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The Relationship of Quality Characteristics of Fried Red Onions with the Chemical Compositions of Red Onion Bulbs of Palu Valley Variety

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Abstract: *The purpose of this study is to investigate the relationship of quality characteristics of fried red onion with the chemical compositions of red onion bulbs of Palu Valley variety. The result shows that the red onions of Palu Valley variety which were harvested from different planting locations significantly affect bulbs chemical compositions. Bulbs productivity, carbohydrate, protein, mineral, calcium, the total solute, and the highest dry weight are found in bulbs harvested from Guntarano planting location. The quality characteristics of fried red onions increase along with the increasing level of bulbs chemical components such as total of soluble solids, calcium, protein, minerals, sulfur and carbohydrates, but decrease with the increasing water and fat content.*
Keywords: *Onions, Leaf Nutrient Content, Bulbs Chemical compositions, Quality characteristics*

I. Introduction

Onion is one of the important herbs used for food seasoning or flavor. Instant Fried Onion (FO) which is commonly called “Palu Fried Onion” is one of the processed red onions (RO) which is well known from Palu Valley Variety (PVV). In the region of Palu Valley (Central Sulawesi), there are 36 industries processing FO with 21 planting locations, five of which is for red onions planted on an ongoing basis. Palu fried onion has a solid texture, tastes delicious and has distinctive aroma which is favored by the community thus makes it categorized as a leading commodity of Central Sulawesi.

The productivity and chemical compositions of red onions bulbs are influenced by variety, soil fertility, growing environment and cultivation technology input [1] [2] [3] [4] [5] [6]. The characteristics of fried food quality (the physical-chemical and sensory characteristics) are largely determined by the quality of its raw material (water content, protein, and starch), the size of the materials, additives, coating and dough composition, processing variables like frying time and temperature, oil type, frequency of oil use and oil content reduction [7] [8] [9] [10] [11]. Previous researchers have reported that there is a linear correlation between the quality characteristics of potato chips [9] [12] and tortilla chips [13] with the chemical compositions of its raw material. A research on Palu Fried Onions has never been done. This research aims at investigating the quality characteristics of fried onions with the chemical compositions of red onion bulbs of PVV harvested from five planting locations

II. Materials And Methods

Material

Red onions of PVV were taken from five planting locations in the village of Bulupontu Jaya, Oloboju, Soulowe, Maku of Sigibiromaru regency, and village of Guntarano of Donggala regency, Central Sulawesi Province.

Methods

Onion bulbs were harvested in each planting location of each village. In each planting location, there is a sample plot of 1 m x 1 m. Red Onions (RO) growing in that plot pad were harvested and weighed. Bulbs were separated from the leaves and roots then they were weighed again. The data obtained were used to determine the land productivity. In order to analyze leaf nutrient content and bulbs chemical compositions, the bulbs samples were processed into fried onions. In frying steps, bulb sliced fryed using Bimoli special brand cooking oil with the ratio of 1 : 5 (b/v) in frying temperature of 160 - 180ºC. Frying were done about fifteen minute and in the end of the frying bulb was air dryed at room temperature.

Chemical and Physical Analysis

Leaf nutrient contents (C, N, P, K, Ca, Mg and S) were determined with a standard procedure [14]. Leaf samples were dried in an oven at 70 ° C for 2-3 hours, then blended and sieved with a fineness of 0.5 mm. Carbon in the sample was extracted using a sulfuric acid solvent and potassium dichromate; N was oxidized with concentrated sulfuric acid using generating color of blue indophenol; P, K, Ca, Mg and S in the sample were extracted with solvent extraction of Morgan Wolf (Sodium Acetate pH 4.8). The uptake extract of C, N, P and S was measured with Spectral-photometer UV-VIS (HITACHI U-1100 Spectrophotometer) at wavelengths of 561, 636, 693 and 432 nm respectively, Ca and Mg by AAS (PG 990 BUCHI AAS) and K with Flame-photometer.

The bulb dry weight was determined by drying method in the temperature of 75 ± 5^oC so that the sample reached constant weight; the ash level was determined by heating 0.5 g of test sample in an oven at temperature of 105 ° C to constant weight; ash content determined by heating 0.5 g of the test sample in an oven with a temperature of 550 ^0C until it became white and gray; protein with macro-Kjeldahl method; fat with Soxhlet technique using ether petroleum eter solvent and carbohydrate was obtained using a procedure described by AOAC methods [15].

Calcium and sulfur in bulb samples were determined by the a standard methods [14]. Free fatty acid (FFA) was determined by the titration methods using ethanol-dietyl ether (1:1 v/v) and 0.1 N NaOH [16]. The total of soluble solids (TSS) is determined by squeezing the bulb tissues and putting one drop of supernatant in each sample in a refractometer (refractometer Atago H-50, Japan) [17]. Fried onions fragility was measured by LLOYD instruments LR50.

The Evaluation Of Sensory Characteristics

Fried Onions (FO) sensory characteristics were tested by inviting respondent to test aromatic, flavor, crispness and the overall characteristics of fried onions following standard methods [18]. In this test, onion flavor was tested to 30 people aged 25-50 years with approximate number of 40% men and 60% women.

Statistical Analysis

The data obtained were analyzed statistically by analysis of variance (ANOVA) using a randomized group design. If it showed significant effect, it was followed by Tukey-HSD test [19]. The degree of correlation (r) between the independent variables and dependent variables was analyzed by correlation analysis of Pearson Product Moment [20].

III. Result And Discussion

Leaf Nutrient Content

The effect of fertilization on the parameters of growth and red onions production can be seen through the analysis of its leaf or bulb nutrient content. Some previous researchers claims that there is a positive linier relationship between increased productivity, fresh weight and bulb diameter with the increasing content of N,P and K in red onion leaf of Giza 20 variety [21] [22] [23] [24] the highest nutrient content of red onions respectively harvested from planting locations of Guntarano>Oloboju>Bulupontu Jaya> Maku > Soulowe. This indicates that the input of RO cultivation technology applied by farmers in planting location of Guntarano is better compared to the other locations. The nutrient content of this research is shown in Table 1. The research showing to Oloboju, Bulupontu Jaya, Maku and Soulowe, thus it gains higher productivity and bulb dry weight (Table 1 and 2).

Bulb Chemical Compositions

Bulb chemical compositions observed in this research including water content, carbohydrate, fat, protein, mineral, calcium, sulfur, TSS and bulb dry weight are significantly affected by the difference of original location of the harvested bulb (Table 2).

Table 1.The Leaf Nutrient Content and Red onion Bulb Productivity of Palu Valley Variety Harvested in Five Planting Locations

Planting Location	C (%)	N (%)	P (mg g-1)	K (mg g^{-1})	Ca (mg g^{-1})	Mg (mg g^{-1})	S (%)	Productivity (t ha $^{-1}$)
Bulupontu Jaya	37,50	3,09	2,12	24,88	21,99	3,26	0,23	6,44
Soulowe	36,00	2,56	1,78	14,72	18,69	3,56	0,14	5,49
Guntarano	39,33	3,45	2,23	26,54	25,67	5,52	0,26	7,59
Maku	38,82	2,86	2,16	20,67	21,69	4,40	0,21	6,06
Oloboju	39,54	2,95	2,13	24,20	20,40	4,92	0,20	6,82

Table2. The Chemical compositions of Red Onion Bulb of Palu Valley Variety Harvested in Five Planting Locations

Planting Location	Bulb Chemical compositions								
	Water (%BS)	Carbohydrate (% BS)	Fat (%BS)	Protein (%BS)	Mineral (%BS)	Calcium (mg 100 g $^{-1}$ BS)	Sulfur (mg 100 g $^{-1}$ BS)	**TSS** (% Brix)	Bulb dry weight (g $^{-column}$
Bulupontu Jaya	86,43±1,27^{b}	9,13±1,26^{ab}	0,87±0,15^{ab}	2,34±0,19^{c}	1,22±0,12^{b}	34,00±2,07^{b}	35,28±0,92^{b}	19,63±1,06^{c}	4.74±0,36^{b}
Soulowe	89,26±0,68^{c}	8,24±0,70^{a}	0,73±0,02^{a}	0,91±0,09^{a}	0,86±0,06^{a}	27,73±1,87^{a}	21,98±3,96^{a}	15,93±0,21^{a}	3.04±0,14^{a}
Guntarano	83,61±1,10^{a}	11,61±0,46^{d}	1,01±0,05^{b}	2,45±0,25^{c}	1,57±0,23^{c}	37,38±2,20^{b}	34,48±3,16^{b}	19,88±1,58^{c}	7.62±0,50^{d}
Maku	86,06±0,66^{b}	10,44±0,49^{cd}	0,86±0,02^{ab}	1,28±0,12^{ab}	1,37±0,24^{bc}	32,17±4,46^{ab}	34,41±2,84^{b}	18,62±0,83^{bc}	5.53±0,72^{b}
Oloboju	85,81±0,31^{b}	10,04±0,30^{bc}	1,29±0,07^{c}	1,68±0,20^{b}	1,18±0,06^{b}	32,15±2,96^{ab}	35,23±1,64^{b}	16,74±1,61^{ab}	6.51±0,52^{c}

The number followed by a letter at the same column is not significantly different with 0,05 HSD test.

Water

The water content of RO bulb of PVV increases linearly when the leaf nutrient content decreases (Table 3). The data in Table 1 show that the lowest leaf nutrient content is found out in red onions harvested in plant location of Soulowe which has higher water content on its bulb compared to other planting locations (Table 2). On the other hand, the increase of bulb water content will cause a decrease in its bulb dry weight (r = -0.97 **). It is similar to the research finding by Nabi et al. (2010) which claims that the texture and dried weight of red onion bulb of Swat-1 variety decreases along with the increasing water content of its bulbs [25]. This suggests that the synthesis of dry materials compounds such as carbohydrate, fat, protein and other organic compounds in bulbs decreases if the uptake or leaf nutrient content is low. On the other hand, the water required for the synthesis reaction of the compound above is not utilized optimally so that the presence of water remains high in the bulbs. Levels of nutrients in the soils is one of the factors causing lower nutrient content. The water content of potato bulbs is in the range of 68.8% at a dose of NPK (140: 140: 210) kg ha-1 increases to 81.4 % when the dose is lowered to NPK (60:60:90) kg ha-1[26].

Carbohydrate

The nutrients which significantly contribute in increasing the bulb carbohydrate levels respectively are Mg> C> Ca = P> S> N (Table 3). These nutrients have a role in photosynthesis: Mg and N serve as the main components of chlorophyll molecules, S assists in the formation of chlorophyll, Ca serves as a translocation of carbohydrate, Storage and ADP and ATP energy transfer in photosynthesis and respiration [27]. Five out of these six nutrients, namely Mg, S, Ca, N and P, are found to reach their highest levels by Red Onion (RO) leaves harvested from Guntarano planting location (Table 1) which serve to provide a better contribution to the rate of carbohydrate metabolism. This causes the level of carbohydrate of red onion bulb in Guntarano planting location higher than other planting locations (Table 2).

Fat

Nutrient C has the highest contribution in increasing bulb fat content (Table 3). This is because C has a role as a constituent of fatty acid [28]. Most of sugar from photosynthesis will be oxidated to produce glycerol which then condenses with fatty acid to produce fat. The highest nutrient C is found in red onion leaves harvested from Oloboju planting location (Table 1) thus providing higher bulb fat content compared to other planting locations (Table 2).

Protein

The increase of bulb protein level is significantly affected by increasing level of N, K and S (Table 3). Nitrogen serves as a component of proteins, K involves in protein synthesis, S is a component of cysteine and methionine amino acids [29]. Therefore, N, K and S directly affect the amount and quality of protein produced. The highest nutrient level of N, K, and S are found in red onion leaves harvested from Guntarano planting location (Table 1) thus providing significant higher bulb protein content compared to Soulowe, Maku and Oloboju (Table 2).

Mineral

Mineral serves as an activator in a variety of metabolic reactions in a plant [30]. Potassium plays a role in the translocation of carbohydrate, protein synthesis, and enzyme activator; Fe serves as chlorophyll synthesis and electrons transfer, Zn is involved in enzyme system that regulates various metabolic activities [27] [28]. Referring to the above description, it can be stated that if the result of metabolism increases, thus it also increases its activator (mineral content).This is observed from the result of correlation analysis showing a linear relationship between the levels of carbohydrate and protein with red onion bulb mineral content (r = 0.95 **; r = 0.69). The highest levels of carbohydrate and protein are found in the Red Onion (RO) bulb of PVV harvested from Guntarano planting locating thus causes higher mineral content compared to other planting locations (Table 2).

Calcium

Calcium plays an important role in the formation of the cell wall strength, enzyme activator system in some protein synthesis, carbohydrate transfer and helps in the absorption of nitrogen [27]. Therefore, calcium will directly contribute to the formation of bulb carbohydrates and proteins. The result of correlation analysis shows that the bulb calcium significantly increases along with the increase of bulb carbohydrate, protein, and mineral (r = 0.83 *; r = 0.92 *; r = 0.92 *). Referring to the result of the correlation analysis, it can be stated that higher level of carbohydrate, protein, and mineral will cause higher calcium level of red onion bulb of PVV which is found in Guntarano planting location (Table 2).

Sulfur

The highest nutrients of C,P,K and S are found in Red Onion (RO) leaf which is harvested from planting locations at Bulupontu Jaya, Guntarano, Maku and Oloboju than Soulowe (Table 1. These four nutrients give significant to very significant contributions in increasing the bulb sulfur content (Table 3). The high sulfur content of bulb harvested from those four locations is affected by higher nutrients of C, P, K and in those area (Table 2). Sulfur plays an important role in synthesizing amino acid used to produce protein. In addition, sulfur is also needed to produce chlorophyll, utilize phosphorus and other essential nutrients synthesis [27] [28] [29]. Therefore sulfur will directly affect the levels of protein produced, including carbohydrates and other organic compounds in RO bulb. This is observed from the result of correlation analysis showing a linier relationship between increasing levels of proteins and carbohydrates along with increasing level of sulfur found in red onions bulbs (r=0.70; r=0.68).

The Total Of Soluble Solids

The total solute is all organic and inorganic substances in the cell fluid produced during the metabolism of plants including mineral that acts as its activator. Scholars point out that there is a linear relationship between the levels of the protein, N, P, K, Fe, Mn, Zn, Cu, Fe of Red Onion (RO) bulb of cv. Giza 20 variety with TSS [22] [24]. TSS of Red onion (RO) of Red Rey variety increases along with the increasing levels of pyruvic acid [31]. Pyruvic acid level is very noticeable in increasing the total compound of S-alk (en) yl-Lcysteine-sulfoxides (ACSOs) and TSS of Red Onion (RO) of Super Star F1 variety [32]. This is in line with the findings of this study which show a linear relationship between increasing levels of protein, minerals and calcium with increased levels of TSS (r = 0.82 *; r = 0.83 *; r = 0.88 *). Therefore, the highest level TSS of Red Onions (RO) is from Guntarano because the levels of protein, minerals and calcium of the bulb is also high (table 2). The total solute increases too because of the increase of leaf nutrient content (Table 3). Similarly, the total leaf nutrient content of N, P and K significantly increases the TSS of Red Onion (RO) bulb of cv. Giza 20 variety [21] [24].

Table 3. The Correlation (r) of Leaf Nutrient Content with Productivity and Chemical Compositions of Red Onion bulb of Palu Valley Variety

Leaf Nutrient content	Productivity	Water	Carbohydrate	Fat	Protein	Mineral	Calcium	Sulfur	**TSS**
C	0,84*	-0,87*	0,87*	0,80	0,47	0,83*	0,69	0,83*	0,40
N	0,72	-0,93*	0,81*	0,40	0,93**	0,88*	0,99**	0,71	0,83*
P	0,71	-0,94**	0,86*	0,55	0,73	0,94**	0,89*	0,95**	0,77
K	0,82*	-0,90*	0,71	0,63	0,92*	0,81*	0,92*	0,90*	0,74
Ca	0,55	-0,91*	0,86*	0,20	0,81	0,92*	0,96**	0,62	0,87*
Mg	0,77	-0,78	0,89*	0,65	0,32	0,72	0,58	0,43	0,21
S	0,66	-0,94**	0,82*	0,38	0,91*	0,93**	0,99**	0,83*	0,91*
The Total of Nutrient	0,82*	-0,99**	0,88*	0,59	0,85*	0,93**	0,96**	0,85*	0,76

r table 0,05 = 0,81; 0,01 = 0,93; ** = very significant;*= significant

Quality Characteristics Of Fried Onions

Red Onion (RO) bulb of PVV harvested from various planting locations very significantly affects oil content, FFA, flavor and crispness, and overall it does not significantly affect the texture of Fried Onions (Table 4)

Table 4.The Quality Characteristics of Fried Onions of Palu Valley Variety Harvested from five planting locations

Planting location	Quality Characteristics of Fried Onions						
	Physical	Chemical		Sensory			
	Texture N/mm)	Oil content (%)	**FFA** (%)	Aroma	flavor	crispness	Overall
Bulupontu Jaya	8,34±2,17	36,78±1,33^{ab}	0,34±0,01^{ab}	4,13±0,82^{c}	4,03±1,07^{ab}	4,23±0,77^{abc}	4,07±0,69^{b}
Soulowe	7,71±2,75	40,53±1,79^{c}	0,37±0,01^{b}	3,33±0,99^{ab}	3,60±1,10^{a}	3,77±1,25^{a}	3,53±0,90^{a}
Guntarano	9,76±2,63	35,45±0,47^{a}	0,32±0,01^{a}	3,80±0,71^{bc}	4,13±0,68^{b}	4,40±0,56^{c}	3,83±1,05^{ab}
Maku	7,81±2,28	37,32±0,51^{ab}	0,33±0,02^{a}	3,40±0,77^{ab}	3,80±0,92^{ab}	4,27±0,69^{bc}	3,53±1,14^{a}
Oloboju	7,28±1,68	38,67±2,06^{bc}	0,35±0,01^{ab}	3,27±0,87^{a}	3,97±0,76^{ab}	3,87±0,94^{ab}	3,53±0,94^{a}

The number followed by a letter of the same column is not significantly different with 0,05 HSD test.

Oil Content

The data in Table 4 show that the oil absorbed in Fried Onions is 35.45 to 40.53 percent while the result of the previous study is 30.64 to 42.66 percent [33]. The quality of this fried onions is not eligible yet because the oil level is still categorized high compared to the oil standard of dry food which has a maximum level of 30 percent (Indonesian Industrial Standard Number: 0368-80 - 0368-85). Excessive oil content in fried food is undesirable because it can stimulate the hydrolysis and oxidation reactions. In addition, it can reduce the appearance of a product, harm producers due to increased production costs and it is less preferred by consumers due to health concern. Excessive oil consumption is considered as a key contributor to cholesterol, high blood pressure and coronary heart disease [34].

Frying oil absorption is very much determined by the water content of its raw material [9] [13] [35]. The total volume of absorbed oil into the fried materials is equal to the total volume of water released [36], higher initial water content also causes higher final oil content of tortilla chips [13]. The water content of fresh pellet samples varies from 41.44 to 78.80 percent and the fat level reaches 0.54 to 1.54 percent. After it is fried the water content decreases into 33.00 to 70.00 per cent while the fat content increases into 2.17 to 20.20 percent [37]. Similar to the result of this study, it demonstrates that the oil content of FO significantly increases along with the increase of bulb water content of its fresh materials (Table 5). While frying, the high temperature will cause water mass transfer and some dissolved materials from the product into the cooking oil. This process is accompanied by the formation of porous structure of the fried materials. Some portion of the oil will migrate into the pores of the materials and causes the material becomes oil. The higher the water content, the more pores are formed and the more oil absorbed into the pores. This phenomenon causes bulb water content to have significant correlation in increasing oil content of fried onions.

Table 5. The correlation coefficient (r) of bulb chemical component With fried onions quality characteristics

Bulb chemical component	fried onions quality characteristics						
	Physical	Chemical		Sensory			
	Texture	Oil content	FFA	Aroma	Flavor	Crispness	Overall
Water content	-0,66	0,89*	0,91*	-0,36	-0,89*	-0,77	-0,35
Carbohydrate	0,61	-0,80	-0,89*	0,12	0,70	0,73	0,08
Fat	-0,10	-0,19	-0,21	-0,20	0,57	-0,05	-0,13
Protein	0,72	-0,85*	-0,69	0,83*	0,96**	0,79	0,84*
Mineral	0,70	-0,94**	-0,99**	0,40	0,78	0,90*	0,35
Calcium	0,79	-0,96**	-0,90*	0,63	0,94**	0,85*	0,62
Sulfur	0,24	-0,78	-0,78	0,84*	0,83*	0,66	0,40
TSS	0,78	-0,96**	-0,89*	0,81	0,76	0,97**	0,76

r table 0,05 = 0,81; 0,01 = 0,93; ** = very significant; *= significant

Organic compounds in bulb like carbohydrate, protein, mineral, calcium, sulfur and TSS have strong correlation - very strong in lowering FO oil content (Table 5). Viewed from the ratio, if these organic compounds have higher level in the bulb, the water content becomes low so it can reduce the amount of absorbed oil when the bulb is fried. Similar to research finding by previous research, the oil content of potato chips decreases along with the increasing level of carbohydrate, protein and mineral of fresh potatoes [9].

Free Fatty Acid Level

Chemical components that greatly influence the deterioration quality of FO is FFA because it can act as a precursor of oxidation reaction which can cause rancidity in oily materials. Rancidity is quality indicator of fried food that has been deteriorated. Free fatty acid is formed through hydrolysis reaction toward triglycerides in the oil and fried materials. Before frying, materials generally have a room temperature and when they are immersed in the cooking oil the temperature becomes 130-200^{o}C. When the temperature reaches its boiling point, the water contained in the material will evaporate and the resulting vapor migrates into hot oil. Some of the oil is hydrolyzed into FFA and partial glycerol ester (diacylglycerol, monoglicerol and even glycerol) in a relatively short time which is 5-10 minutes [38].

Oil hydrolysis reaction is accelerated by high temperature, air pressure and the amount of excess water [39]. It is stated that hydrolysis reaction is affected by water, temperature, oxygen and fatty acid type [40]. The excessive amount of water can hydrolyze oil faster [41]. Therefore, when frying is done to high water content materials , the rate of FFA formation is accelerated. It is observed on the data in Table 5 showing the increasing level of FFA of Fried Onions (FO) along with the increasing bulb water content of raw materials. Scholar point out that samples of peanut with water content of 4.2; 4.5; 5.8 and 6.6 percent of its fresh weight are fried in peanut oil and placed in storage for 48 weeks. Samples having high water levels have higher significant FFA level than low water content samples [42].

Organic compounds in bulb like carbohydrate, mineral, calcium and TSS has significant correlation to very significant in reducing FFA level (Table 5) .The water content in bulb will be reduced if it has high level of organic compounds. This condition will cause a decrease in the level of FFA because of the limited number of hydroxyl groups of water used for the hydrolysis reaction. One of the main contributions of organic compounds mainly carbohydrate toward a decreased level of FFA of FO is its role in coating materials surface. Carbohydrate in the bulb will transform into a gel due to the influence of heat from cooking oil. Gel will coat the surface of the fried onions to prevent or reduce migration of water out of the material into the cooking oil. The effect of this process is the amount of water in the oil will be reduced so that the rate of hydrolysis decreases and the level of free FFA formed is lower [43].

The characteristics of FO sensory quality observed in this research include the aroma, flavor, and crispness. The data presented in table 4 and 5 show that Fried Onions texture and sensory quality positively correlate with the increase level of carbohydrate, protein, mineral, calcium, sulfur and TSS, but decrease with increasing water content and fat level of bulb fresh material. This is in line with previous research that notes the sensory characteristics (texture, aroma, flavor, appearance) of potato chips depend on the potato bulb chemical compositions[9]. Potato chips texture increase linearly along with the increasing level of protein, mineral, carbohydrate, non-polysaccharide starch and negatively correlates with the water content and fat [9] [44]. The bulb chemical compositions which has the highest contribution in improving the quality characteristics of DO consecutively is TSS>Calcium>protein>minerals>sulfur>carbohydrate but the opposite is found in the water and fat content (Table 5). Calcium has larger effect on physical quality, mineral on its chemical quality and protein in FO sensory quality.

IV. Conclusion

Red Onion of PVV which is harvested from different planting locations,very significantly affects the bulb chemical compositions. Bulb productivity, carbohydrate level, protein, mineral, calcium, TSS and the highest dry weight is found in bulb harvested from Guntarano planting location. The quality characteristics of FO increase along with the increasing levels of bulb chemical components such as TSS, calcium, protein, minerals, sulfur and carbohydrate, but decreases with the increasing water content and fat.

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