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The application of the tsukamoto fuzzy method in controlling the dryer for shrimp cracker hygienization

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ABSTRACT

The process of drying crackers is traditionally carried out on the side of the road and open places. The impact of drying on product quality, especially hygiene because it is directly contaminated with dust, pollutants and pathogenic microbes. Drying depends on the sun's heat which affects the continuity of production and the level of drought. How to identify food hygiene using an inductive proximity sensor functions as a metal content detector. Because the metal content when ingested by humans is very dangerous. Drying is affected by temperature, moisture content and capacity. Oven drying application is equipped with an inductive proximity sensor and a DS18B20 temperature sensor. The Fuzzy Tsukamoto method for weight problems is grouped into a separate set. So that it can process oven temperature data. The drying process of 3 shelves of shrimp crackers with fuzzy tsukamoto method produces defuzzification value of 28.1775 and 5 shelves of shrimp crackers with fuzzy tsukamoto method produces defuzzification value of 38.5084. By using fuzzy tsukamoto can help in estimating the drying time of shrimp crackers based on the capacity of the oven.

1. Introduction

Crackers as one of the regional superior products that have great potential are required to be of quality krupuk that is suitable for consumption and safe by meeting the requirements of SSOP (Sanitation Standard Operating Procedure) and

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GMP (Good Manufacturing Practice). Sanitary and hygienic aspects of production through the use of production tools must be clean to maintain food security [1] as well as production space based on quality standards [2]. Krupuk drying is carried out for the purpose of killing microbes that affect health and are safe for consumption, and can be stored longer [3].

The health risks posed by heavy metals are particularly high in developing countries where large amounts (≈70%) of the most polluting industries are around aquatic ecosystems [4]. If the habitat is contaminated by various metals, it will result in metal concentrations that can be consumed by marine life. Shrimp as one of the marine life as the basic ingredient of crackers if it has been contaminated by various metals [5] can cause health risks so that it is categorized as less hygienic, which arises from metal toxicity, especially including kidney and bone disorders, neurological disorders, endocrine disorders, cardiovascular dysfunction, and carcinogenic effects [6]. Food exposure to various heavy metals has been identified as a health risk to humans through the consumption of contaminated food.

Drying is a process of removing moisture content bound to cracker material. Based on the BSN in SNI 2714.3:2009, the water content of shrimp crackers is a maximum of 12% [7]. Drying crackers can be carried out two methods, solar drying method and oven drying. The solar drying method takes 8 hours, while drying using the oven takes 5 hours [8]. The use of the oven is not carried out in the open air, crackers become clean from dust and other impurities [9]. Cracker oven temperatures of 50^{o}C, 60^{o}C and 70^{o}C until they reach maximum temperatures. The oven method for crackers produces a high protein content, while at a temperature of 50^{o}C the moisture content in the crackers is dry [10]. The drying time of crackers depends on the fluffy volume, color, aroma, crispiness, and flavor exerting different influences [11].

Inductive proximity sensors are used to detect the presence of metal in food objects. The sensor works optimally at a maximum distance of 3mm so there is no need for manual [12]. Metal content is a mining material in the form of metal fragments. Mining materials include coal, sand, and rock. While metal fragments in the form of iron (Fe), Copper (Cu), and Aluminum (Al). Inductive proximity sensors can detect metal fragments with a success rate of 92.59% [13]. The sensor component consists of a ferrite core coil, an oscillator, a trigger signal level detector, and an output circuit [14]. The equivalent circuit capacitance is picofarad-valued, for frequency work in the megahertz range and faster response time. The coil moves closer to the target [15]. So that the sensor works automatically to detect the presence of metal in an object [16].

The DS18B20 temperature sensor [17] is used as a temperature stability controller [18] during heating. The DS18B20 temperature sensor uses a 1-Wire bus: which means it only needs one data line for communication with the microcontroller. The DS18B20 sensor has a selectable resolution of 9 to 12 bits. IEC61724 standard, the accuracy of the temperature sensor is better than ±2^{o}C, the highest resolution selected operating temperature range of the DS18B20 sensor is -55^{o}C to 125^{o}C, but the manufacturer ensures an accuracy of ±0.5^{o}C from the operating temperature range of -10°C to +85°C [19]. The DS18B20 temperature sensor can be used to monitor in real-time temperature changes ([20] [21] [22] [23]). The DS18B20 sensor performs temperature readings every 30 seconds with a measurement error rate of ± 0.1°C after calibration [24]. Temperature changes produced by dryers with very varied values and read by sensors so that a system is needed that can control temperature changes to be more measurable and standard.

The use of fuzzy logic in the prototype of a solar energy cracker dryer can streamline the cracker drying process and the drying process faster. Where the tool works automatically using the DHT11 sensor as a temperature and humidity controller in the tool room so that deviations do not occur [25]. Fuzzy logic with the tsukamoto method is one of the methods for controlling varied temperature changes [26]. The Tsukamoto method [27] is an IF-THEN rule in the form of a fuzzy set, with monotonous membership functions. As a result, the output of inference results from each rule is given based on predicates [28].

2. Method

2.1. Drying System

The proximity sensor and DS18B20 sensor are used to detect the metal content in shrimp crackers and the temperature in the drying oven. The STM32 microcontroller performs the process of reading the sensor results. The DS18B20 sensor readings are processed using the Fuzzy Tsukamoto method [29] [30] [31]. The stages of the drying system begin with a power supply that functions to turn on the oven connected to the filament as a heater. Next step down is used for sensor power needs, the STM32 microcontroller contains a fuzzy tsukamoto method program that processes the sensor readings, then displayed on the LCD. The buzzer is used as a warning indicator, and PhotoTRIAC serves to on off the filament. The output display of the STM32 reading process is in the form of the presence or absence of metal content, oven temperature, drying time, and on off filament. The buzzer output signals the optimum temperature limit is reached, and the oven is ready to shut down. Dryer oven temperature diagram blog as Figure 1.

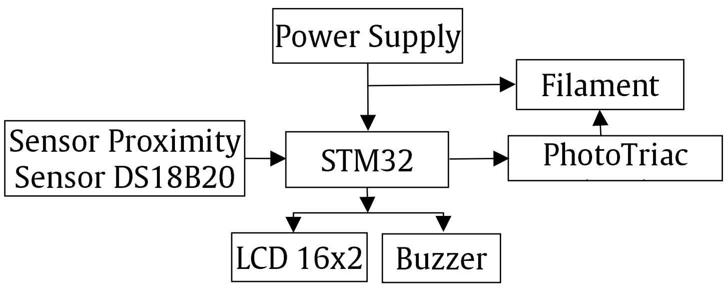


Figure 1. Dryer Oven Diagram Blog

2.2. Hygiene Process

The hygienicization process is carried out using inductive proximity sensors. Inductive proximity sensors are made of an isolated magnetic field on the sensing surface [32]. The magnetic field uses LC insulators in the form of capacitors and coils [33]. The circuit will produce oscillation frequencies for AC between 10-20Hz, for DC in the range of 500Hz-5kHz. When a metal object is in the resulting magnetic field, it will induce an electric current inside the object. Thus causing an eddy current (a line of electric force that occurs in a magnetic field that gives rise to an ambular current) to circulate in the object. The eddy current with the presence of metal objects will cause inductive proximity to ignite [34]. If it does not contain metal the magnetic field will not be induced electric current and the proximity will die [35]. Flow chart of hygienic processes that detect metal content such as Figure 2.

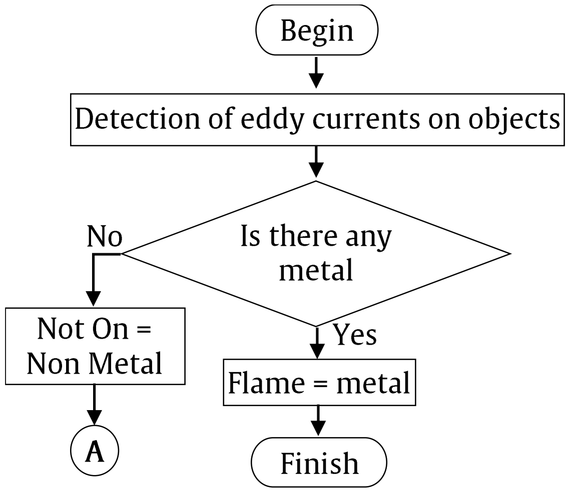


Figure 2. Flowchart of hygienic processes that detect metal content

2.3. Temperature Process Oven

The cracker drying process begins with a sensor to detect the oven temperature. The heating process will be stopped when the temperature reaches 70^{O}C which is indicated by the buzzer sound indicator. If it has not been reached the process will repeat until it is fulfilled. Oven temperature process flowchart as Figure 3.

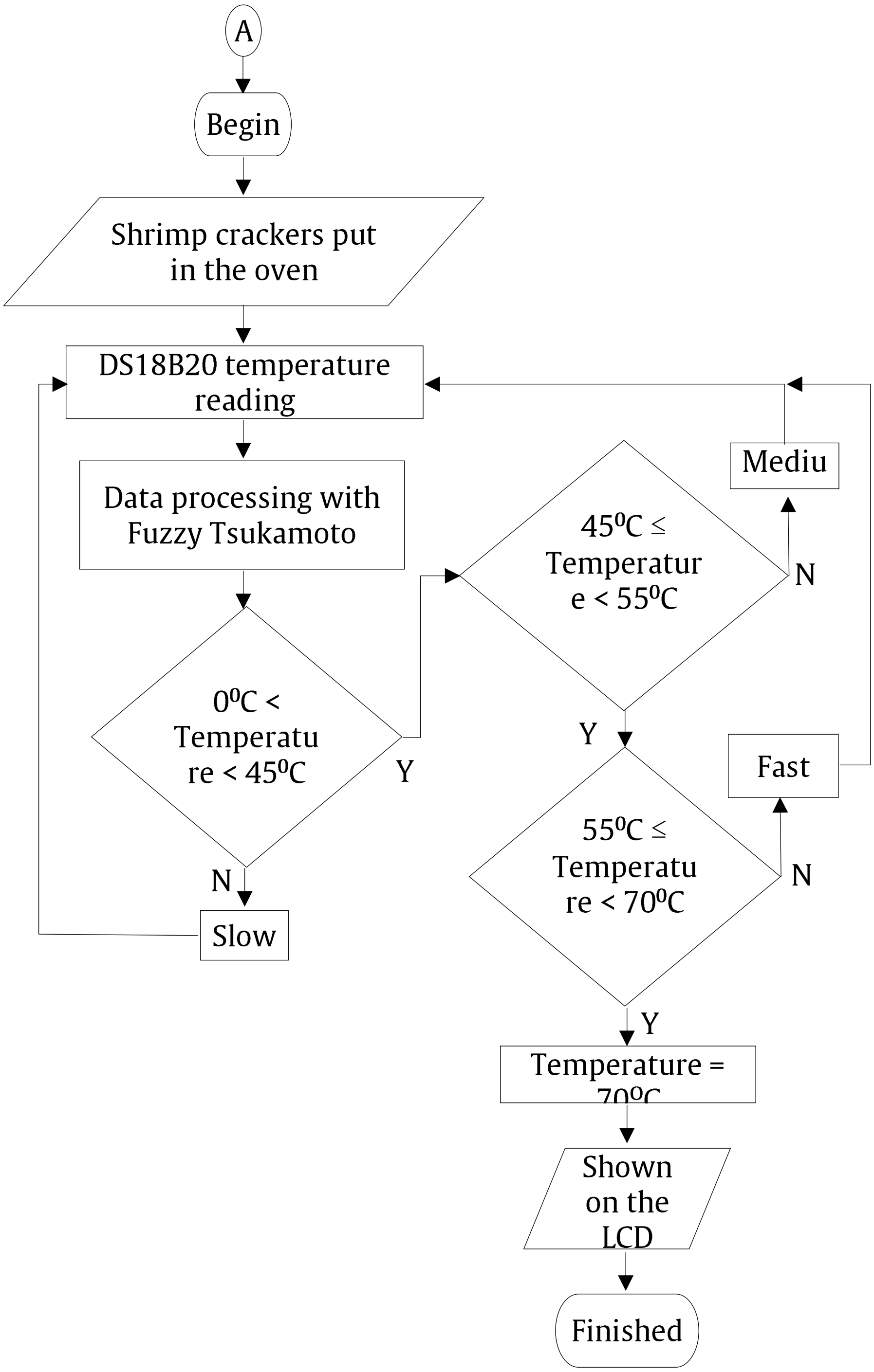


Figure 3. Oven temperature process flowchart

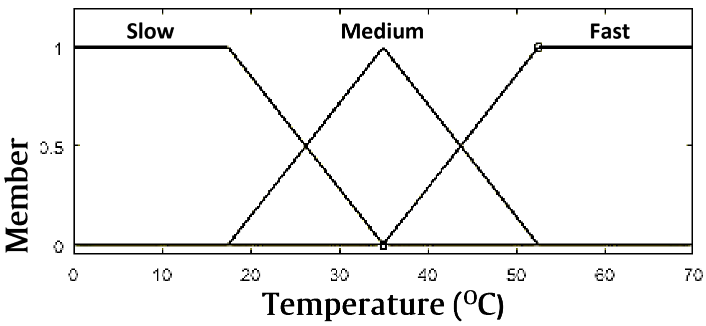
2.4. Fuzzy Tsukamoto

The Tsukamoto method is an extension of monotonous reasoning, In the Tsukamoto Method, any consequent to the if-then rule must be represented with a fuzzy set with a monotonous membership function. The output of inference results from each rule is given expressly (crisp) based on D-predicate (fire strength). The end result is obtained using weighted averages. The following are the stages of inference in Tsukamoto's fuzzy method:

1. Fuzzyfication, which is the process of converting system inputs that have firm values into linguistic variables using membership functions stored in the fuzzy knowledge base.
2. Establishment of a Fuzzy knowledge base (Rule in the form of IF... THEN), i.e. In general the form of the Fuzzy Tsukamoto model is IF (X IS A) and (Y IS B) and (Z IS C), where A,B, and C are fuzzy sets.
3. Inference Engine, which is a process using the MIN implication function to obtain the value of the a-predicate of each rule (a_1, a_2, a_3, ... a_n). Then each of these predicate values is used to calculate the output of the inference results expressly (crisp) each rule (z_1, z_2, z_3, ... z_n).
4. Defuzzyfication of fuzzy logic, after fuzzy inference. Fuzzy inference is a computational framework based on fuzzy set theory and fuzzy rules in the form of IF-THEN, and fuzzy reasoning.

Fuzzification process to convert two input crisp values (temperature and number of crackers) to fuzzy inputs using the membership function.

Temperature data uses slow, medium and fast variable references. Illustration of crisp fuzzy tsukamoto input values in Figure 4.



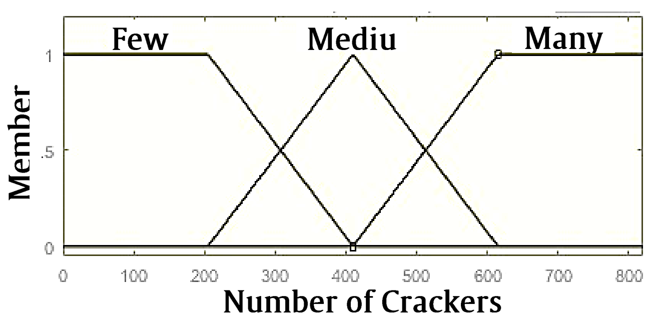
$$\mu\text{Slow} = \begin{cases} 1, & x \le 25 \\ \dfrac{40-x}{15}, & 25 \le x \le 40 \\ 0, & x \ge 40 \end{cases}$$

$$\mu\text{Medium} = \begin{cases} 0, & x \le 25 \\ \dfrac{x-25}{15}, & 25 \le x \le 40 \\ \dfrac{40-x}{15}, & 40 \le x \le 55 \\ 0, & x \ge 55 \end{cases}$$

$$\mu\text{Fast} = \begin{cases} 0, & x \le 40 \\ \dfrac{x-40}{15}, & 40 \le x \le 55 \\ 1, & x \ge 55 \end{cases}$$

Figure 4. Temperature Membership Function

The cracker count data uses few, medium and many variable references. Illustration of crisp fuzzy tsukamoto input values in Figure 5.



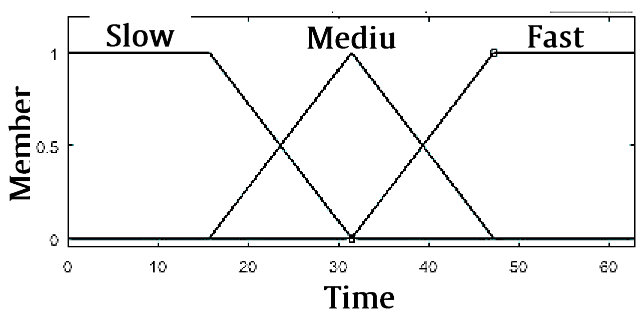
$$\mu\text{Few} = \begin{cases} 1, & x \le 205 \\ \dfrac{410-x}{205}, & 205 \le x \le 410 \\ 0, & x \ge 410 \end{cases}$$

$$\mu\text{Medium} = \begin{cases} 0, & x \le 250 \\ \dfrac{x-205}{205}, & 205 \le x \le 410 \\ \dfrac{410-x}{205}, & 410 \le x \le 615 \\ 0, & x \ge 615 \end{cases}$$

$$\mu\text{Many} = \begin{cases} 0, & x \le 410 \\ \dfrac{x-410}{205}, & 410 \le x \le 615 \\ 1, & x \ge 615 \end{cases}$$

Figure 5. Temperature Membership Function

The drying time output data uses slow, medium and fast variable references. Illustration of crisp fuzzy tsukamoto output value in Figure 6.



$$\mu Slow = \begin{cases} 1, & x \le 15{,}75 \\ \frac{31{,}5 - x}{15{,}75}, & 15{,}75 \le x \le 31{,}5 \\ 0, & x \ge 31{,}5 \end{cases}$$

$$\mu Medium = \begin{cases} 0, & x \le 15{,}75 \\ \frac{x - 15{,}75}{15{,}75}, & 15{,}75 \le x \le 31{,}5 \\ \frac{47{,}25 - x}{15{,}75}, & 31{,}5 \le x \le 47{,}25 \\ 0, & x \ge 47{,}25 \end{cases}$$

$$\mu Fast = \begin{cases} 0, & x \le 31{,}5 \\ \frac{x - 31{,}5}{15{,}75}, & 31{,}5 \le x \le 47{,}25 \\ 1, & x \ge 47{,}25 \end{cases}$$

Figure 6. Time Membership Function

3. RESULTS AND DISCUSSION

Tsukamoto fuzzy system testing on shrimp cracker drying oven aims to determine how the processing system in shrimp cracker drying oven using fuzzy logic method. This shrimp dry ing oven system has 2 inputs, namely temperature and number of crackers, and also has 1 output, namely time. Drying oven testing is done based on the capacity of the rack is 3 rack crackers, and 5 rack crackers.

3.1. 3 Racks Of Crackers

Matlab simulation and manual calculation with input temperature 35^{0}C and the number of crackers 250 pieces produces an output time of 25.6 minutes.
Temperature = 35^{0}C
Using fuzzy variables:

Slow : $\frac{40-x}{15} = \frac{40-35}{15} = \frac{10}{15} = 0{,}3$

Medium : $\frac{x-15}{15} = \frac{35-15}{15} = \frac{20}{15} = 1{,}3$

Fast : 0

Number of crackers = 250 pieces
Using fuzzy variables

Slow : 0

Medium : $\frac{369-x}{123} = \frac{369-250}{123} = \frac{119}{123} = 0{,}97$

Fast : $\frac{x-123}{123} = \frac{250-123}{123} = \frac{127}{123} = 1$

By using matlab simulation obtained implications for fuzzy tsukamoto as much as 27 rules with 3 values of the best approach.

Rule [R1] – [R3] and [R7] - [R9] on the variable number of crackers produce a value of 0. Rule [R13] – [R15] and [R22] - [R24] on the temperature variable produces a value of 0. While the Rule [R10] – [R12], [R16] – [R21], and [R25] – [R27] in the variable temperature and the number of crackers produce a value of 0. So the Rule that is not worth 0 is [R4] - [R6] and the time span can be formed with the resulting value. With the inference picture below:

Inference

[R4] If (temperature = "slow‟) and (Number_cooper = "medium") then (Time = "slow")

α4 = min (µslow, µ medium)
= min (0,3, 0,97)
= 0,3
µslow = α4
µslow = $0{,}3 = \frac{25{,}5-x}{12{,}75}$
x = 21,675

[R5] If (temperature is slow) and (quantity is medium) then (Time is medium)
α5 = min (µslow, µmedium)
= min (0,3, 0,97)
= 0,3
µmedium = α5
µmedium = $0{,}3 = \frac{25{,}5-x}{12{,}75}$
x = 21,675

[R6] If (temperature is slow) and (quantity is medium) then (Time is fast)
α6 = min (µslow, µmedium)
= min (0,3, 0,97)
= 0,3
µfast = α6
µfast = $0{,}3 = \frac{x-38{,}25}{12{,}75}$
x = 42,075

By using matlab simulation obtained implications for fuzzy tsukamoto as much as 27 rules with 3 values of the best approach. Here are the broad implications of the resulting area:

[R4] If (temperature = "slow‟) and (Number_cooper = "medium") then (Time = "slow")

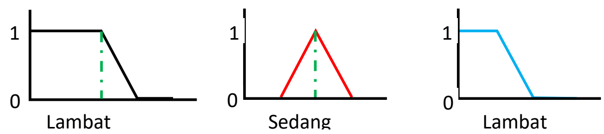


Figure 7. The area of the rule of 4 fuzzy inference

[R5] If (temperature is slow) and (quantity is medium) then (Time is medium)

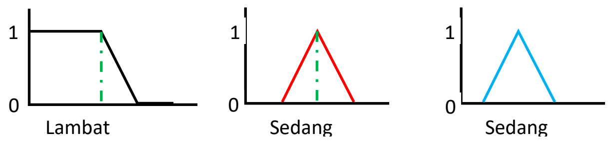


Figure 8. The area of the rule of 5 fuzzy inference

[R6] If (temperature is slow) and (quantity is medium) then (Time is fast)

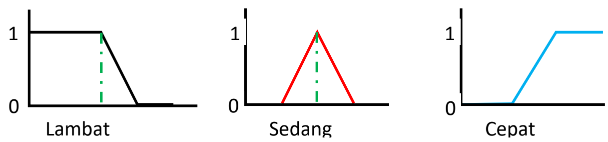


Figure 9. The area of the rule of 6 fuzzy inference

From the implications of tsukamoto's 27 fuzzy rules, the total area of the area shown during the drying process is 51 minutes (shown in Figure 10).

Figure 10. Total fuzzy inference drying process.

Defuzzyfikasi

$$Z = \frac{\sum_{i=1}^{n} \alpha i \, xi}{\sum_{i=1}^{n} \alpha i}$$

$$= \frac{(0{,}3 \times 21{,}675) + (0{,}3 \times 34.425) + (0{,}3 \times 42{,}075)}{0{,}3 + 0{,}3 + 0{,}3}$$

$$= \frac{2{,}40975 + 10{,}3275 + 12{,}6225}{0{,}9}$$

$$= 28{,}1775$$

3.2. 5 rack of crackers

Matlab simulation and manual calculation with temperature input 35^{0}C and the number of crackers 410 pieces produces an output time of 31.6 minutes.
Temperature = 35^{0}C
Using fuzzy variables:

Slow : $\frac{40-x}{15} = \frac{40-35}{15} = \frac{10}{15} = 0{,}3$

Medium : $\frac{x-15}{15} = \frac{35-15}{15} = \frac{20}{15} = 1{,}3$

Fast : 0

Number of crackers = 410 pieces
Using fuzzy variables

Slow : 0

Medium : $\frac{x-205}{205} = \frac{410-205}{205} = \frac{205}{205} = 1$

Fast : 0

By using matlab simulation obtained implications for fuzzy tsukamoto as much as 27 rules with 3 values of the best approach.

Rule [R1] – [R3] and [R7] - [R9] on the variable number of crackers produce a value of 0. Rule [R13] – [R15] and [R22] - [R24] on the temperature variable produces a value of 0. While the Rule [R10] – [R12], [R16] – [R21], and [R25] – [R27] in the variable temperature and the number of crackers produce a value of 0. So the Rule that is not worth 0 is [R4] - [R6] and the time span can be formed with the resulting value. With the inference picture below:

Inference

[R4] If (temperature = "slow‟) and (Number_cooper = "medium") then (Time = "slow")

$\alpha 4$ = min (µslow, µmedium)

= min (0,3, 1)
= 0,3
µslow = α4
µslow = $0,3 = \frac{31,5-x}{15,75}$
x = 26,775

[R5] If (temperature is slow) and (quantity is medium) then (Time is medium)
α5 = min (µslow, µmedium)
= min (0,3, 1)
= 0,3
µmedium = α5
µmedium = $0,3 = \frac{47,25-x}{15,75}$
x = 42,525

[R6] If (temperature is slow) and (quantity is medium) then (Time is fast)
α6 = min (µslow, µmedium)
= min (0,3, 1)
= 0,3
µfast = α6
µfast = $0,3 = \frac{x-31,5}{15,75}$
x = 46,225

By using matlab simulation obtained implications for fuzzy tsukamoto as much as 27 rules with 3 values of the best approach. Here are the broad implications of the resulting area:

[R4] If (temperature = "slow") and (Number_cooper = "medium") then (Time = "slow")

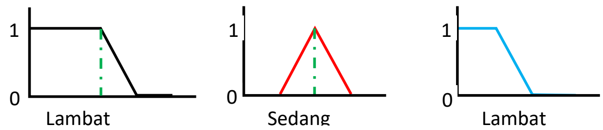


Figure 11. The area of the rule of 4 fuzzy inference

[R5] If (temperature is slow) and (quantity is medium) then (Time is medium)

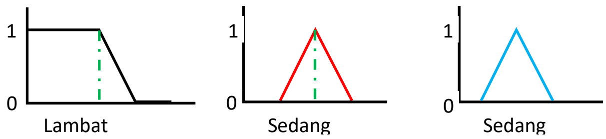


Figure 12. The area of the rule of 5 fuzzy inference

[R6] If (temperature is slow) and (quantity is medium) then (Time is fast)

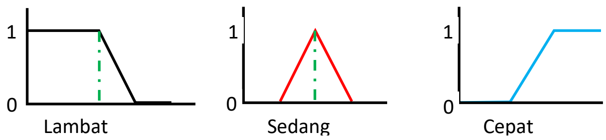


Figure 13. The area of the rule of 6 fuzzy inference

From the implications of tsukamoto's 27 fuzzy rules, the total area of the area shown during the drying process is 63 minutes (shown in Figure 14).

Figure 14. Total fuzzy inference drying process.

Defuzzyfikasi

$$Z = \frac{\sum_{i=1}^{n} \alpha i\, xi}{\sum_{i=1}^{n} \alpha i}$$

$$= \frac{(0{,}3 \times 26{,}775) + (0{,}3 \times 42.525) + (0{,}3 \times 46{,}225)}{0{,}3 + 0{,}3 + 0{,}3}$$

$$= \frac{8{,}0325 + 12{,}7575 + 13{,}8675}{0{,}9}$$

$$= 38{,}5084$$

Based on defuzzyfication drying process for a capacity of 3 shelves using matlab simulation obtained drying time 28.2 minutes, drying using oven obtained drying time 42 minutes. For defuzzyfication drying process capacity of 5 racks using matlab simulation obtained drying time 38.5 minutes, drying with oven obtained drying time 63 minutes. By using fuzzy tsukamoto can help in estimating the drying time of shrimp crackers. This can be seen from the drying process with a capacity of 3 shelves and 5 shelves.

4. Conclusion

Shrimp cracker drying oven control system to control the temperature and number of crackers in the process of ovenan. This shrimp cracker Oven is designed to maintain the hygiene of shrimp crackers with an inductive proximity sensor. The developed system can control the temperature by tsukamoto's fuzzy method to identify the heat generated by the filament. The temperature Data is then processed using fuzzy logic to determine the length of drying time. This system is able to control the time according to the number of shrimp crackers. The use of the system can stop the novenation process once the temperature reaches the maximum point. The drying process of 3 shelves of shrimp crackers with fuzzy tsukamoto method produces defuzzification value of 28.1775 and 5 shelves of shrimp crackers with fuzzy tsukamoto method produces defuzzification value of 38.5084. By using fuzzy tsukamoto can help in estimating the drying time of shrimp crackers based on the capacity of the oven.

REFERENCES

[1] R. Anjali, A. Achankunju, U. Bini Babu, J. Varghese, and A. S. Varghese, "Clean and Hygienic Automated Butter Extractor for Households," 2019 2nd Int. Conf. Intell. Comput. Instrum. Control Technol. ICICICT 2019, pp. 918–921, 2019, doi: 10.1109/ICICICT46008.2019.8993189.

[2] Z. Floridiana, "The assessment of Food Handlers' Hygiene and Environmental Sanitation in Tofu Home Industry Jombang 2018," J. Kesehat. Lingkung., vol. 11, no. 1, p. 75, 2019, doi: 10.20473/jkl.v11i1.2019.75-82.
[3] I. Juliyarsi, S. Melia, and D. Novia, "Perbaikan Sanitasi dan Higienis Kerupuk Kulit IKM Aulia di Kabupaten Agam, Provinsi Sumatera Barat," J. Dedik. Masy., vol. 3, no. 1, pp. 26–35, 2019.
[4] T. Agusa et al., "Exposure assessment for trace elements from consumption of marine fish in Southeast Asia," Environ. Pollut., vol. 145, no. 3, pp. 766–777, 2007, doi: 10.1016/j.envpol.2006.04.034.
[5] H. Guhathakurta and A. Kaviraj, "Heavy metal concentration in water, sediment, shrimp (Penaeus monodon) and Mullet (Liza parsia) in some brackish water ponds of Sunderban, India," Mar. Pollut. Bull., vol. 40, no. 11, pp. 914–920, 2000, doi: 10.1016/S0025-326X(00)00028-X.
[6] E. A. Renieri et al., "Cadmium, lead and mercury in muscle tissue of gilthead seabream and seabass: Risk evaluation for consumers," Food Chem. Toxicol., vol. 124, no. 2019, pp. 439–449, 2019, doi: 10.1016/j.fct.2018.12.020.
[7] M. A. Fatoni, S. Sumardianto, and L. Purnamayati, "THE ADDITION OF TILAPIA BONE NANOCALCIUM (Oreochromis niloticus) TO THE PHYSICO-CHEMICAL CHARACTERISTIC OF SHRIMP CRACKERS," J. Teknol. Has. Pertan., vol. 14, no. 1, p. 1, 2021, doi: 10.20961/jthp.v14i1.42545.
[8] T. S. Nugroho and U. Sukmawati, "Pengaruh Metode Pengeringan Kerupuk Udang Windu (Paneaus Monodon) Terhadap Daya Kembang Dan Nilai Organoleptik," Manfish J., vol. 1, no. 2, pp. 107–114, 2020.
[9] Purnomo dkk, "Implementasi Alat Pengering Cabinet Dryer untuk Mengatasi Masalah Pengeringan Kerupuk pada Usaha Kecil Kerupuk," Pros. Semin. Nas. Publ., no. September, pp. 606–609, 2017.
[10] A. Kusumaningrum, E. R. N. Herawati, A. Nurhikmat, and A. Restuti, "Influence of drying method on chemical properties of dried cracker," IOP Conf. Ser. Earth Environ. Sci., vol. 462, no. 1, 2020, doi: 10.1088/1755-1315/462/1/012013.
[11] F. B. Lilir, C. K. M. Palar, and N. N. Lontaan, "Pengaruh lama pengeringan terhadap proses Pengolahan kerupuk kulit sapi," Zootec, vol. 41, no. 1, p. 214, 2021, doi: 10.35792/zot.41.1.2021.32667.
[12] M. Akbar, D. Anjasmara, D. K. Diah, and K. Wardhani, "Jurnal Politeknik Caltex Riau Rancang Bangun Alat Pendeteksi Sampah Organik dan Anorganik Menggunakan Sensor Proximity dan NodeMCU ESP8266," J. Komput. Terap., vol. 7, no. 2, pp. 290–299, 2021, [Online]. Available: https://jurnal.pcr.ac.id/index.php/jkt/.
[13] A. Djafar, R. Gunawan, H. D. Haryono, and D. Suanggana, "Efektifitas Respon Sensor Proximity Induktif dalam Menyortir Pecahan Logam pada Model Conveyor," vol. VIII, no. 1, pp. 4492–4499, 2023.
[14] D. Purcaru, I. M. Gordan, and A. Purcaru, "Study, testing and application of proximity sensors for experimental training on measurement systems," 2017 18th Int. Carpathian Control Conf. ICCC 2017, pp. 263–266, 2017, doi: 10.1109/CarpathianCC.2017.7970408.
[15] C. Bartoletti, R. Buonanni, L. G. Fantasia, R. Frulla, W. Gaggioli, and G. Sacerdoti, "The design of a proximity inductive sensor," Meas. Sci. Technol., vol. 9, no. 8, pp. 1180–1190, 1998, doi: 10.1088/0957-0233/9/8/007.
[16] E. Indasyah, L. N. Khoirillah, A. Musthofa, and F. Istiqomah, "Toothpaste Tube Detector Inside Cardboard Using Proximity Inductive Sensor to Maintain Quantity of Product," 2019 Int. Conf. Adv. Mechatronics, Intell. Manuf. Ind. Autom. ICAMIMIA 2019 - Proceeding, pp. 259–262, 2019, doi: 10.1109/ICAMIMIA47173.2019.9223391.
[17] D. Awtrey, "The 1-wire weather station," Sensors (Peterborough, NH), vol. 15, no. 6, pp. 34–40, 1998.
[18] A. Salimun Thoha, B. Dwirastiaji, and S. Samsugi, "Monitoring Dan Kontrol Suhu Aquascape Menggunakan Arduino Dengan Sensor Suhu Ds18B20," J. Ilm. Mhs. Kendali dan List., vol. 2, no. 2, pp. 2723–598, 2021.
[19] A. Lopez-Vargas, M. Fuentes, M. V. Garcia, and F. J. Munoz-Rodriguez, "Low-Cost Datalogger

Intended for Remote Monitoring of Solar Photovoltaic Standalone Systems Based on Arduino™," IEEE Sens. J., vol. 19, no. 11, pp. 4308–4320, 2019, doi: 10.1109/JSEN.2019.2898667.
[20] W. Zhang and T. Jiang, "Design of Biomolecule Interaction Detection System Based on Fiber Biosensor," IEEE Sens. J., vol. 20, no. 16, pp. 8922–8929, 2020, doi: 10.1109/JSEN.2020.2984808.
[21] C. Du, Q. Wang, X. Liu, Y. Zhao, X. Deng, and L. Cui, "Research and Application of Ice Thickness and Snow Depth Automatic Monitoring System," IEEE Trans. Instrum. Meas., vol. 66, no. 2, pp. 325–331, 2017, doi: 10.1109/TIM.2016.2636518.
[22] X. Deng, J. Cai, L. Li, B. Jia, L. Cui, and X. Tu, "Design and Application of the Measuring System of Ice Sheet Profile Based on Thermal Conductivity Difference of Medium," IEEE Sens. J., vol. 21, no. 3, pp. 3822–3830, 2021, doi: 10.1109/JSEN.2020.3024848.
[23] A. N. Fathoni, N. Hudallah, R. D. M. Putri, K. Khotimah, T. Rijanto, and M. Ma' Arif, "Design Automatic Dispenser for Blind People based on Arduino Mega using DS18B20 Temperature Sensor," Proceeding - 2020 3rd Int. Conf. Vocat. Educ. Electr. Eng. Strength. Framew. Soc. 5.0 through Innov. Educ. Electr. Eng. Informatics Eng. ICVEE 2020, 2020, doi: 10.1109/ICVEE50212.2020.9243254.
[24] Y. Wang, A. Yang, X. Chen, P. Wang, Y. Wang, and H. Yang, "A Deep Learning Approach for Blind Drift Calibration of Sensor Networks," IEEE Sens. J., vol. 17, no. 13, pp. 4158–4171, 2017, doi: 10.1109/JSEN.2017.2703885.
[25] F. Teknik and U. T. Madura, "Prototipe Alat Pengering Kerupuk Energi Matahari menggunakan Mikrokontroler Atmega16 berbasis Fuzzy Logic," pp. 47–52.
[26] I. Muhandhis, A. S. Ritonga, and M. H. Murdani, "Implementasi Metode Inferensi Fuzzy Tsukamoto Untuk Memprediksi Curah Hujan Dasarian Di Sumenep," J. Ilm. Edutic Pendidik. dan Inform., vol. 8, no. 1, pp. 01–10, 2021, doi: 10.21107/edutic.v8i1.8907.
[27] A. Z. Rakhman, H. N. Wulandari, G. Maheswara, and S. Kusumadewi, "Fuzzy Inference System Dengan Metode Tsukamoto Sebagai Pemberi Saran Pemilihan Konsentrasi (Studi Kasus: Jurusan Teknik Informatika Uii)," Semin. Nas. Apl. Teknol. Inf., vol. 0, no. 0, pp. 15–16, 2012, [Online]. Available: https://journal.uii.ac.id/Snati/article/view/2903.
[28] T. Hidayat and M. Alaydrus, "Performance Analysis and Mitigation of Virtual Machine Server by using Naive Bayes Classification," Proc. 2019 4th Int. Conf. Informatics Comput. ICIC 2019, pp. 0–4, 2019, doi: 10.1109/ICIC47613.2019.8985932.
[29] M. Nizam, H. Maghfiroh, A. Ubaidilah, Inayati, and F. Adriyanto, "Constant current-fuzzy logic algorithm for lithium-ion battery charging," Int. J. Power Electron. Drive Syst., vol. 13, no. 2, pp. 926–937, 2022, doi: 10.11591/ijpeds.v13.i2.pp926-937.
[30] M. S. Anggreainy, B. Kurniawan, and F. I. Kurniadi, "Reduced False Alarm for Forest Fires Detection and Monitoring using Fuzzy Logic Algorithm," Int. J. Adv. Comput. Sci. Appl., vol. 13, no. 7, pp. 535–541, 2022, doi: 10.14569/IJACSA.2022.0130764.
[31] X. Wang and S. Li, "Multipoint temperature measurement system of hot pack based on DS18B20," Proc. - 2010 WASE Int. Conf. Inf. Eng. ICIE 2010, vol. 1, pp. 26–29, 2010, doi: 10.1109/ICIE.2010.14.
[32] Asrul, S. Sahidin, and S. Alam, "Mesin Cuci Tangan Otomatis Menggunakan Sensor Proximity Dan Dfplayer Mini Berbasis Arduino Uno," J. Mosfet, vol. 1, no. 1, pp. 1–7, 2021.
[33] N. Febriana, Yulkifli, and R. Wulan, "Pembuatan Pengukur Tekanan Pada Klem Arteri Mosquito Berbasis Sensor Proximity Lj12a3-4-Z / Bx Staf Pengajar Jurusan Fisika , Fmipa Universitas Negeri Padang," Pillar Phys., vol. 9, pp. 25–32, 2017.
[34] H. Meidia and S. Prawira, "Kajian Literatur : Perbandingan Sensor Dalam Mensortir Material Berbahan Metal," Ultim. Comput. J. Sist. Komput., vol. 11, no. 1, pp. 16–19, 2019, doi: 10.31937/sk.v11i1.1085.
[35] T. Rocha, H. Ramos, A. L. Ribeiro, and D. Pasadas, "Sub-surface defect detection with motion induced eddy currents in aluminium," Conf. Rec. - IEEE Instrum. Meas. Technol. Conf., vol. 2015-July, pp. 930–934, 2015, doi: 10.1109/I2MTC.2015.7151394.