledge base created, and the rule base of the fuzzy model in MATLAB R2016b program is shown in Figure 8.

The rules determined as in Figure 8 are summarized below.

1. If income, food spending and frequent are low then amount is low.
2. If income is low, food spending and frequent are medium then amount is medium.
3. If income, food spending and frequent are medium then amount is medium.
4. If income is low, food spending and frequent are medium then amount is medium.
5. If income is low, food spending is high and frequent is medium then amount is medium.
6. If income is low, food spending and frequent are high then amount is medium.
7. If income is low, food spending is high and frequent are medium then amount is high.
8. If income is medium, food spending and frequent are high then amount is high.
9. If income and food spending are medium, frequent is high then amount is high.
10. If income is high, food spending is medium and frequent is high then amount is high.
11. If income, food spending and frequent are high then amount is high.
12. If income and food spending are high and frequent is medium then amount is high.
13. If income is high, food spending is low and frequent is medium then amount is medium.
14. If income is medium, food spending is low and frequent is medium then amount is medium.
15. If income is low, food spending is medium and frequent is low then amount is medium.
16. If income and frequent are low, food spending is medium then amount is low.

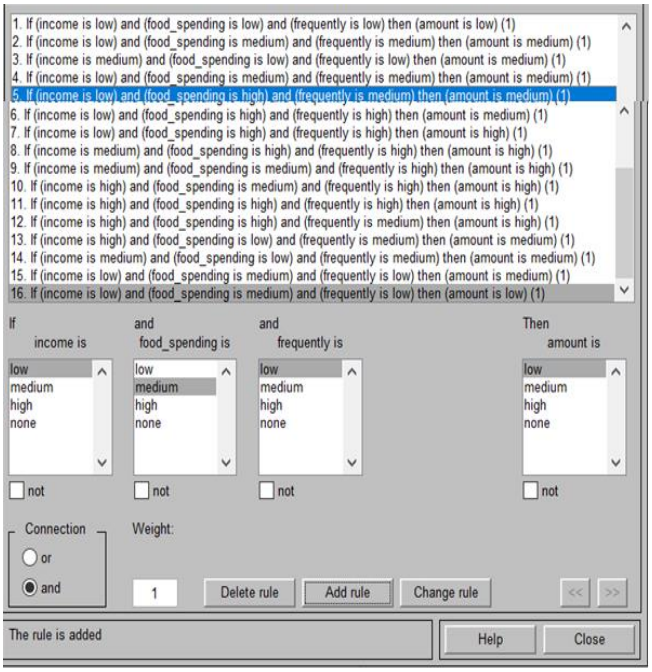

Figure 8. Fuzzy rule base

The image of the process of estimating the amount of consumption with fuzzy logic method in MATLAB R2016b program is shown in Figure 9.

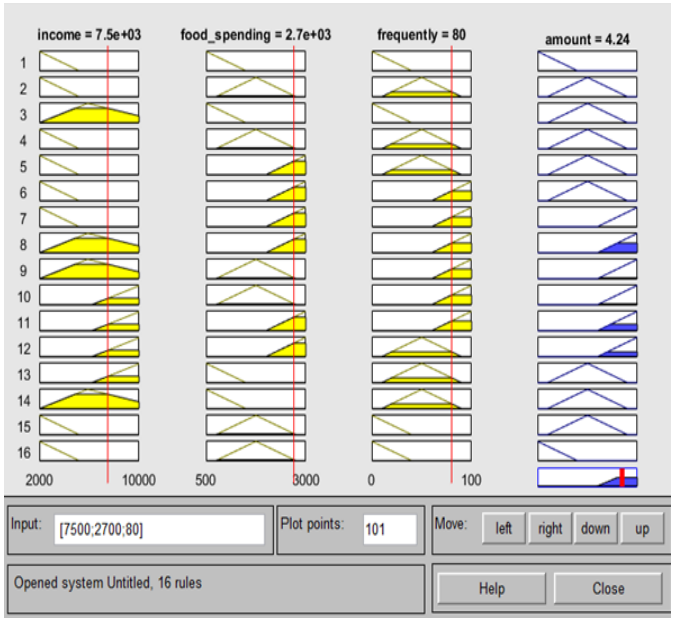

Figure 9. The defuzzification screen for the decision-making process of the model

As seen in Figure 9, the amount of consumption, which is the output variable, predictable by taking income, food spending and frequently, which are the input variables, into account. Here, when the income is 7500 TRY, the food spending is 2700 TRY and the frequently is 80, the amount of red meat consumed per month will be 4.24 kg. Red meat consumption can be estimated by using various values for income and food expenditure variables. According to this rule base, the amount of consumption predicted by the model using different values for income, food spending and frequently is displayed in Table 2.

Table 2. Amount of consumption predicted according to input variables for different values

Income	Food spending	Frequently	Amount of consumption
6000	1750	50	2.50
3000	1750	40	2.50
4000	1900	55	2.50
5000	2200	65	3.18
3500	1600	35	2.39
7500	2750	80	4.24
9000	3000	90	4.30
6000	2000	45	2.50
3800	2300	25	2.06
3500	1100	20	2.03
3000	1000	18	1.78
5000	1000	18	2.45
5000	1300	27	2.39
5750	1800	33	2.50
6250	2100	45	4.03

The effect of input variables on output variables according to the fuzzy rule base is given in Figure 10.

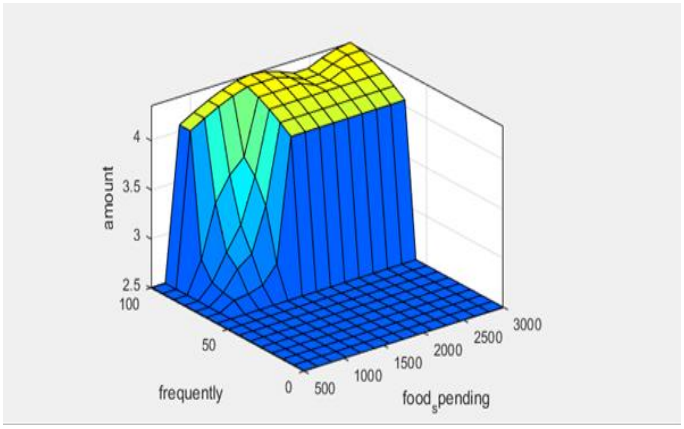

Figure 10. The effect of the exit of input variables to the rule base

When Figure 10 is examined, it is clearly seen that the amount of consumption increases as the numerical ranges of Income, Food Spending and Frequently input variables increase.

A study on red meat found that 50.6% of 516 individuals in Gaziantep, Turkey preferred red meat while 1.7% did not consume red meat. The most commonly preferred red meat types were mutton (77.9%), beef (6.2%), and goat's meet (2.3%), respectively [19]. In a questionnaire administered to 463 individuals in Elazig, Turkey, it was found that 58.4% of the participants preferred red meat and the most commonly preferred red meat types were "beef" (55.3%), "mutton" (15.3%), and goat's meat (11.7%). Considering the type of red meat consumption, it was found that 40.8% preferred "grilled-fried", 40.8% preferred "with vegetables", 8.6% preferred "stewed", and 9.7% preferred "other" [20].

IV. CONCLUSION

In this study, a fuzzy logic model was established for the estimation of red meat consumption using the information on income, food spending and consumption frequent. In the model, income, food spending and frequent were used as input variables, while the amount of consumption was used as the output variable. To understand the relationship between input and output variables, a fuzzy rule base was created. Mamdani type was used as the mechanism of inference. Centroid method was used for defuzzification.

In this research, a model was created to estimate the monthly amount of red meat consumed by individuals using fuzzy logic. The maximum amount of red meat consumed by individuals per month was predicted to be 4.3 kg when income was 9000 TL, food spending was 3000 TRY and meat 90 times a year. It has been observed that the fuzzy logic model can provide successful results in estimating the consumption level of a product according to the monthly income, food spending and frequent of the consumers.

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