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Physical and Sensory Properties of Vegetarian Burger Patty

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Abstract: Burger patties is considered a processed meat product that is usually produced by using minced chicken, lamb, pork, turkey, and other palatable meats. Excess cholesterol, sodium, and flavoring agents in commercial burger patties led to an unhealthy diet pattern and an increased consumer craving for fast food. Thus, this study was aimed at observing the unripe soursop's incorporation into the burger patty as the meat alternative and its effect on the physical properties (moisture, pH, color, texture, cooking loss) and sensory attributes (appearance, taste, texture, aroma, and overall acceptance). There were 6 formulations of the burger patty were formulated, which were: F1 (mushroom 58%), F2 (soursop 58%), F3 (mushroom 29% + soursop 29%), F4 (mushroom 29% jackfruit 29%), F5 (jackfruit 29% + soursop29%), F6 (mushroom 19.3% + jackfruit19.3% + soursop19.3%). The unripe soursop and oyster mushrooms were cleaned, dried (1 hour at 108˚C)**,** minced, incorporated with plant-based ingredients, molded, frozen overnight (-18˚C)**,** and pan-fried for 2-10 minutes at 180-200˚C**.** Gathered analysis data interpreted statistically using one-way ANOVA**.** The moisture content of raw and cooked burger patty F1 obtained the highest, 68.58% and 64.53%. The pH of F1;7.13 reveals a significant difference (p<0.05) while, the cooked burger patty of the control sample has the lowest pH, 5.69. The vegetarian burger patty L*(lightness) in raw; 67.18 and cooked burger; 32.17 patties attained no significant difference (p>0.05) and for the raw burger patty F4; 9.88 followed by F1 cooked burger patty F1 indicated the highest a*(redness). Simultaneously, the control and F2 burger patties of raw and cooked samples obtained the lowest a*(redness), 3.43 and 0.83 respectively. Meanwhile, the highest b*(yellowness) was attained in the control formulation for both raw and cooked burger patties. The hardness of F1 and cohesiveness of control formulation on cooked burger patties have the highest which are 9.03kg and 88.64%. In addition, cooking loss (%) F6 attained the highest; 33.97 and F2 obtained the slightly higher acceptability in sensory acceptance. To conclude, substitution of unripe soursop effectively replaced as meat substitution in the vegetarian burger patty.

Keywords: Burger Patty, Soursop, Physical Properties, Sensory Evaluation

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1. Introduction

In recent years, markets for plant-based seafood have already opened in Asia, Europe, and North America, with 20%, 40%, and 40% of production and consumption, respectively. It has been predicted that the distribution will increase to 30% in Asian markets by 2030 [1]. This is due to their abundance, lack of cholesterol, and lower levels of saturated fatty acids, plant-based proteins are preferable to animal-based proteins [2]. A vegetarian diet is gaining popularity due to ethical motivations, religious beliefs, environmental and cultural issues, and health-related aspects [3]. Due to this trend, the demand for vegetarian food products also increases respectively. In addition, certain research studies claimed that the tropical fruit namely jackfruit was chosen to ensure proper utilization of jackfruit in the food industry, as well as the fact that jackfruit was considered the central element while developing a plant-based meat protein [4]. Studies also revealed that oyster mushroom and soursop do have potential to improve quality of processed food without undesirable changes in physical properties and sensory attributes. Patties are a type of meat that is commonly eaten with burgers. It is made of beef, as opposed to the other types of meat [5]. Meanwhile, it has been noticed that most of the meat products such as burger patties are fat-rich but lacking in complex carbohydrates. High levels of animal fat, saturated fatty acids, and cholesterol in various meat products have been linked to cardiovascular disease. Consumers are concerned about their health and prefer to consume healthier processed meat products. As a result, they may regard burger patties as unhealthy food because of their high fat content, especially the cholesterol (LDL) presence in the animal-based burger patty. Therefore, this research study intended to formulate vegetarian burger patty by using plant-based sources such as unripe jackfruit, unripe soursop and oyster mushroom as meat alternative which mimicking the taste and texture of animal-based burger patty and as well as to reduce the reliance of red meat in processed foods.

2. Materials and Methods

The experimental work started with the development of the vegetarian burger patty by using unripe soursop and oyster mushroom.

2.1 Formulate vegetarian burger patty.

The burger patty recipe and ingredients were referred to [6] research study based on the potential of utilizing jackfruit as the meat analogue alternative. All the ingredients have been evaluated by using Mixture Design in the Design Expert Trial version 13 software. The ingredients that have been used are mostly from plant sources to produce a quality vegetarian burger patty. Meanwhile, the ingredients that were used to formulate the vegetarian burger patty are illustrated in Table 2.1.

Table 2.1: The formulation used in the making of vegetarian burger patty

Ingredients	Control	F1	F2	F3	F4	F5	F6
	%	%	%	%	%	%	%
Jackfruit	58	-	-	-	29	29	19.3
Mushroom	-	58	-	29	29	-	19.3
Soursop	-	-	58	29	-	29	19.3
Vital wheat	20	20	20	20	20	20	20
Isolated soy protein	8	8	8	8	8	8	8
Vegetable oil	6	6	6	6	6	6	6
Starch	5	5	5	5	5	5	5
Mushroom seasonings	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Nutritional yeast	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Turmeric powder	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Garlic powder	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Onion powder	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Chili powder	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Salt	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Black pepper powder	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Chinese five spices powder	0.5	0.5	0.5	0.5	0.5	0.5	0.5

2.2 Selection and preparation of soursop fruit and mushroom

The unripe soursop (*Annona Muricata*) species has been purchased from FAMA (Federal Agricultural Marketing) supplier at Muar, Johor and the *Pleurotus ostreatus* (oyster mushroom) was purchased from the local market located at Muar. The fruits were washed and cleaned using running tap water and the skin will be peeled off and for the oyster mushroom the stem will be cut off. After that, the soursop fruit pulp size was reduced by cutting using a sharp knife into a chunk shape while the cleaned oyster mushroom was sliced in half and arranged on a clean tray for the drying process. Next, the oven-drying method used for reducing water content which was for 1 hour at 105˚C [7]. Then, the semi-dried soursop chunk minced through a food processor. The minced soursop fruit and oyster mushroom has weighed in a bowl using an electronic weighing scale.

2.3 Preparation of ingredients and molding the burger patty

The ingredients, such as vital wheat, isolated soy protein, vegetable oil, starch, nutritional yeast, mushroom seasonings, turmeric powder, garlic powder, onion powder, chili powder, salt, black paper powder, and Chinese five spices, were weighed using a weighing balance according to the Table 3.1 required quantity for each formulation and mixed thoroughly with minced oyster mushroom, and unripe soursop. The well-mixed vegetarian burger patty mixture then undergoes a molding process. The burger patty mixture has been placed into a round-shaped non-stick molder and molded it according to desirable and uniform shape. Each vegetarian burger patty net weighs 100g per piece.

2.4 Freezing

Next, the vegetarian burger arranged neatly in a container and allowed to freeze overnight in a blast freezer. To retain the quality of burger patty, it was frozen under -18˚C temperature for 1 day before cooking process.

2.5 Frying

The vegetarian burger patty cooked by pan-fried method for 2-10 minutes at 180-200˚C.

2.6 Physical analysis of the vegetarian burger patty

The physical properties that were evaluated in the burger patty include moisture content, texture, pH, color, cooking loss. The properties were then compared with raw and cooked vegetarian burger patties. The test conducted in triplicate and the results expressed as mean ± standard deviation values.

2.6.1 Determination of moisture

The moisture analysis was performed on the vegetarian burger patty according to the method described in [7]. The moisture will be determined by using the Moisture Analyzer (MX-50 Japan).

$$Cooking\ loss\ (\%) = \frac{raw\ weight - cooked\ weight}{raw\ weight} \times 100 \qquad \ldots\ldots\ldots\ldots eq\ 1$$

2.6.2 Determination of texture

The texture of the vegetarian burger patty has been analyzed by using Texture Analyzer (TA-XT Plus, Stable Micro System, UK) which is equipped with a 35mm aluminum cylinder probe. The test speed will be 2.0 mm/s, while the compression strain should be 10%, and the recovery period between the two compressions, 5 seconds. The basic property that will be measured on the vegetarian burger patty hardness and cohesiveness [8]. The hardness is defined as the force (g) applied during the first compression while the cohesiveness is the strength of the internal bond in the sample [9]. The test conducted in triplicate and the results expressed as mean ± standard deviation value.

2.6.3 Determination of color

A colorimeter used to determine the color of vegetarian burger patty samples colorimeter (MiniScan EZ, USA). Lightness (L*), redness (a*), and yellowness (b*) are all elements of the color reading for raw and cooked meat products. The white color standard was used to standardize the

equipment [10]. The obtained values for each L*, a*, and b* values were recorded for data analysis. The test conducted in triplicate and the results will be expressed as mean ± standard deviation value.

2.6.4 Determination of pH

The pH evaluated by using a pH meter after 5g of the raw and cooked vegetarian burger patty samples were homogenized with 20 ml of distilled water in a stomacher bag. This method will be obtained by using a pH meter [11]. The test will be conducted in triplicate and the results have been expressed as mean ± standard deviation value.

2.6.5 Determination of cooking loss

To determine the cooking loss, 3 samples from each formulation of vegetarian burger patty which was from (control to formulation 6) weighed immediately after development and after being cooked to record the values of cooking loss. The test conducted in triplicate and the results have been expressed as mean ± standard deviation value.

$$Cooking\ loss\ (\%) = \frac{raw\ weight - cooked\ weight}{raw\ weight} \times 100 \qquad \ldots\ldots\ldots\ldots\ldots eq\ 2$$

2.7 Sensory analysis of vegetarian burger patty

An affective test for sensory evaluation was conducted on the vegetarian burger patty sample through hedonic assessment. Therefore, about 30 panelists (the students at University Tun Hussein Onn Pagoh) have been invited to evaluate the vegetarian burger patty.

2.8 Statistical analysis of vegetarian burger patty

By using SPSS 18.0 and the XL Stat application for Windows, all data were subjected to a one-way analysis of variance (ANOVA). Duncan's multiple range tests have been used to assess the differences between the means. The significance level has chosen at (p<0.05), and the findings are reported as the mean± standard deviation value.

3. Results and Discussion

3.1 Moisture Content

The highest moisture content value was obtained on the burger patty F2 for the raw burger patty, and the lowest was obtained on F5 for the raw burger patty. Meanwhile, F1 had the highest moisture content in the cooked sample, while F5 had the lowest. Furthermore, significant differences (p< 0.05) were obtained on the F1, F2, F5, and F6 whereas there were no significant differences (p> 0.05) on the control, F3, and F4. [12] studies stated that oyster mushrooms have a moisture content in the range of 90–95%, whereas unripe soursop contains a 75–83% range of moisture on its edible part [13]. As a result, when a portion of both variables were incorporated into the burger patty, has affected the moisture content of the developed burger patties increased in value. In contrast, the lowest moisture content found in the burger patties incorporated with jackfruit which represented the control formulation. Moreover, the unripe jackfruit bulb contains 72–78% moisture content [14]. This indicated that the jackfruit burger patty contains less moisture content compared to the other two variables, so this could aid in prolonging the shelf life of the burger patty as no preservatives were used to develop the burger patties.

Table 1: Moisture analysis on raw and cooked burger patty

SAMPLES	MOISTURE (%)	
	Raw	Cooked
Control (jackfruit 58%)	63.94±1.4 ab	62.59±3.84 a
F1 (mushroom 58%)	68.58±6.6 bc	64.53±0.3 a
F2 (soursop 58%)	67.03±0.8 a	60.95±2.2 ab
F3 (mushroom 29%+soursop29%)	63.27±2.1 ab	50.03±3.1 bc
F4 (mushroom 29%+jackfruit 29%)	60.81±0.5 ab	55.76±1.5 bcd
F5 (jackfruit 29% + soursop 29%)	59.04±5.2 abc	48.07±2.8 cd
F6 (jackfruit 19.3% + soursop 19.3% + mushroom 19.3%)	59.13±1.8 c	54.59±1.4 d

3.2 pH

The highest pH values were observed on the F1 raw burger patty, while the lowest pH value was obtained on the F4 raw burger patty. On the other hand, for cooked burger patty, the highest pH was presented on the F6, followed by the lowest attained on the control burger patty. There was a significant difference (p<0.05) observed in the F1of raw burger patty. For the cooked burger patty, the control, F1, F2, and F6 attained a significant difference (p<0.05). According to [11], raw oyster pH ranges from 6.10 to 6.37. The significant increase on the burger patty was caused by the basic properties of the extender protein reported by [15]. Besides, the lowest pH value obtained on the burger patties is due to both tropical fruit being unripe and still under the ripening stage, thus making the presence of citric acid and malic acid in the fruits moderately high at the earlier stage of maturation. Not only that, due to the reduction of free acid groups as the cooking temperature of plant-based meat patties increases [16]. However, the lowest pH obtained on the burger patty incorporated with plant-based sources implicated solubilization of hemicellulose and caused pectin breakdown when the acidity slightly increased [16].

Table 2: Th pH value of raw and cooked burger patties

Samples	pH	
	Raw	Cooked
Control (jackfruit 58%)	6.18±0.0 b	5.69±0.2 a
F1 (mushroom 58%)	7.13±0.4 a	5.98±0.0 ab
F2 (soursop 58%)	6.22±0.1 b	5.94±0.0 bc
F3 (mushroom 29%+soursop29%)	6.45±0.0 b	6.23±0.0 cd
F4 (mushroom 29%+jackfruit 29%)	6.10±0.0 b	5.91±0.0 cd
F5 (jackfruit 29% + soursop 29%)	6.17±0.0 b	5.78±0.0 cd
F6 (jackfruit 19.3% + soursop 19.3% + mushroom 19.3%)	6.40±0.0 b	6.27±0.0 d

3.3 Color

For the L* (lightness) observed on the raw burger patty, the F3 and F5 do not reveal a significant difference (p>0.05). This is because there is a portion of soursop added into the formulation for the F3 and F5, which maintain the degree of whiteness on the burger patty since unripe soursop has a hard and whitish pulp when it is young [17]. Simultaneously, a significant difference (p<0.05) was observed on the control, F1, F2, F4, and F6, respectively. The incorporation of mushroom and jackfruit has a greater effect on the L* (lightness) of the raw burger patty due to the presence of phenolic compounds on both. Apart from that, there were significant differences (p<0.05) on the a* (redness) of the F1, F2, and F5 raw burger patties compared to the control, while the F1 and F4 along with F3 and F6 burger patties did not show any significant differences (p>0.05) between the burger patties. In the red meat burger patty, a* (redness) obtained a higher value due to the presence of myoglobin protein on the red meat [18]. Thus, it elevates the intensity of the "redness" of the processed meat.

Meanwhile in this case, plant-based ingredients do not have the presence of myoglobin, but due to the presence of flavonoid properties, they could slightly affect the a* (redness) of the burger patty. Furthermore, where there were significant differences (p<0.05) obtained on the F3, F4, and F6 raw burger patties, b* (yellowness) intensity had the greatest impact and could be the reason for the incorporation of mushrooms, jackfruit, and soursop. Furthermore, the L* (lightness) on the cooked burger patty for the control, F2 and F6 showed no significant difference (p> 0.05), whereas the F1, F3, F4, and F5 showed significant differences (p< 0.05) on the vegetarian burger patty.

The frying time and temperature influence the burger patties made from soursop and jackfruit because they reduce the lightness index of the vegetarian burger patties. However, for the a* (redness) in burger patties for F3 and F5, there is no significant difference (p>0.05) compared to other burger patties. Although all formulations of burger patties obtained a significant difference on the b* (yellowness) index due to the frying factor, which the incorporated ingredients oxidized with unsaturated fats in the oil, this elevated the b* (yellowness) of the burger patties. In fact, due to the composition of other ingredients also influenced the b* (yellowness) in the burger patty.

Table 3: The color intensity (L*, a* and b*) value of raw and cooked burger patties

SAMPLES	COLOUR					
	Raw			Cooked		
	L*	a*	b*	L*	a*	b*
Control (jackfruit 58%)	57.76±0.01^{a}	3.43±0.01^{a}	33.63±0.06^{b}	32.17±0.55^{a}	9.55±0.39^{c}	35.08±0.41^{a}
F1 (Mushroom 58%)	57.22±1.18^{c}	4.37±0.05^{c}	30.71±0.60^{b}	26.98±1.55^{c}	16.65±0.83^{a}	23.23±0.22^{bc}
F2 (Soursop 58%)	67.18±0.20^{a}	0.83±0.01^{f}	31.43±0.39^{b}	32.17±0.55^{a}	9.55±0.39^{c}	21.21±0.36^{cd}
F3 (Mushroom 29%+soursop29)	61.45±0.66^{b}	3.77±0.04^{d}	26.75±2.01^{c}	34.40±0.30^{a}	10.07±0.47^{bc}	18.96±1.14^{e}
F4 (Mushroom 29%+jackfruit 29%)	53.50±1.64^{d}	9.88±0.20^{a}	31.75±0.58^{ab}	30.88±1.93^{b}	11.49±0.39^{b}	14.44±0.52^{f}
F5 (Jackfruit 29% + soursop 29%)	61.59±0.50^{b}	5.21±0.06^{b}	29.92±0.37^{b}	34.58±1.22^{a}	10.93±0.58^{bc}	23.41±0.75^{b}
F6 (Jackfruit 19.3% + soursop 19.3% + mushroom 19.3%)	58.87±0.30^{c}	3.81±0.02^{d}	26.97±0.50^{c}	32.17±1.50^{a}	11.52±1.16^{b}	19.78±1.24^{de}

3.4 Texture

3.4.1 Hardness

Figure 1 depicted the hardness of various vegetarian burger patties formulations. The lowest hardness value obtained was on the control sample for raw burger patties and cooked F3 burger patties, respectively. Meanwhile, the highest hardness was observed on the F3 raw burger patty and the F1 cooked burger patty. Overall, there was no significant difference (p>0.05) between the control and formulated burger patties. Therefore, the analysis of variance results reveals that the ratio of raw material processing does not affect the characteristics of the developed burger patties and due to ice crystal development causes cell walls (or membranes) to rupture. Thus, cells are partially or totally drained of their liquid content upon thawing, resulting in drip loss which results in no effect on the texture [19] [20].

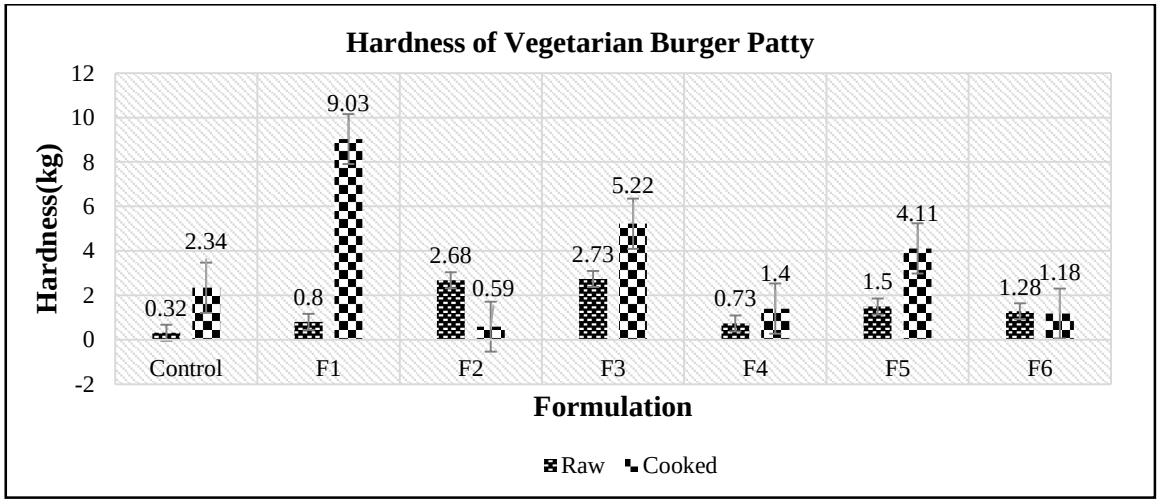

Figure 1: The texture parameter (hardness) obtained on the raw and cooked vegetarian burger patty

3.4.2 Cohesiveness

Figure 2 illustrated the cohesiveness parameter that was observed on the burger patty surface of a different formulation. The greater cohesiveness observed in the control sample for both raw and cooked burger patties. Not only that, but the F5 burger patty had the lowest cohesiveness, as did the raw and cooked burger patties. Overall, there was no significant difference (p>0.05) between the control and formulated vegetarian burger patties. The plant-based ingredients' incorporation had no effect on the cohesiveness of the burger patty.

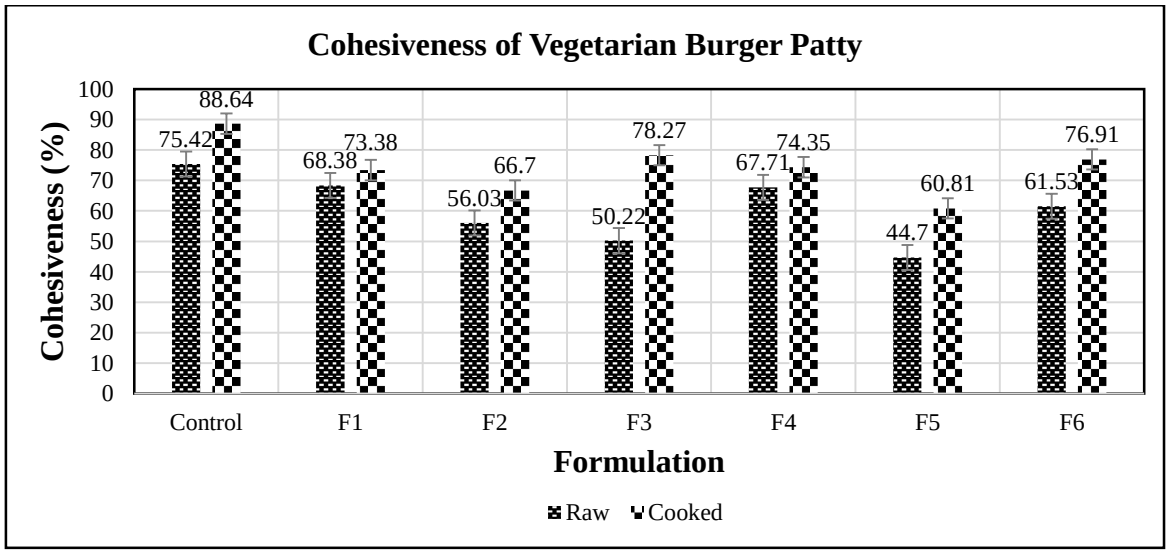

Figure 2: The texture parameter (cohesiveness) obtained on the raw and cooked vegetarian burger patty

3.5 Cooking loss

The greater cooking loss was observed on the F6, whereas F5 has the lowest cooking loss among the other formulated burger patty. The cooking loss is mainly caused by the decrease in water and fat. It clearly seen that no significant difference (p>0.05) on the control, F1 and F4 burger patties sample. Furthermore, there were significant difference (p<0.05) obtained on the formulated burger patty from F2, F3, F5 and F6. Therefore, the meat-analogue based burger patty has affected the cooking loss in the vegetarian burger patty. Protein denaturation, matrix disintegration, heat shock-induced fast protein degradation, and large-scale water and fat liberalization were the main causes of cooking loss in the burger patty [21].

Table 4: The cooking loss observed on the formulated burger patty

SAMPLES	Cooking loss
	Cooked
Control (jackfruit 58%)	28.13±0.3[c]
F1 (mushroom 58%)	27.82±0.12[c]
F2 (soursop 58%)	26.16±0.57[d]
F3 (mushroom 29%+soursop29%)	29.18±0.61[b]
F4 (mushroom 29%+jackfruit 29%)	27.73±0.08[c]
F5 (jackfruit 29% + soursop 29%)	17.80±0.20[e]
F6 (jackfruit 19.3% + soursop 19.3% + mushroom 19.3%)	33.97±0.08[a]

3.6 Sensory Evaluation

Figure 3 illustrates the spider web evaluation of the vegetarian burger patties' 7 formulation sensory attributes (appearance, taste, texture, aroma, and overall acceptability) based on the responses of 30 panelists.

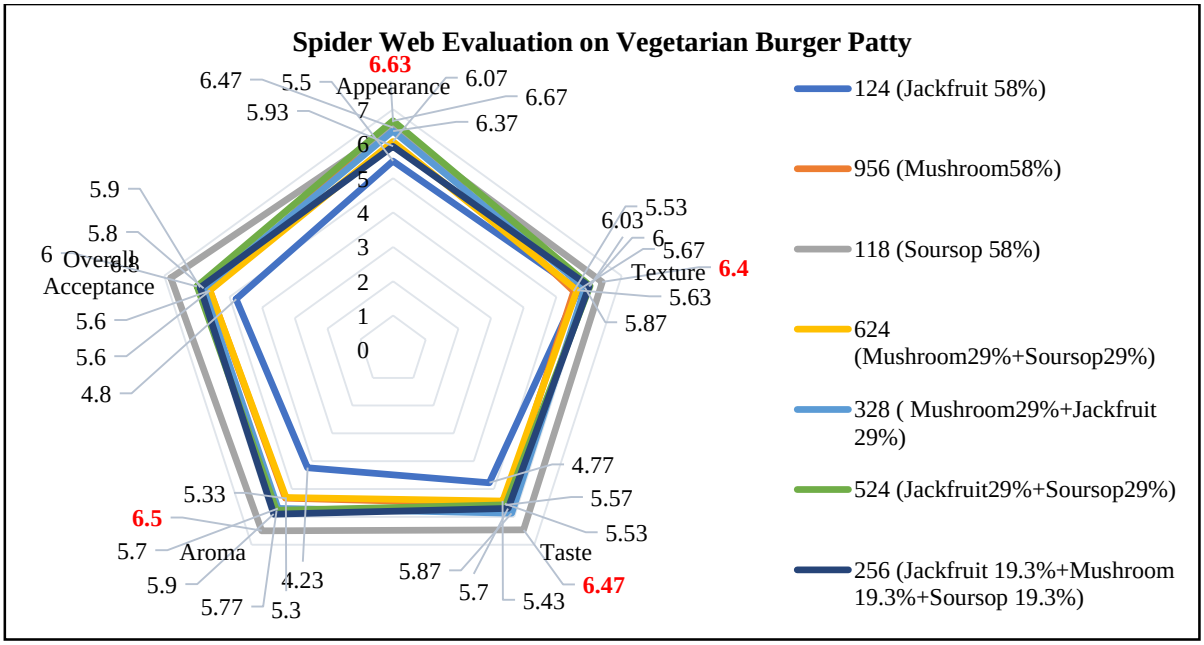

Figure 3: The sensory evaluation of vegetarian burger patty of different formulation

Based on the spider web the sensory evaluation of vegetarian burger patty in different formulation attributes namely appearance, taste, texture, aroma, and overall acceptability was measured, and observed it has significant different (p<0.05) on the attributes. The spider web result depicted that, the soursop 58% sensory attributes for appearance, texture, taste, aroma, and overall acceptance has attained significant reduction (p<0.05) compared to another formulated burger patty. This also means that the research objective of this study has been achieved successfully on determining the sensory acceptability of burger patty developed from soursop. The appearance, texture, taste, aroma, and overall acceptance for the vegetarian burger patty developed from 58% soursop attained scores in the range of 6-8, that indicate the soursop burger patty was palatable and extremely liked by the panelists.

4. Conclusion

In this study, the incorporation of unripe soursop with plant-based ingredients as a meat analogue was intended to produce a nutritious burger patty with low cholesterol as it does not contain animal fat. The substitution of soursop in the burger patty has attained slightly high acceptability. Thus, the objective of this research study, which was to formulate a plant-based burger patty using unripe soursop and oyster mushroom, was achieved successfully. Therefore, findings revealed that the soursop is convenient to be used in the development of plant-based foods especially as the meat-analogues substitution without affecting the pH; 5.94, color intensity (a*, redness; 9.55 and b*yellowness; 21.21), cooking loss; 26.16 and sensory attributes on overall acceptability; 6.8 which was attained as the highest score compared to other formulation. Hence, based on the study, can conclude that the substitution of unripe soursop effectively replaced as meat substitution in the vegetarian burger patty. The recommendation may apply for future studies where physiochemical studies can be conducted on the vegetarian burger patty to analyze and evaluate its nutritional composition.

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