Fuzzy Expert System for Acidification and Deacidification Process in Red Wine Grape Juice

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***Abstract*—The fermentation process is one of the most important processes in wine making. A certain amount of ratio of chemical compounds in red wine grape juice provides good quality wine. Acidifying and deacidifying grapes juice process is very complicated and non–linear, and ambiguous. Before starting the fermentation process the optimum balance of acid and pH is necessary. The purpose of this study is to develop a fuzzy expert system, this system can easily manipulate how much amount of acid or carbonates are required in red wine grape juice which saves time and gives good quality to the wine. A fuzzy interference system is used, if the acid level is low i.e. below 5 g/L then the acidification process will be carried out if the acid level is high i.e. above 8 g/L deacidification process will be carried out. A fuzzy rule base system handles uncertainty and gives a decision on acidifying and deacidifying processes. Domain expert takes trials of tartaric acid and pH values to get the optimum required amount of tartaric acid and carbonates value which is a time-consuming task. According to results, this system can easily manipulate how much amount of acid or carbonates are required in red wine grape juice which saves time and gives good quality to the wine.**

***Index Terms*—acidification, deacidification, fuzzy logic, pH, Tartaric acid**

I. Introduction

Among all the fruits grape fruit is more popular for the winemaking process because more organic acids are present in grape juice. More research attention has been received due to commercialization of the wine production for the industry. Wine is the most common noble beverage which is formed by the fermentation of crushed grapes juice. The Quality of wine is depending on many factors including the location of the vineyard, climate type, agricultural engineering, and production technology. Also, some chemical compounds affect the quality of wine such as sugars, acids, tannins, vitamins, etc. Sugar is present in large amounts as compared to organic acid. Sugar and organic acid compositions, also measured through total soluble solids (TSS), contribute considerably to the overall taste. Grape is one of the rare fruit that contains tartaric acid in large quantity more rather than other fruits also, malic, citric, etc. as shown in table 1 below [4][5].

The acidification process is the addition of acids, usually tartaric used to increase the acidity of grape juice. The acidification process stabilizes a drooping wine. If TA is considerably lesser than .50%, you will need to raise the TA level by adding tartaric acid [6]. TA is expressed in either %TA or g/L of Tartaric Acid. TA and pH are inversely proportional and always observe proportion during the winemaking process. Their proportion ratio gives the signal to the winemaker of the overall balance of the fermentation juice. pH protects the wine and specifies how effectively the blend of acidic and basic compounds will be useful to protect the wine. pH values of less than 7.0 are acidic. The usual pH range for red wines is between 3.5 and 3.8[7]. A high pH value will cause a wine to be unstable and it will produce off-flavors. Winemakers are looking for grape juice to be in a range of 0.60-0.90% TA at the start of fermentation. Large acid adjustments should be made before fermentation is started. An addition of four grams of tartaric acid per gallon of juice will raise the TA by about 0.1 percent [9].During the fermentation of grape must the amount of tartaric and malic acids decrease, however, the amount of citric and succinic acids increase, which is natural.

TABLE I
ACID QUANTITY(GRAMS/LITER) PRESENT IN WINE

Sr. No	*Acid type*	*Quantity(grams/liter)*
1	Tartaric	1 to 5
2	Malic	1 to 4
3	Succinic	0.4 to 1
4	Lactic	0.1 to 0.4
5	Citric	0.04 to 0.7
6	Acetic	0.05 to 0.5

Low acidity and high pH value range give a plain taste, whereas high acidity and low pH value range give a sour taste to the wine. The deacidification process is a reduction in the tartaric acid in grape juice at the fermentation level [11]. Some strategies used to decrease acid levels may be chemical (carbonates, cold stabilization process) or biological (malic reducing yeast, lactic acid bacteria). Another method used to dilute acidity is blending or adding sweetening using free drain grapes juice with optimum sugar level. Potassium bicarbonate (KHCO3) is suitable for small adjustments, e.g. 0.9 g/L addition of KHCO3, which yields an estimated 1 g/L drop in TA. Calcium carbonate (CaCO3) is suitable for

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larger quantities of acid (less than 2g/L) and should be added only at the juice/must stage, e.g. 1 g/L addition can reduce an estimated 1.5 g/L of TA. Potassium carbonate (K2CO3) is a final option for chemical deacidification but it is not recommended because of shelf stability issues [13][14].

Web-based expert systems store information on a web server and take decisions on methods (acidify or deacidify) instead of human experts. Expert systems with web services define the benefits in the form of information collecting, validation, and inferencing decisions in the system implementation and maintenance. Choosing the appropriate expert system development methodology and environment is important for the successful implementation of web-based expert systems. The fuzzy system decides the uncertainty of the control system, provides a basic structure to model ambiguity, like the human way of thinking, and reasoning, and takes a decision on the process. This research work proposes a web-based fuzzy expert system that uses fuzzy logic for drawing acidify and deacidify assessments.

II. RELATED WORK

This section focuses on a few prominent works that are related to our work.

- The work presented in the research paper Web-based Fuzzy Expert System for Symptomatic Risk Assessment of Diabetes Mellitus expert system designed to assist in the management of diabetes, along with determining the level of risk of diabetes. Using a web-based expert system people can check their diabetes risk online. It is useful to spread alertness about diabetes risk among people. The interface is designed with HTML to accept user input, and the fuzzy inference engine produces a result with the help of a knowledge base. Rule set predicts output. Python programming language is used for the Inference mechanism and Knowledge Base [15].
- In acid and base reactions pH process plays an important role. In the research paper Design and Development of Ph Neutralization Process: A Fuzzy Logic Based Electronics Sensing and Control System by Dr. Magan. P. Ghatule author presents a fuzzy controller for pH parameters. The author developed a fuzzy expert operator without a mathematical format that resolves the uncertain behavior of the pH process [16].
- The web-based fuzzy approach used in the research paper Fuzzy logic-driven expert system for the diagnosis of heart failure disease in which knowledge base inference is used for diagnosis of heart failure. Output Analysis based on a survey of some experts on heart failure data [17].
- Fuzzy modeling for contaminated soil parameters T.S. Umesha et.al. [18] The determination of soil properties due to acid contamination is highly ambiguous due to the complex behavior of soils. The fuzzy set theory provides a powerful tool for modeling uncertainty associated with vagueness and imprecision.
- Smart Fuzzy Cupper: Employing approximate reasoning to derive coffee bean quality scoring from individual attributes by J. Livio et. al[23] designed a fuzzy system with Software as a Service for assessment of coffee beans with web browser service to the client. They provide linguistic terms instead of traditional numerical values to express coffee bean attributes. These linguistic terms are assisted by expert systems or automation.

III. DESIGNING WEB BASE FUZZY MODEL FOR ACIDIFYING AND DEACIDIFYING GRAPE JUICE

A fuzzy system method such as fuzzification, knowledge base, decision-making logic, and defuzzification.

A. Data collection

For data collection, we visited the Deccan Plateau winery situated in Pune city, Maharashtra. For purposed research work, red wine data is preferred, with emphasis on Cabernet Sauvignon red wine grape type.

B. Data selection and data distribution

Cabernet Sauvignon red wine grapes are the most common grape type and are cultivated worldwide because it has medium acidity and tannin and Brix level is also optimum.

C. Methodology

a) Definition of linguistic variables: For the proposed work, tartaric acid and pH present in grape juice were selected as input variables. Acidify and Deacidify are output variables used to calculate the required amount of TA for acidifying process which increases TA, and the required amount of carbonate (KHCO3, CACO3) for the deacidifying process which decreases acidity. If TA and pH ratio is optimum, then no need for acidifying and deacidifying process.

b) Determination of fuzzy set and fuzzy operator: A universe of discourse U is described in a fuzzy set with A (x) membership function which holds values in the interval [0, 1]. It is an overview of a standard set that allows the membership function to take values from 0 to 1 involving 0 and 1[19]. For rule base construction "and," "or," operators are used. For constructing an inference rule "and," "or," operators are used. The fuzzy "and" operator is given as:

$$\mu A \cap B(x) = min[\mu A(x), \mu B(x)] \tag{1}$$

We find the minimum number of the membership values and calculate the "and" operation. The fuzzy "or" operator is defined as:

$$\mu A \cup B(x) = max[\mu A(x), \mu B(x)] \tag{2}$$

We find the maximum number of membership values and calculate the "or" operation [20]. For proposed work fuzzy input variable TA (Small(S), Medium(M), Large(L)), pH((Small(S), Medium(M), Large(L), Very Large(VL)), and output variable for acidify ((Small(S), Medium(M), Large(L) and deacidify (Small(S), Medium(M), Large(L)). t-Norms operator was used for the proposed study.

c) Fuzzification: In the fuzzification process, the triangular membership function was used and a, b, and c was fuzzy parameters as shown in equation1 below

$$\mu A(x) = \begin{cases} 0 & \text{if } x \leq a \\ \frac{x-a}{b-a} & \text{if } a \leq x \leq b \\ \frac{c-x}{c-b} & \text{if } b \leq x \leq c \\ 0 & \text{if } c \leq x \end{cases} \quad (3)$$

TABLE II
FUZZY TRIANGULAR PARAMETER

Sr. No	*Category*	*Fuzzy Variables*	*Linguistic Variables*	*Fuzzy Triangular Parameters*
1 2 3 4	Input	pH	Small Medium Large Very Large	[0.0,0.5,1.0] [0.0,1.0,2.0] [1.0,2.0,3.0] [2.0,3.0,4.0]
5 6 7 8	Input	TA	Small Medium Large Small	[4.0,5.0,6.0] [5.0,7.0,9.0] [8.0,10.0,13.0] [30,40,50]
9 10	Output	Acidify	Medium Large	[40,50,70] [60,70,100]

d) Fuzzy Inference System (.fis file): A fuzzy inference system is an important block of a fuzzy system that allows users to create input and output using a rule base fuzzy inference systems file consisting of membership functions, an if-then rule base, and logical operators. Fuzzy inference systems Sugeno and Mamdani these two types used in fuzzy systems. In the proposed research work Mamdani inference systems were used. For research work Mamdani inference system with 2 inputs and 2 outputs. We set the values for pH in a range from 0 to 4 because an optimum range of pH in red wine is between 3.3 to 3.5 and TA between 6 to 8g/L. The addition of 1.0 g/L of Tartaric acid will decrease the pH by 0.1 pH units. Example 3.8 grams of Tartaric Acid per Gallon raises TA by + 1 g/L Then, to determine the quantity of Tartaric Acid will be needed: Gallons: (8 gallons) x (7.6 grams, from 2 x 3.8 grams per gallon) = 60.80 gram.

e) Designing Rule Base: Conditional statements are used in the rule base of fuzzy systems which helps to take decisions. Rules in the IF-THEN statements format. IF x is A THEN y is B, where x and y present linguistic variables and A and B are linguistic values.For the proposed study rule base was designed with the help of domain experts and also using the thumb Rule of acidifying and deacidifying process in the wine making process.

Some of the rules as an interpretation of the table III are given below.

- Rule1 = If TA['S'] and pH['M'] Then Acidify['L']
- Rule5 = If TA['S'] and pH['VL'] Then Deacidify['L']
- Rule8 = If TA['M'] and pH['VL'] Then Acidify['S']

f) Defuzzification: The defuzzification method aggregates and produces crisp values. Mean of Maximum, Bisector

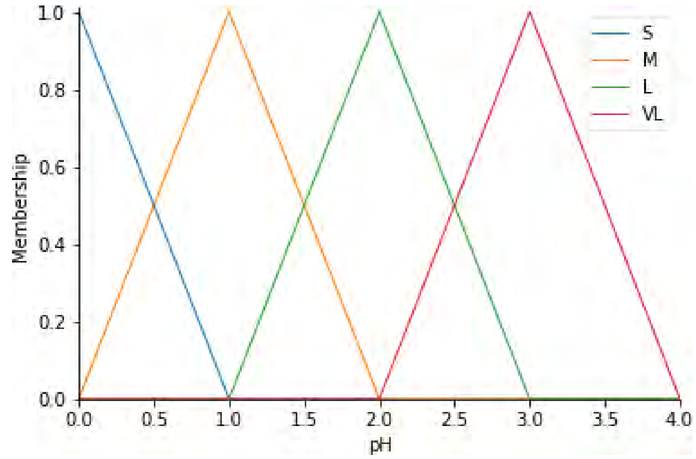


Fig. 1. Membership graphics of fuzzy variable pH.

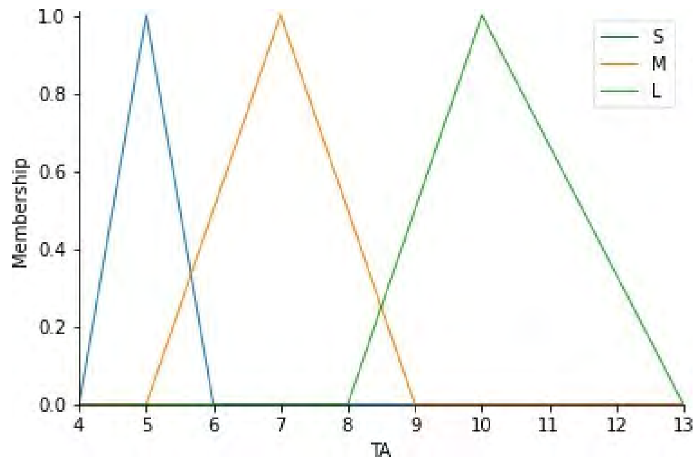


Fig. 2. Membership graphics of fuzzy variable TA.

of Area, and Centre of Area are normally used as defuzzification methods. In the proposed research work centroid method was used to convert fuzzy value to crisp value.

g) Proposed algorithm for acidifying and deacidifying process:

- Input: The crisp values for TA, and pH.
- Output: The crisp value for Acidify and Deacidify. Begin

TABLE III
THUMB RULE FOR ACIDIFYING AND DEACIDIFYING PROCESS IN WINEMAKING

PH	TA		
	less than 5 g/L	***6 – 9 g/L***	***greater than 10 g/L***
less than 2.9	Low pH Trouble	Reduce acidity	Reduce acidity a lot
2.9 - 3.4	Add acidity	Optimum	Reduce acidity
3.4 - 3.9	Add acidity	Optimum	Reduce acidity
greater than 4	Add acidity a lot	add acidity	High pH Trouble

[a]Source data: Vinmetrica.

- Step1: Input the crisp values of fuzzy variables (TA, pH).
- Step 2: Generate the fuzzy numbers for TA and pH.
- Step 3: Generate the fuzzy number for Acidify and Deacidify for the output.
- Step 4: The triangular membership function is calculated for each linguistic variable.
  - TA (Small, Medium, Large), pH(Small, Medium, Large, VeryLarge.
- Step 5: Perform the Fuzzy inference mechanism by Mamdani's method.
  - Use rule base (rule1, rule2 ...., rule n).
  - Use of fuzzy AND operator for rule degree match for input linguistic variables.
  - Calculate the aggregation of used rules for fuzzy output variables Acidify and Deacidify.
- Step 6: Use the Centroid defuzzification method for generating crisp values.

$$X^* = \frac{\sum_{i=1}^{N} A_i - X_i}{\sum_{i=1}^{N} A_i} \tag{4}$$

  Here, Ai represents the firing area of ith rules, N is the total number of rules fired and X represents the center of the area.
- Step 7: Display the Required amount of tartaric acid and carbonates value in an unskilled person's understandable form.
- Step 8: Stop.

IV. WEB SYSTEM DEVELOPMENT

The proposed study web-based expert system for Acidification and Deacidification process in winemaking. Software development methodology (SDLC) is used in the present paper.

A. Development Environment

For programming python language, scikit-fuzzy and flask, a framework has been selected for the development of the web system. Python is highly used in research areas because it happen-source libraries with a wide range of research areas. The User Interface is designed with HTML5, CSS, and Bootstrap. client-side scripting with JavaScript.

B. Code Samples

- Code for setting universe of discourse for input variables
  - TA = ctrl.Antecedent(np.arange(4, 14, 1), 'TA')
  - pH = ctrl.Antecedent(np.arange(0, 5, 1), 'pH')
- Code for setting triangular membership function for fuzzy linguistic variables
  - TA ['S'] = fuzz.trimf(TA.universe, [4, 5, 6])
  - TA ['M'] = fuzz.trimf(TA.universe, [5, 7, 9])
  - TA ['L'] = fuzz.trimf(TA.universe, [8,10,13])
- Rule base
  - rule3 = ctrl.Rule(TA['S'] & pH['VL'], Acidify['M'])
  - rule4 = ctrl.Rule(TA['M'] & pH['S'], Deacidify['S'])
- Input-output Interface
  As shown in figure 3 user can select acidify and deacidify tab from the expert system splash screen. If the Tartaric acid value is below 6g/L then acidify process will be carried user selects Acidify tab from the expert system after clicking the tab acidify process tartaric acid details form will display. A user enters TA and pH values in a respective textbox. After entering TA and pH values by user fuzzy output and the required amount of acid value display web form using a fuzzy system. When the user clicks on the save button data will save into the database and clicking on show data will display it on a web page. Stored values in a database which is centralized data to access all users of the winemaking process at a remote location and at any time for every user. As shown in figure 4 if the pH value is below 2.9 pH units and TA 6-9g/L then deacidify process is carried out by clicking deacidify. After clicking deacidify tab deacidification process detail page opens, a user enters TA and pH values then the required carbonate values and fuzzy output will display.

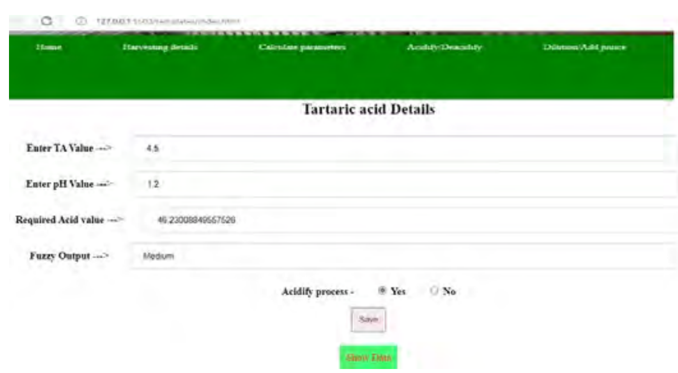


Fig. 3. The Expert System for Acidification Process

V. RESULT AND DISCUSSION

Using this expert system unskilled people or trainees can calculate the required amount of molecular TA (g/L) and carbonates values for acidifying and deacidifying process. To validate the result of .fis file output compared with lab test data of the must for pilot scale tests with the required amount of molecular TA before alcoholic fermentation (table number

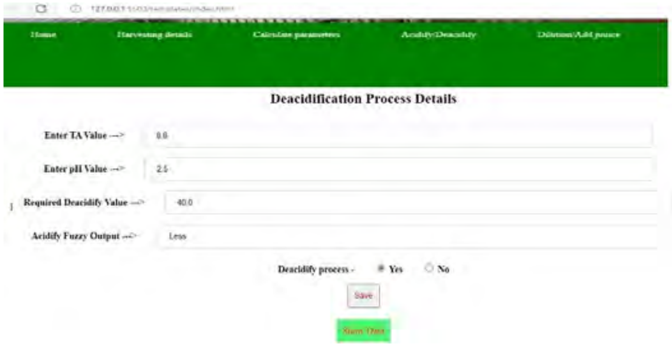


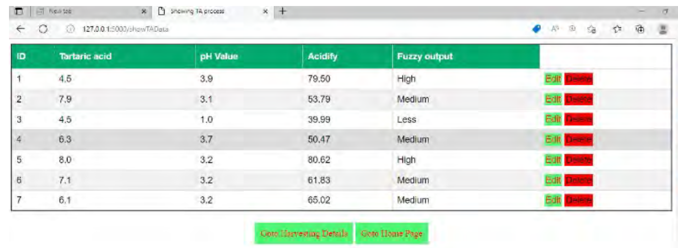
Fig. 4. The Expert System for Deacidification Process

3 data) was selected from the research paper Juan Gómez et.al. Acidification of musts in warm regions with tartaric acid and calcium sulfate at industrial scale, BIO Web of Conferences[22].TA and pH values are inversely proportional, as shown in table IV constant values of pH (e.g 3.2) belong to a small membership function), and as TA gradually increases from 6 (g/L) to 8 (g/L) required amount of molecular TA increases. When the pH value belongs to a large membership function (e.g. 3.7) required quantity of molecular TA is small due to the inverse proportionality of pH and TA. By designing and comparing a fuzzy rule base for the acidification of grape juice we got 91% accuracy. This is simulation model results are appropriate as shown in table 4 and less complex. After designing the prototype of the simulation model it is easy to validate the efficiency of the result. When we increase the database number of rules also increases.

TABLE IV
VALIDATE THE REQUIREMENT OF MOLECULAR TA (G/L) .FIS FILE OUTPUT WITH PRESENT SYSTEM DATA

Sr. No	*Tartaric Acid (g/L)*	*pH*	*.fis file Output*	*Present System Output*	*Fuzzy Output*
1	6.3	3.7	50.47	48	Medium
2	8.0	3.2	83.62	90	High
3	7.1	3.2	61.83	78	Medium
4	6.1	3.2	65.02	64	Medium

The developed system performance is evaluated as shown in table III validating the thumb rule table for acidifying and deacidifying process with data with fuzzy output regarding table II. In table V, the first and the last cell of the diagonal are not applicable because pH less than 2.9 and TA less than 5g/L make trouble for fermentation also pH greater than 4 and TA greater than 11g/L make trouble. High acidity and gradual increase in pH value require a deacidification process. Deacidification values go decreasing as pH values increases and with low acid with increases in pH values acidification values increases. The expert system can also save the time of skilled persons who take trials of TA and pH values to achieve optimum values of TA and pH. All the calculated data will be stored on the web server so that the same amount of TA and carbonates are will be added in another fermentation tank that has the same TA and pH values which are more useful at the time of the blending process. In blending, process deacidification is done naturally.



ID	Tartaric acid	pH Value	Acidity	Fuzzy output	
1	4.5	3.9	79.50	High	Edit Delete
2	7.9	3.1	53.79	Medium	Edit Delete
3	4.5	1.0	39.99	Less	Edit Delete
4	6.3	3.7	50.47	Medium	Edit Delete
5	8.0	3.2	80.62	High	Edit Delete
6	7.1	3.2	61.83	Medium	Edit Delete
7	6.1	3.2	65.02	Medium	Edit Delete

Fig. 5. Expert System result

TABLE V
VALIDATE THUMB RULE FOR ACIDIFYING AND DEACIDIFYING WITH DATA

PH	**TA**		
	S (4.5)	***M (7.5)***	***L (12)***
S (0.5)	X	49.39 Medium	54.22 High
M (1.3)	39.99 Less	OK	50.79 Medium
L (2.0)	53.88 Medium	OK	40.22 Less
VL (3.9)	79.50 High	54.75 Medium	X

VI. CONCLUSION

The wine-making process is complex and without domain expert knowledge it's not an easy task to do. Designing fuzzy expert systems which draw better results that are useful and easy to calculate for an unskilled person. Domain expert decides when to add tartaric acid or carbonates and in which amount it is required. All the calculations were done manually which is a time-consuming job. also, domain experts take trails processes to get optimum results which is a tedious task. In this paper acidify and deacidifying thumb rule method is used and designed a fuzzy system that shows the results when carrying the acidification process or deacidification process in which the amount of tartaric acid and carbonate is added during the fermentation process. Using developed system domain experts takes trails of process within a minute. Present work can be extended future by adding a blending process so winemakers deacidify grape juice value naturally between the 3.3 to 3.5 range. Blending is done with 2 types of wines made from different grape varieties or combined wines from various vintages.

REFERENCES

[1] M.Bobai, D.Mohammed, D.Emmanuel and U.Harriet,"Production of Wine from Fermentation of Grape (Vitis vinifera) and Sweet Orange (Citrus Sinensis) Juice using Saccharomyces cerevisiae Isolated from Palm Wine," International Journal of Current Microbiology and Applied Sciences,Volume 6,No 1,PP.868-881,2017.

[2] K.Jindriska and J. Siroky, "Study of changes in organic acids in red wines during malolactic fermentation," Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis,2011,59(5),pp.145-150.

[3] Munoz-Robredo PR, R.Paula, M.Daniel, Molina R. and D.Bruno, “Characterization of sugars and organic acids in commercial varieties of table grapes,” Chilean Journal of Agricultural Research,452-458,2011.

[4] L. Eisenman, “Wine Acids section of Chapter 5,” in The Home WinemakersManual[Online]. Available: https://www.homebrewit.com, [Accessed 25 August 2022].

[5] P.Kamble and Dr.B. T. Jadhav, “ Quality Parameters of Wine: A Review,” International Journal of Engineering Applied Sciences and Technology, Vol. 6, P.177-182,December 2021.

[6] D.Fahey and Dr. G. Scollary, “Managing acidity in grapevines and wines,” [E-book] Available: https://www.dpi.nsw.gov,au, [Accesed 2 September 2022.

[7] F.Cosme, V. Alice and J. Antonio,“The Role of Tartaric Acid in Grapes and Wines in Beverages,” Vol. 1, no. 4 pp. 292 – 310, November 2015.

[8] L.Eisenman,“The Home Winemakers Manual”, [Online]. Avalaible: https://erowid.org/, Mar 1998,[Accesed 12 September 2022].

[9] V.Bayraktar,“ORGANIC ACIDS CONCENTRATION IN WINE STOCKS AFTER Saccharomyces cerevisiae FERMENTATION in Biotechnologia Acta,” 2013, DOI:10.15407/biotech6.02.097.

[10] H.Stanka, M.Ana,T.Pavica, S.Redzepovic and O.Sandi,“Reduction in Acidity by Chemical and Microbiological Methods and Their Effect on Mos lavac Wine Quality,” Food Technologyand Biotechnology,Vol.41,no.3,pp.231–236,(2003).

[11] M.Rezaei, M.Alizadeh Khaledabad, E.Moghaddas Kia and Z. Ghasempour, “Optimization of grape juice deacidification using mixture of adsorbents: A case study of Pekmez,”Food Science and Nutrition, 21 Apr 2020, https://doi.org/10.1002/fsn3.1586.

[12] D.Jackson and D.Schuster, “The Production of Grapes and Wine in Cool Climates,” Wellington, New Zealand: Buterworths, 1987.

[13] R.Thornton and S.Rodriguez,“Deacidification of red and white wines by a mutant of Schizosaccharomyces malidevoransunder commercial winemaking conditions,”Food Microbiology, pp.475-482,1996, 10.1006/fmic.1996.0054.

[14] I.Mujawar, B.Jadhav and K.Patil, “Web-based Fuzzy Expert System for Symptomatic Risk Assessment of Diabetes Mellitus,” International Journal of Computer Applications, Volume 182,2018.

[15] Dr.M.P.Ghatule, “Design and Development of Ph Neutralization Process: A Fuzzy Logic Based Electronics Sensing and Control System,“ INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH and TECHNOLOGY (IJERT), Volume 02, Issue 08 (August 2013).

[16] O.C.Akinyokun, G.B.Iwasokun, S.A.Arekete and R.W.Samuel, “Fuzzy logic-driven expert system for the diagnosis of heart failure disease,”Artificial Intelligence Research, DOI: 10.5430/air.v4n1p12 URL: http://dx.doi.org/10.5430/air.v4n1p12

[17] T.S. Umesha, S.V.Dinesh and M.A.Jayaram, “Fuzzy modeling for contaminated soil parameters,” INTERNATIONAL JOURNAL of FUZZY SYSTEMS and ADVANCED APPLICATIONS,Volume-1,pp.66-73,2014.

[18] B.G.Mapari1,Dr.A.Naidu, “Study of Fuzzy Set Theory and Its Applications,” IOSR Journal of Mathematics (IOSR-JM) e-ISSN: 2278-5728, p-ISSN: 2319-765X,Volume 12, Issue 4 Ver. II,PP 148-154, (Jul-Aug.2016)

[19] Taylor,“Managing pH and TA in wine,”[Online],Available: https://vinmetrica.com, [Accessed 26 September 2022].

[20] S.Rizvi,J.Mitchell and Razaque, “A fuzzy inference system (FIS) to evaluate the security readiness of cloud service,” Journal of Cloud Computing, Volume 9,Issue Number 1,December 2020.

[21] Lu.providers ,X.Pan, and H.Xian,“An efficient and secure data sharing scheme for mobile devices in cloud computing,” J.Cloud.Comp.9,(2020), https://doi.org/10.1186/s13677-020-00207-5.

[22] G.Benitez, Juan, L.Cristina, P.Santander, Jose, L.Cubillana-Aguilera, “Acidification of musts in warm regions with tartaric acid and calcium sulfate at industrial scale,” BIO. Web of Conferences, 5. 10.1051/bioconf/20150502007.

[23] J.Livio,W.C.Flores,R.Hodhod and D.Umphress,“Smart Fuzzy Cupper: Employing approximate reasoning to derive coffee bean quality scoring from individual attributes,”2018 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE),pp. 1-7,2018,doi: 10.1109/FUZZ-IEEE.2018.8491513.