International Journal of Mathematical Archive-9(7), 2018, 68-74
Available online through www.ijma.info ISSN 2229 – 5046

A FUZZY APPROACH FOR SOLVING PRODUCTION SYSTEM PROBLEM

M. M. SOLOMON
M.Sc. thesis in Operations Research and Management,
Cairo University, ISSR, 12613 Giza, Dr. Ahmed Zoweel Street, Egypt.

Prof. Dr. Hegazy Mohamed Zaher
Professor of Mathematical Statistics, Cairo University, ISSR.

Assoc. Prof. Dr. Naglaa Ragaa Saeid
Assoc. Prof. of Operations Research and Management, Cairo University, ISSR.

(Received On: 04-06-18; Revised & Accepted On: 03-07-18)

ABSTRACT

Solving multi-objective optimization problem in manufacturing field normally includes variety of challenges. It is important to maximize profit, improve quality of a product mean while reduce losses and cost. This trade-off plays a multiple role in solving many manufacturing optimization problems. The Chocoman Company USA produces varieties of chocolate bars, candy and wafer by means of raw materials. The decision maker has a fuzzy goal such as objective functions and the objective of this company is to maximize the five objective functions with eight variables. The formulation of this problem resulted in five functions to be optimized based twenty nine constraints to be satisfied. This is typical fuzzy multi-objective linear programming problem. This problem occurs in production planning management where by a decision maker plays an important role in making decision in a fuzzy goal environment. As an analyst, we try to find a good enough solution for the decision maker to satisfy his goals. Many methods attempted to solve this problem without considering the decision maker has a fuzzy goal. In this paper, we provide a fuzzy multi-objective linear programming method to solve the chocolate production system problem.

***Keywords**: multi-objective optimization, fuzzy goal, Chocolate Production System, fuzzy multi-objective linear programming fuzzy Decision.*

1. INTRODUCTION

Most manufacturing engineering problems involve multi-objective and sometimes the decision maker has a fuzzy goals. For example, maximize profit, maximize revenue, minimize cost, maximize units produced etc. these are difficult but practical problems which normally happen [4]. In this paper, we report on the application of the fuzzy programming methodology to a real life problem of production system chocolate problem. The data for this problem has been adopted from the data-bank of chocolate Inc., USA [8]. In 2012 Alaa Sheta et al. solved this problem by used both the Scalarization and the Pareto methods; they compared their results with the results [6]. The developed results show an improvement in the produced optimal values to solve the multi objective problem for the chocolate production system than the recent reported results. The new problem occurs in manufacturing engineering where a decision maker plays an important role in making decisions within a fuzzy goal such as objective functions. As an analyst, we seek the best methodology for the decision maker with fuzzy goals to adopt in order to identify a final decision for implementation to satisfy a decision maker's goals [7]. There is a generality of content for this problem where the decision maker has a fuzzy goal. Therefore it is appropriate that this problem is solved using a (FMOLP) fuzzy multi-objective linear programming approach [5]. In this paper the main motivation is to solve the well-known chocolate production system problem using fuzzy multi-objective linear programming algorithm. A comparison between the results of fuzzy multi-objective linear programming method and the results of Pareto method [1] will be provided. A real life industrial problem is selected to demonstrate the methodology and a solution is achieved. The paper is outlined as follows. In section 2, we present problem definition. In section 3, we present the methodology of fuzzy multi-objective linear programming. In section 4, we present the case study of chocolate production system problem. In section 5, we present the results and discussion. The paper ends with conclusion.

Corresponding Author: M. M. SOLOMON
M.Sc. thesis in Operations Research and Management,
Cairo University, ISSR, 12613 Giza, Dr. Ahmed Zoweel Street, Egypt.

2. PROBLEM DEFINITION

Main problem is about solving multi-objective optimization problem and the decision maker has a fuzzy goal such as objective functions. The fuzzy objective functions are characterized by their membership functions and the degree of satisfaction of these membership functions. We want to satisfy (optimize) the objective functions of this problem and we want to reach to the highest degree of satisfaction of the fuzzy goals of the decision maker. This problem contained five objective functions with 8 parameters to be optimized and 29 constraints that should be satisfied at the end of the solution process that finds the optimal set of parameters.

3. METHODOLOGY OF FMOLP PROBLEM

The concept of decision making in fuzzy environment involving several objectives was first proposed by bellman and Zaden (1970). Zimmermann (1978) applied their approach to vector maximum problem by transforming (FMOLP) fuzzy multi-objective linear programming problem to single objective linear programming.

In this paper we proposed fuzzy multi-objective linear programming approach as a tool to solve multi-objective optimization problem with fuzzy goal. In our problem we assumed that the decision maker has a fuzzy goal such as the objective function.

This approach can be used in particular for decision problems which have the structure of linear programming. Decision problems can be formulated as fuzzy decision models [5].

Zimmermann called the fuzzy decision the minimum operator, and for other aggregation patterns than the minimum operator.

H.-j. Zimmermann extended his fuzzy linear programming approach to the following multi-objective linear programming problem with K linear objective function $Z_i(x) = c_i\, x$, $i = 1, 2,\dots, k$.

$$\text{Minimize } Z(x) \triangleq (Z_1(x), Z_2(x)\dots Z_k(x))^T \qquad (1)$$
$$AX \le b$$
$$X \ge 0$$

where $c_i = (c_{i1},\dots,c_{in})$, $i = 1,2,\dots,k$, $x = (x_1, x_2, \dots, x_n)^T$, $b = (b_1, \dots, b_m)^T$ and $A = [a_{ij}]$ is an m*n matrix for each of the objective function $Z(x) = c_i\, x$, $i = 1,2,\dots,k$, of the problem, assume that the decision maker has a fuzzy goal such as " the objective function $Z_i(x)$ should be substantially less than or equal to some value p_i " then the corresponding linear membership function.
$\mu^L_i(Z_i(x))$ is defined as:

$$\mu^L_i(Z_i(x)) = \begin{cases} 0 & ;\ Z_i(x) \ge Z_i^o \\ \frac{Z_i(x)-Z_i^O}{Z_i^1-Z_i^O} & ;\ Z_i^o \ge Z_i(x) \ge Z_i^1 \\ 1 & ;\ Z_i(x) \le Z_i^1 \end{cases} \qquad (2)$$

Where Z_i^o or Z_i^1 denotes the value of the objective function $Z_i(x)$ such that the degree of membership function is 0 or 1 respectively.

Figure 1 illustrates the graph of the possible shape of the linear membership function.

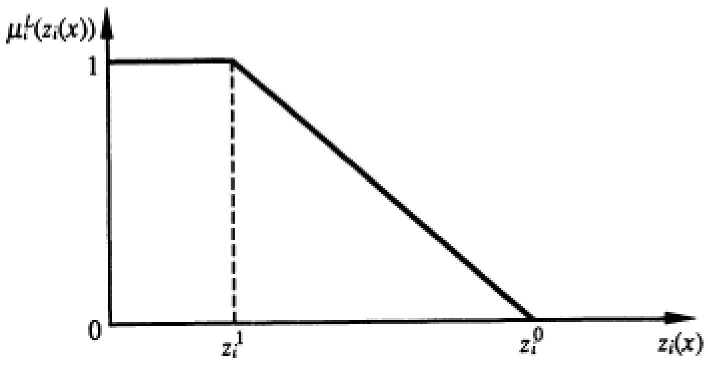

Figure-1: Linear membership function

The original multi-objective linear programming problem can be interpreted as:

$$\text{Maximize } \min_{i=1,\dots,k}\{\mu_i^L(Z_i(x))\} \qquad (3)$$
$$\text{Subject to } AX \le b$$
$$X \ge 0$$

By introducing the auxiliary variable λ, it can be reduced to the following conventional linear programming problem:

$$\begin{aligned} &\text{Maximum} && \lambda \\ &\text{Subject to} && \lambda \le \mu_i^L(Z_i(\mathrm{x})),\ i = 1, 2,\dots, k \\ & && AX \le b \\ & && X \ge 0 \end{aligned} \tag{4}$$

By assuming the existence of the optimal solution X^{io} of the individual objective function minimization problem under the constraints defined by

$$\min_{x \in X} Z_i(\mathrm{x}) \quad ,\ i = 1, 2,\dots, k \tag{5}$$

Zimmermann suggested a way to determine the linear membership function $\mu_i^L(Z_i(\mathrm{x}))$. To be more specific, using the individual minimum

$$Z_i^{min} = Z_i(X^{io}) = \min_{x \in X} Z_i(\mathrm{x}) \quad ,\ i = 1, 2,\dots, k \tag{6}$$

Together with

$$Z_i^m = \max(Z_i(X^{io}), \dots, Z_i(X^{i-1,o}), Z_i(X^{i+1,o}), Z_i(X^{ko}))\ ,\ i = 1, 2,\dots, k \tag{7}$$

He determines the linear membership function as in (2) by choosing $Z_i^1 = Z_i^{min}$ and $Z_i^o = Z_i^m$. For this membership function, it can be easily shown that if the optimal solution of (3) or (4) is unique.

Amid *et al.* (2005) has provided procedure to state the classical linear programming as a fuzzy multi-objective linear programming (FMOLP) and subsequently formulize the equivalent crisp single objective model for the (FMOLP). Sequence of that procedure, which has been customized according to production system chocolate problem, is described as follows.

Step-1: Construct the fuzzy model of production system chocolate problem according to the criteria and the constraints of the decision maker (Equation 1).

Step-2: Determine the lower bound Z_i^o and Z_i^1 upper bound of aspiration level (DM's goal) for each objective. The limit of aspiration level (Z_i^o,Z_i^1) can be obtained by either solving multi-objective as single objective problem.

Step-3: For the objective functions and fuzzy constraints, find the membership function according to (Equation 2).

Step-4: Formulate the equivalent crisp model of the fuzzy optimization problem according to (Equation 4).

Step-5: Solve the crisp model by using simplex method by any program to find the optimal solution **x***.

4. CASE STUDY OF PRODUCTION SYSTEM CHOCOLATE PROBLEM

Chocoman Company USA is the famous production system chocolate problem for a chocolate exporting company. This company produces varieties of chocolate bars, candy and wafer using number of raw material and processes. Elaborately the Chocoman company manufactures produced 8 different kinds of chocolate products since there are 8 raw materials to be mixed in different proportions and 9 processes (i.e. facilities) to be utilized. The objective of this problem is to maximize the five objective functions with eight variables. The decision variables and the mathematical model for the chocolate problem are presented in [1].

To illustrate the fuzzy multi-objective linear programming, consider the following production system chocolate problem with five objective functions.

As we illustrated in step 1, we will construct the fuzzy model of production system chocolate problem according to the criteria and the constraints of the decision maker

Minimization – five objective functions

F_1: Revenue

$$-F_1 = -375x_1-150x_2-400x_3-160x_4-420x_5-175x_6-400x_7-150x_8$$

F_2: profit

$$-F_2 = -180x_1-83x_2-153x_3-72x_4-130x_5-70x_6-208x_7-83x_8$$

F_3: market share for chocolate bars

$$-F_3 = -0.25x_1-0.1x_2-0.25x_3-0.1x_4-0.25x_5-0.1x_6$$

F_4: units produced

$$-F_4 = -x_1-x_2-x_3-x_4-x_5-x_6-x_7-x_8$$

F_5: plant utilization

$$-F_5 = -1.65x_1-0.9x_2-1.975x_3-1.03x_4-1.75x_5-0.94x_6-4.2x_7-1.006x_8$$

Subject to

1: $X_1-0.6x_2 \leq 0$

2: $X_3-0.6x_4 \leq 0$

3: $X_5-0.6x_6 \leq 0$

4: $-56.25x_1-22.5x_2-60x_3-24x_4-63x_5-26.25x_6+400x_7+150x_8 \leq 0$

5: (cocoa usage)

$87.5x_1+35x_2+75x_3+30x_4+50x_5+20x_6+70x_7+12x_8 \leq 100000$

6: (milk usage)

$62.5x_1+25x_2+50x_3+20x_4+50x_5+20x_6+30x_7+12x_8 \leq 120000$

7: (nuts usage)

$0x_1+0x_2+37.5x_3+15x_4+75x_5+30x_6+0x_7+0x_8 \leq 60000$

8: (confectionary sugar usage)

$100x_1+40x_2+87.5x_3+35x_4+75x_5+30x_6+210x_7+24x_8 \leq 200000$

9: (flour usage)

$0x_1+0x_2+0x_3+0x_4+0x_5+0x_6+0x_7+72x_8 \leq 200000$

10: (aluminum foils usage)

$500x_1+0x_2+500x_3+0x_4+0x_5+0x_6+0x_7+250x_8 \leq 500000$

11: (paper usage)

$450x_1+0x_2+450x_3+0x_4+450x_5+0x_6+0x_7+0x_8 \leq 500000$

12: (plastic usage)

$60x_1+120x_2+60x_3+120x_4+60x_5+120x_6+1600x_7+250x_8 \leq 500000$

13: (cooking facility usage)

$0.5x_1+0.2x_2+0.425x_3+0.17x_4+0.35x_5+0.14x_6+0.6x_7+0.096x_8 \leq 1000$

14: (mixing facility usage)

$0x_1+0x_2+0.15x_3+0.06x_4+0.25x_5+0.1x_6+0x_7+0x_8 \leq 200$

15: (forming facility usage)

$0.75x_1+0.3x_2+0.75x_3+0.3x_4+0.75x_5+0.3x_6+0.9x_7+0.36x_8 \leq 1500$

16: (grinding facility usage)

$0x_1+0x_2+0.25x_3+0x_4+0x_5+0x_6+0x_7+0x_8 \leq 200$

17: (wafer making facility usage)

$0x_1+0x_2+0x_3+0x_4+0x_5+0x_6+0x_7+0.3x_8 \leq 100$

18: (cutting facility usage)

$0.5x_1+0.1x_2+0.1x_3+0.1x_4+0.1x_5+0.1x_6+0.2x_7+0x_8 \leq 400$

19: (packaging facility usage)

$0.25x_1+0x_2+0.25x_3+0x_4+0.25x_5+0x_6+0x_7+0.1x_8 \leq 400$

20: (packaging 2 facility usage)

$0.05x_1+0.3x_2+0.05x_3+0.3x_4+0.05x_5+0.3x_6+2.5x_7+0.15x_8 \leq 1000$

21: (labor usage)

$0.3x_1+0.3x_2+0.05x_3+0.3x_4+0.3x_5+0.3x_6+2.5x_7+0.25x_8 \leq 1000$

22: (demand for MC 250)

$X_1 \leq 500$

23: (demand for MC 100)

$X_2 \leq 800$

24: (demand for CC 250)

$X_3 \leq 400$

25: (demand for CC 100)

$X_4 \leq 600$

26: (demand for CN 250)

$X_5 \leq 300$

27: (demand for CN 100)

$X_6 \leq 500$

28: (demand for candy)

$X_7 \leq 200$

29: (demand for wafer)

$X_8 \leq 400$

Note that these five objective functions are the minimization of among the minus revenue (F_1), profit (F_2), market share for chocolate bars (F_3), units produced (F_4) and plant utilization (F_5).

As we illustrated in step 2, we will determine the lower bound Z_i^o and Z_i^1 upper bound of aspiration level (DM's goal) for each objective. Then the individual minimum and maximum of these objective functions in table 1 becomes:

Table-1: Minimum and maximum value of objective functions

Objective function	F_i^{min}	F_i^{max}
$\mathbf{F_1}$	-611106	0
$\mathbf{F_2}$	-265206	0
$\mathbf{F_3}$	-357	0
$\mathbf{F_4}$	-2826	0
$\mathbf{F_5}$	-3520	0

As we illustrated in step 3, we will assume that the decision maker subjectively determined the corresponding linear membership functions μ_i^L (F_i) , i = 1,2,3,4,5 as following:

$$\begin{cases} fuzzy\ goal\ for\ F_1 \ ;\ \mu_1^L(-530000) = 0\ , \mu_1^L(-590000) = 1 \\ fuzzy\ goal\ for\ F_2 \ ;\ \mu_2^L(-220000) = 0\ , \mu_2^L(-270000) = 1 \\ fuzzy\ goal\ for\ F_3 \ ;\ \mu_3^L(-290) = 0\ , \mu_3^L(-340) = 1 \\ fuzzy\ goal\ for\ F_4 \ ;\ \mu_4^L(-2200) = 0\ , \mu_4^L(-2700) = 1 \\ fuzzy\ goal\ for\ F_5 \ ;\ \mu_5^L(-2750) = 0\ , \mu_5^L(-3150) = 1 \end{cases} \tag{8}$$

Where linear functions are assumed from μ_L= 0 to μ_L= 1 for i = 1, 2,3,4,5.

The fuzzy goals of the decision maker are assumed to be expressed by the following membership functions:

$$\mu^L{}_i\,(F_i(x)) = \begin{cases} 0 & ;\ F_i(x) \geq F_i^o \\ \frac{F_i(x)-F_i^O}{F_i^1-F_i^O} & ;\ F_i^o \geq F_i(x) \geq F_i^1 \\ 1 & ;\ F_i(x) \leq F_i^1 \end{cases} \tag{9}$$

$$\mu^L{}_1(F_1(x)) = \begin{cases} 0 & ;\ F_1(x) \geq -530000 \\ \frac{-375X1-150X2-400X3-160X4-420X5-175X6-400X7-150X8+530000}{-60000} & ;\ -530000 \geq F_1(x) \geq -590000 \\ 1 & ;\ F_1(x) \leq -590000 \end{cases} \tag{10}$$

$$\mu^L{}_2(F_2(x)) = \begin{cases} 0 & ;\ F_2(x) \geq -220000 \\ \frac{-180X1-83X2-153X3-72X4-130X5-70X6-208X7-83X8+220000}{-50000} & ;\ -220000 \geq F_2(x) \geq -270000 \\ 1 & ;\ F_2(x) \leq -270000 \end{cases} \tag{11}$$

$$\mu^L{}_3(F_3(x)) = \begin{cases} 0 & ;\ F_3(x) \geq -290 \\ \frac{-0.25X1-0.1X2-0.25X3-0.1X4-0.25X5-0.1X6+290}{-50} & ;\ -290 \geq F_3(x) \geq -340 \\ 1 & ;\ F_3(x) \leq -340 \end{cases} \tag{12}$$

$$\mu^L{}_4(F_4(x)) = \begin{cases} 0 & ;\ F_4(x) \geq -2200 \\ \frac{-X1-X2-X3-X4-X5-X6-X7-X8+2200}{-500} & ;\ -2200 \geq F_4(x) \geq -2700 \\ 1 & ;\ F_4(x) \leq -2700 \end{cases} \tag{13}$$

$$\mu^L{}_5(F_5(x)) = \begin{cases} 0 & ;\ F_5(x) \geq -2750 \\ \frac{-1.65X1-0.9X2-1.975X3-1.03X4-1.75X5-0.94X6-4.2X7-1.006X8+2750}{-400} & ;\ -2750 \geq F_5(x) \geq -3150 \\ 1 & ;\ F_5(x) \leq -3150 \end{cases} \tag{14}$$

As we illustrated in step 4, the equivalent crisp model of the fuzzy optimization problem formulated as following:

Maximum λ

Subject to

$$0.006x_1-0.0025x_2+0.007x_3+0.0026x_4+0.007x_5+0.003x_6+0.007x_7+0.0025x_8-\lambda \leq 8.8$$
$$0.0036x_1-0.0017x_2+0.003x_3+0.0014x_4+0.0026x_5+0.0014x_6+0.0042x_7+0.0017x_8-\lambda \leq 7.7$$
$$0.005x_1-0.002x_2+0.005x_3+0.002x_4+0.005x_5+0.002x_6-\lambda \leq 4.4$$
$$0.002x_1-0.002x_2+0.002x_3+0.002x_4+0.002x_5+0.002x_6+0.002x_7+0.002x_8-\lambda \leq 4.4$$
$$0.004x_1-0.0023x_2+0.005x_3+0.0026x_4+0.0044x_5+0.0024x_6+0.011x_7+0.0025x_8-\lambda \leq 6.88$$
$$X_1-0.6x_2 \leq 0$$
$$X_3-0.6x_4 \leq 0$$
$$X_5-0.6x_6 \leq 0$$
$$-56.25x_1-22.5x_2-60x_3-24x_4-63x_5-26.25x_6+400x_7+150x_8 \leq 0$$
$$87.5x_1+35x_2+75x_3+30x_4+50x_5+20x_6+70x_7+12x_8 \leq 100000$$

$$62.5x_1+25x_2+50x_3+20x_4+50x_5+20x_6+30x_7+12x_8 \le 120000$$
$$0x_1+0x_2+37.5x_3+15x_4+75x_5+30x_6+0x_7+0x_8 \le 60000$$
$$100x_1+40x_2+87.5x_3+35x_4+75x_5+30x_6+210x_7+24x_8 \le 200000$$
$$0x_1+0x_2+0x_3+0x_4+0x_5+0x_6+0x_7+72x_8 \le 200000$$
$$500x_1+0x_2+500x_3+0x_4+0x_5+0x_6+0x_7+250x_8 \le 500000$$
$$450x_1+0x_2+450x_3+0x_4+450x_5+0x_6+0x_7+0x_8 \le 500000$$
$$60x_1+120x_2+60x_3+120x_4+60x_5+120x_6+1600x_7+250x_8 \le 500000$$
$$0.5x_1+0.2x_2+0.425x_3+0.17x_4+0.35x_5+0.14x_6+0.6x_7+0.096x_8 \le 1000$$
$$0x_1+0x_2+0.15x_3+0.06x_4+0.25x_5+0.1x_6+0x_7+0x_8 \le 200$$
$$0.75x_1+0.3x_2+0.75x_3+0.3x_4+0.75x_5+0.3x_6+0.9x_7+0.36x_8 \le 1500$$
$$0x_1+0x_2+0.25x_3+0x_4+0x_5+0x_6+0x_7+0x_8 \le 200$$
$$0x_1+0x_2+0x_3+0x_4+0x_5+0x_6+0x_7+0.3x_8 \le 100$$
$$0.5x_1+0.1x_2+0.1x_3+0.1x_4+0.1x_5+0.1x_6+0.2x_7+0x_8 \le 400$$
$$0.25x_1+0x_2+0.25x_3+0x_4+0.25x_5+0x_6+0x_7+0.1x_8 \le 400$$
$$0.05x_1+0.3x_2+0.05x_3+0.3x_4+0.05x_5+0.3x_6+2.5x_7+0.15x_8 \le 1000$$
$$0.3x_1+0.3x_2+0.05x_3+0.3x_4+0.3x_5+0.3x_6+2.5x_7+0.25x_8 \le 1000$$
$$X_1 \le 500$$
$$X_2 \le 800$$
$$X_3 \le 400$$
$$X_4 \le 600$$
$$X_5 \le 300$$
$$X_6 \le 500$$
$$X_7 \le 200$$
$$X_8 \le 400$$

5. RESULTS AND DISCUSSIONS

We solved this problem by the simplex method of linear programming yields. The optimal solution:

Table-2: the optimal solution of the Chocoman Inc. problem

Objective function	Solution values
F_1 (revenue)	608501
F_2 (profit)	263538
F_3 (market share chocolate bars)	333.85
F_4 (units produced)	2822.1
F_5 (plant utilization)	3440.7
Decision variables	**Solution values**
$\mathbf{X_1}$	15.4
$\mathbf{X_2}$	800
$\mathbf{X_3}$	260
$\mathbf{X_4}$	600
$\mathbf{X_5}$	300
$\mathbf{X_6}$	500
$\mathbf{X_7}$	68.9
$\mathbf{X_8}$	277.77
$\boldsymbol{\lambda}$	0.8769

This means that the overall satisfaction of the fuzzy goals of the decision maker is **0.8769**, the total revenue ($-F_1$) is **608501**, and the total profit ($-F_2$) is **263538**, and the market share chocolate bars ($-F_3$) is **333.85**, and the total units produced ($-F_4$) is **2822.1**, and the plant utilization ($-F_5$) is **3440.7**

Alaa Sheta *et al.* (2012) used Scalarization method to maximize the profit and comparing their results with previous work and used Pareto method to maximize the all objective functions of production system chocolate problem.

Alaa Sheta *et al*. solved the problem by running the GEATbx at different population sizes 20, 50, and 100. The sizes of the populations were selected arbitrary. In each case, they run GEATbx to find the optimal value of each function used various population sizes.

By the end of the evolutionary process, the developed results with population size 100 looked the best. In our paper we compared our results with the results of the Pareto method with population size 100.

The computed values of the parameters X_1 to X_8 along with the optimal values of the objective functions of the Pareto method with population size 100 and fuzzy multi-objective linear programming method are presented in table 3.

Table-3: comparisons between results of Pareto method with population 100 and results of fuzzy multi-objective linear programming method

objective function	Pareto method with population size = 100	Fuzzy multi-objective linear programming method
$\mathbf{F_1}$	539890	608.501
$\mathbf{F_2}$	242650	263538
$\mathbf{F_3}$	310.24	333.85
$\mathbf{F_4}$	2456.4	2822.1
$\mathbf{F_5}$	2967.8	3440.7
	Decision variables and solution values	
$\mathbf{X_1}$	271.96	15.37
$\mathbf{X_2}$	681.61	800
$\mathbf{X_3}$	134.89	260
$\mathbf{X_4}$	520.2	600
$\mathbf{X_5}$	183.76	300
$\mathbf{X_6}$	424.11	500
$\mathbf{X_7}$	44.42	68.88
$\mathbf{X_8}$	195.4	277.7

After comparison between results of Pareto method with population 100 and results of fuzzy multi-objective linear programming method we note that the optimal values of the objective functions using fuzzy multi-objective linear programming method are (F1) Revenue **608501**, (F2) Profit **263538**, (F3) market share chocolate bars **333.85**, (F4) units produced **2822.1**, and (F5) plant utilization **3440.7** which are better than the optimal values (F1) Revenue **539890**, (F2) Profit **242650**, (F3) market share chocolate bars **310.24**, (F4) units produced **2456.4**, and (F5) plant utilization **2967.8** which were obtained by Pareto method with population size 100.

5. CONCLUSION

In this paper, we provided a solution to the most famous production system chocolate problem using fuzzy multi-objective linear programming approach. The problem was about solving multi-objective optimization problem and the decision maker had a fuzzy goal such as the objective function. The constructed fuzzy multi-objective linear programming as a methodology for this work has solved the problem successfully and the comparison with Pareto method appeared best results. And we found the decision maker process and the implementation will be easier if the decision maker and the implementer can work together with the analyst to achieve the best outcome with respect to degree of satisfaction.

REFERENCES

1. Alaa Sheta, Abdel Karim Baareh, Mohamed Ababna, and Noor Khrisat, "multi-objective evolutionary computation solution for chocolate production system using Pareto method.", in the international journal of computer science issues, vol 9, issue 1, no. 3,(2012), p. 75-83.
2. Amid, A., Ghodsypour, S. H., and O'Brien, C., "Fuzzy multi-objective linear model for supplier selection in a supply chain". International Journal Production Economics, 104, (2005), 394-407.
3. Bellman, R. E and L. A. Zadeh. "Decision making in a fuzzy environment." Management Science, 17, (1970), pp. 141-164.
4. C. Coello "an empirical study of evolutionary techniques for multi-objective optimization in engineering design." Ph.D. dissertation in department of computer science, Tulane University, (1996).
5. H.-J. Zimmermann, "fuzzy programming and linear programming with several objective function.", fuzzy set and systems 1, (1978), p. 45-55.
6. H. Turabieh, A. Sheta, and P. Vasant, "Hybrid optimization genetic algorithm (HOGA) with interactive evolution to solve constraint optimization problems for production system.", in the international journal of computational science, vol. 1, no. 4, (2007), pp. 395-406.
7. Pandian M. vasant, Ramachandran Nagarajan, and Sazali Yaacob, "application of modified s-curve membership function in decision making process using FLP approach.", in the Scientia Mathematicae Japonicae Online, vol. 10,(2004), pp. 513-527.
8. S. Susanto, P .Vasant, A. Bhattacharya, and F. Pratikto, "Fuzzy LP with a nonlinear MF for product-mix solution: A case-based re-modeling and solution.", in The 11th International Conference on Fuzzy Theory and Technology FTT in conjunction with 9th Joint Conference on Information Sciences (JCIS), Kaohsiung, Taiwan, ROC, (2006), pp. 1305–1308.

Source of support: Nil, Conflict of interest: None Declared.