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Impact of post-conversion chicken meat combination of active muscle and passive muscle and its effect on chicken sausage quality

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Abstract
This research aims to examine the combination formulation of chicken meat from the conversion of active muscle and passive muscle to improve the quality of chicken sausage. This research was conducted for 1 month at the Animal Products Technology Laboratory, Faculty of Animal Husbandry, Udayana University. The sausage making will be carried out at Bumdes Pempatan, Rendang Karangasem District, Bali. The experimental design used was a Completely Randomized Design (CRD) with four treatments and four replications. The four treatments are A (sausage formulation with the amount of meat from active muscle 3:0 and passive muscle), B (active muscle 2:1 passive muscle), C (active muscle 1:2 passive muscle), D (active muscle 0: 3 passive muscles). The variables observed were physicochemical quality, color evaluation, texture profile, SEM (Scanning Electron Microscopy), and organoleptic value. The research results showed that treatment B showed results that significantly reduced ($P<0.05$) water holding capacity and water content, showed results that significantly increased ($P<0.05$) the springiness and cohesiveness values. The combination formulation of treatments B and C showed no significant results ($P>0.05$) on organoleptic values. It can be concluded that the combination formulation of sausages with treatment B (active muscle 2:1 passive muscle) improves the quality of chicken sausages.

Keywords: Chicken sausage, active passive muscle, color evaluation, texture profile, organoleptic, SEM

Introduction
Sausage is a food product produced by livestock and is a product resulting from restructuring of meat and its characteristics are rich in protein and this sausage product is very popular in the world. Meat restructuring is one of the processing technologies used to improve the quality of processed meat (Miwada *et al*., 2010) [13]. In the process of restructuring meat into sausage products, especially chicken sausage, several problems were found, especially related to the use of chicken meat as the main component in chicken sausage. Characteristics of chicken meat after rigormortis, its quality is determined by the characteristics of the meat before the conversion of muscle into meat. In this process, the properties of the muscle meat (chest meat-passive muscle and thigh meat-active muscle) are the physical or chemical basis for determining the quality of processed meat (Listrat *et al*., 2016) [11]. Active muscles before their conversion into meat have a higher proportion of muscle fibers than passive muscles (Choe *et al*., 2008) [2]. The characteristics of active muscles and passive muscles will be related to the tenderness of meat and processed products (Lee *et al*., 2012) [7]. Various research studies have been developed to improve the quality of sausages, such as fat reduction or fat replacement treatments, reducing agents or nitrite replacement (Kang *et al*., 2014; Lee *et al*., 2015; Lim *et al*., 2017; Han and Bertram, 2017; Yoo and Kim, 2017; Lim and Chin, 2018) [5, 8, 9, 4, 10]. To our knowledge, there is no study regarding the use of chicken meat from active and passive muscles in the formulation of chicken sausage dough, so this research was carried out. Meanwhile, it is known that chicken meat and processed products have several advantages, including low fat, low cholesterol and high nutritional value (Choi *et al*., 2011) [3]. This research was conducted to examine the potential of active and passive muscles in chicken meat in sausage-making formulations. Indicators for assessing the quality of chicken sausage from active muscles and passive muscles include color quantity tests, texture profiles, microstructure and organoleptic values.

Materials and Methods

The main ingredients for the research was chicken breast and thigh fillets (a reflection of active and passive muscles) obtained from slaughterhouses, salt, garlic, pepper, chicken powder, modified starch, isoprotein enzymes, STTP, ice cubes. Chicken sausage treatment includes: A (Sausage formulation with 3:0 amount of meat from active muscle and passive muscle), B: (2:1 amount of meat from active muscle and passive muscle), C: (1:2 amount of meat from active muscle and passive muscles), D: (Sausage formulation with the amount of meat from active muscles and passive muscles 0:3). Each treatment used 4 repetitions.

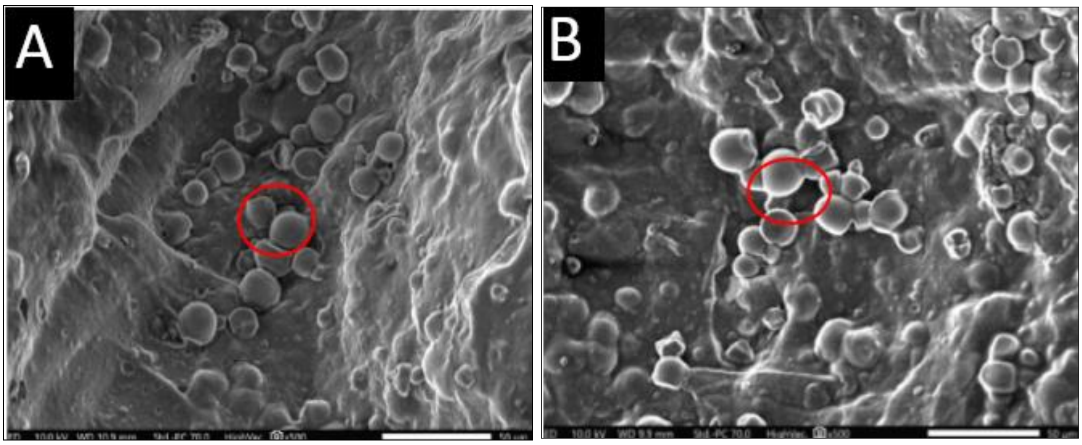
Results

The results of the statistical analysis of lightness (L*) of chicken sausage with a combination formulation of chicken meat from active muscle and passive muscle according to table 1, show that treatment B (29.39) is significant compared to D (32.85). Treatment C (30.61) is significant compared to D (32.85). The results of this study state that the effect of a combination of active and passive muscle meat from treatments B and C reduces the L* value from treatment D. The results of statistical analysis of redness (a*) of chicken sausages with a combination formulation of chicken meat from active muscle and passive muscle according to table 1, show that in treatment B (1.79) is non-significant with A (2.60) and D (1.48). Treatment C (1.78) is non-significant with A (2.60) and D (1.48). The combination of active and passive muscle does not affect the a* value. The results of statistical analysis of yellowness (b*) of chicken sausages with a combination formulation of chicken meat from active muscle and passive muscle according to table 1, show that treatment B (12.34) is significant compared to D (12.07). Treatment C (11.84) is significant with D (12.07). The combination of active and passive muscle meat influences the yellowish color of treatment D (chest).

Based on the results of statistical analysis of the hardness of chicken sausages with a combination formulation of chicken meat from active muscle and passive muscle in table 2, it shows that in all treatments A (5907.689), B (6797.035), C (7271.08) and D (5780.461) non-significant. The results of statistical analysis of the springiness of chicken sausages with a combination of chicken meat formulation from active muscle and passive muscle in table 2, show that in treatment B (0.89) it is significant with A (0.85) and D (0.83). Treatment C (0.88) is significant with A (0.85) and D (0.83). The results of the statistical analysis of the adhesiveness of chicken sausages with a combination of chicken meat formulations from active muscles and passive muscles, table 2, show that in all treatments A (-40.71), B (-29.32), C (-26.36) and D (-26.36) is non-significant. The results of the statistical analysis of cohesiveness of chicken sausages with a combination formulation of chicken meat from active muscles and passive muscles, Table 2, shows that treatment B (0.64) is significant compared to A (0.60) and D (0.55). Treatment C (0.62) is significant with A (0.60) and D (0.55). The results of this study show the gumminess value of chicken sausage with a combination formulation of chicken meat from active muscle and passive muscle in table 2, treatments A (3559.62), B (4346.34), C (4546.04), and D (3190, 36) which is non-significant. The results of the statistical analysis of the chewiness of chicken sausage with a combination of chicken meat formulation from active muscle and passive muscle, table 2, shows that treatment C (4044.47) is significant with A (3071.24), B (3896.57), and D (2674). .34).

The results of this study show the organoleptic value of color in chicken sausages with a combination formulation of chicken meat from active muscle and passive muscle in table 3, treatments A (3.67), B (3.53), C (2.93), and D (3.53) is not significantly different (P>0.05), namely non-significant. The organoleptic value of aroma in chicken sausage with a combination formulation of chicken meat from active muscle and passive muscle in treatments A (2.67), B (3.06), C (3.53), and D (3.6) is non-significant. The organoleptic value of taste in chicken sausages with a combination formulation of chicken meat from active muscle and passive muscle in treatments A (3.67), B (3.67), C (3.6), and D (3.73) is non-significant. The organoleptic value of texture in chicken sausages with a combination formulation of chicken meat from active muscle and passive muscle in treatments A (3.8), B (3.06), C (3.73), and D (3.46) is non-significant.

The overall acceptability organoleptic value of chicken sausage with a combination formulation of chicken meat from active muscle and passive muscle in treatments A (2.93), B (3.26), C (3.93), and D (3.46) was not significantly different. (p>0.05), namely non-significant.



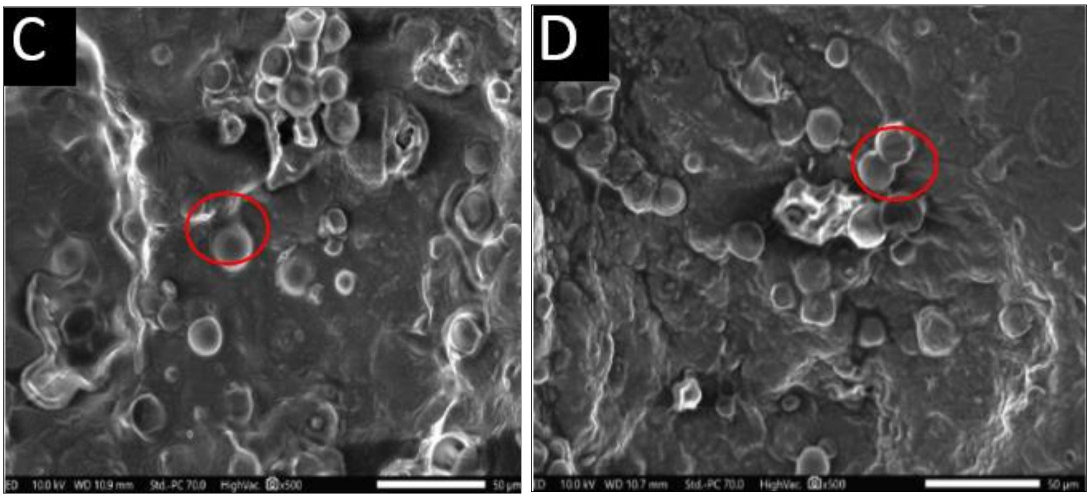


Fig 1: (Scanning electron microscopy (SEM) results of sausages; A (Thigh), B (Thigh 2:1), C (Thigh 1:2), D (Chest).)

Table 1: (Average color value (quantitative) of chicken sausages resulting from dough formulation from the use of a combination of active muscle-meat and passive muscle-meat)

Variable	Treatment			
	A	B	C	D
L*	30,61±0,96[a]	29,39±0,88[a]	30,61±0,57[a]	32,85±0,67[b]
a*	2,60±0,96[b]	1,79±0,18[ab]	1,78±0,46[ab]	1,48±0,31[a]
b*	11,88±0,11[a]	12,34±0,67[a]	11,84±0,36[a]	12,07±0,48[b]

Table 2: (The average value of the texture profile of chicken sausages is the result of dough formulation from the use of a combination of active muscle-meat and passive muscle-meat)

Variable		Treatment			
		A	B	C	D
Hardness	(N)	5907,689±1646,44[a]	6797,035±875,70[a]	7271,087±1623,66[a]	5780,461±1625,10[a]
Springiness	(%)	0,85±0,01[a]	0,89±0,1[b]	0,88±0,03[b]	0,83±0,03[a]
Adhesiveness	(N. sec)	-40,71±17,59[a]	-29,32±22,10[a]	-26.36±12,06[a]	-26.36±10,75[a]
Cohesiveness	(%)	0,60±0,03[a]	0,64±0,02[b]	0,62±0,04[b]	0,55±0,01[a]
Gumminess	(N)	3559,62±1019,96[a]	4346,34±527,65[a]	4546,04±1054,14[a]	3190,36±951,06[a]
Chewiness	(N)	3071,24±804,08[a]	3896,57±408,69[a]	4044,47±996,28[b]	2674,34±869,87[a]

Table 3: (The average organoleptic value of chicken sausage is the result of dough formulation from the use of a combination of active muscle-meat and passive muscle-meat)

Variable	Treatment			
	A	B	C	D
Colour	3,67±0,81[a]	3,53±0,83[a]	2,93±0,0,96[a]	3,53±0,99[a]
Aroma	2.67±1,29[a]	3,06±1,1[a]	3,53±0,83[a]	3,6±0,98[a]
Flavor	3,67±0,73[a]	3,06±1,03[a]	3,6±0,73[a]	3,73±0,7[a]
Texture	3,8±0,94[a]	3,06±1,09[a]	3,73±0,7[a]	3,46±0,83[a]
Overall Acceptance	2,93±1,16[a]	3,26±1,03[a]	3,93±0,7[a]	3,46±1,12[a]

Discussion

A decrease in the L* value indicates a change in meat pigment (Rahayu *et al*., 2012) [16]. The results of this research state that the effect of a combination of active and passive muscle meat in treatments B and C reduces the L* value of treatment D. The low fat content in the sample can be the main cause of the lighter color of the product (Alaei *et al*., 2018) [1]. By combining meat from active and passive muscles, the L* value in treatments B and C decreased significantly. If the L* value decreases, it can be said that the product color is going towards dark. According to Sriyani *et al*. (2015) [20] the main determining factor that influences meat color is the concentration of meat muscle pigment, namely myoglobin. The combination of active and passive muscle meat (B and C) does not affect the a* value. Low a* values in samples are associated with myoglobin oxidation, metmyoglobin formation, and lipid oxidation in meat products (Shah *et al*., 2015) [18]. Krishnan *et al.* (2014) [6] reported the possibility of pigment oxidation which catalyzes lipid oxidation and produces free radicals which may oxidize iron atoms and change the properties of the myoglobin molecule which can cause a decrease in meat color. This is in line with the opinion of Suman and Joseph (2013) [21] that the pigment that determines meat color is myoglobin. The combination of active and passive muscle meat influences the yellowish color of treatment D (chest). The effect of adding thigh meat makes the color difference become darker. This is because the thigh meat has a higher amount of fat (Rusdiansyah *et al*., 2021) [17]. Fibers in meat muscle can influence the color of meat products because of their varied colors and the presence of pigments (Yadav *et al*., 2018) [22].

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The hardness of chicken sausage from a combination formulation of chicken meat from active muscle and passive muscle in this study did not provide significant results. The nature of active and passive muscles when combined has not been able to influence the hardness value of sausages. Soglia *et al*. (2016) [19] also stated that the myofibrillar content decreases and the connective tissue deposition increases along with the increase in muscle toughness, especially in the chest area. Active and passive muscles can act as binding and tenderizing agents which can form the hardness texture of meat. Elasticity or springiness, reversibility after sample pressing treatment and chewability of meat samples (Miwada *et al*., 2022) [14]. The raw material for making sausages from broiler chickens taken from a combination formulation of active and passive muscles is thought to have different characteristics due to different muscle positions. This causes the springiness values in treatments B and C to increase significantly. The combination of active and passive muscles influences the springiness value in this study. The springiness of chicken sausages is increasing due to the combination of active and passive muscle meat, this means that the elasticity of chicken sausages is increasing, and the ease of chewing will increase (Prijambodo *et al*., 2017) [15]. Sausage adhesiveness is determined by the starch-protein matrix and the water content of the sausage. chicken. With lower starch gelatinization, free water will increase, but the starch and sausage protein matrix can retain free water between the matrix by disulfide bonds. This means that there is no force that pushes upward pressure in each treatment (Prijambodo *et al*., 2017) [15], this is thought to be the reason why the adhesiveness value is not significantly different. The combination of active and passive muscle meat provides a difference from the control treatment, regarding cohesiveness or what can be called cohesiveness. The ability to spread and increase the length of meat muscle before forming a texture is known as cohesiveness (Miwada *et al*., 2022) [14]. Fat in muscle has high elasticity, resulting in the formation of a strong structure to preserve the substances present in sausage formulations (Liu *et al*., 2021) [12]. The main reason for this result can be attributed to the creation of an HLB (lipophilic hydrophilic balance) system where proteins in meat, it practically acts as an emulsifier (Alaei *et al*., 2018) [1]. The high and low gumminess value indicates that the sausage is easier to destroy when chewed. The combination of active and passive muscle meat did not affect the gumminess value. The contents of muscle meat, especially starch and protein, fill the empty spaces in the sausage protein matrix, so that the matrix structure will be tighter and less easily destroyed when chewed. The combination formulation in treatment C has water binding, fat emulsifying, and gel stabilizing properties, which helps in improving the texture parameters of meat products (Zhu *et al*., 2018) [23]. This is in accordance with the results of this study where the chewiness value in treatment C produced a significant difference between all treatments. According to research by Bae *et al*. (2018), if sausages are made by adding different parts of meat, the larger the size of the meat particles, the more difficult it is to distribute evenly in the emulsified sausage so as to increase the chewiness value.

Scanning Electron Microscopy (SEM) on sausages was carried out to determine the comparison between the microstructure of the best treatment product and the control treatment. In the results that can be seen after SEM (Figure 1), there is a microstructure of the surface of the sausage emulsion in 4 treatments including active muscle, combination and passive muscle. After observing the surface structure of the sausage, the different combinations of treatments with different meat protein structure properties for each treatment did not show differences in the results of the microscopic observation images. From microscopic observation, the distribution of the emulsion from the combination of active and passive muscles was even, this indicates the stability of the emulsion in the sausage.

The Kruskall-Wallis test results in Table 3 show that the comparison of chicken meat sausages with different combination formulations is not significantly different in the panelists' color preferences. Likewise for aroma, taste, texture and overall acceptability. This combination did not statistically influence the panelists' assessments.

Conclusion

Based on the research results, it can be concluded that the combination formulation of sausages with treatment B (Thigh 2:1 Breast) and C (Thigh 1:2 Breast) increases the color evaluation value of chicken sausages, showing the best results (L* and b*). The combination formulation of sausages with treatment B (Thigh 2:1 Breast) and C (Thigh 1:2 Breast) increases the texture profile value of chicken sausages showing the best results (springiness, cohesiveness, chewiness).

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