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Encapsulation Properties of Red Chili Powder (*Capsicum Annum L.*) Using Gelatin As a Coating Agent

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***Abstract*-Red chili contains the active compound capsaicin, which is easily degraded during processing. To minimize this degradation, encapsulation was performed using specific coating materials. The aim of this research was to investigate the influence of gelatin concentration as a coating material and determine the optimal concentration of gelatin in characteristic encapsulation of red chili powder. A Complete Randomized Design (CRD) was used for gelatin concentration treatments (0%, 2%, 4%, 6%). The data obtained were analyzed by ANOVA at the 1% and 5% contents, followed by a Duncan's multiple range test at a significance level of P<0,05). The research showed that the concentration of gelatin as a coating agent affected the characteristic encapsulation. The concentration of gelatin as a coating agent affected the characteristics of red chili powder encapsulation such as the yield, water content, solubility, capsaicin content and encapsulation efficiency, but it did not affect the color of red chili powder encapsulation. Gelatin coating material with a concentration of 4% the best concentration treatments with a yield of 66,86%; the color value of L*43,30; a*14,92; b*21,74 respectively; water of content 16,32%, solubility value 83,35%; capsaicin content CE 260 µg /g; CT 5,362 µg/g; encapsulation efficiency of 43,76. The research conclude that a gelatin concentration of 4% can be used as a coating material that enhances the encapsulation characteristics of powdered red chili.**

***Keywords*-Gelatin, Encapsulation, Red Chili Powder**

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I. INTRODUCTION

Red chili powder (*Capsicum annuum L.*) is a horticultural plant belonging to the *Solanaceae family*. The chili is rich in active compounds flavonoids, capsaicin, minerals, and antioxidant compounds such as vitamin c, vitamin e, vitamin K, phytosterols, β-carotene, and β-cryptoxanthin [1].

Red chili powders contain an active compound called capsaicin, which causes a spicy and hot taste when consumed. The capsaicin content in red chili powders ranges from 0,1% to 1,5%, depending on the type and variety of chili peppers and the environmental conditions in which they grow [2]. Capsaisin functions as an anticancer agent by suppressing BCa tumorigenesis so that proliferation is inhibited, as well as increasing and preventing p53 antibody that play a role in cancer cell apoptosis[3].

Capsaicin compounds are volatile and easily degraded during storage [4]. Even in powder form, these compounds can still evaporate and degrade during the processing process. Therefore, efforts are needed to protect and reduce the evaporation and degradation of capsaicin in red chili powder. One way that can be done is through encapsulation.

Encapsulation technology is a useful technique in the food industry to include bioactive compounds in food systems, protect products from environmental conditions such as moisture, oxygen, light, free radicals and prolonged shelf life [5]. This technology is economically efficient, easy to do, and has a fairly fast process [6]. Encapsulation can be performed by various techniques, such as complex conservation, ionic gelation, centrifugation, lyophilization, and spray drying.

Research conducted by [7] concluded that the addition of 6% gelatin to gotu kola extract as an encapsulant material showed the highest solubility value compared to other methods. Since alginate gels have a macroporous structure with pore diameters in the order of 10 μm [8], who states that an increase in solubility value indicates that a material is more soluble in solvents. The total amount of substance that can dissolve in a solvent at the equilibrium point is referred to as solubility. The choice of encapsulant material in a product can affect solubility, where solubility tends to increase with an increase in the concentration of gelatin used.

In the current study, gelatin was used as the coating material. Gelatin was chosen for its high emulsifying characteristics, which can reduce product size and bind oil in water [9]. Gelatin is soluble in warm water and, when cooled below 30°C, its colloidal solution forms a gel with tyxotropic characteristics. When reheated, this gel can revert to liquid, which is a reversible process [10]. A study was conducted on encapsulation properties of red chili powder using gelatin as a coating agent". In this investigation, changes were made to include gelatin-encapsulated red chili powder.

II. MATERIAL AND METHODS

A. Material

The main ingredient used is curly red chili. The materials used for the encapsulation process are distilled water, Na alginate, $CaCL_2$ 0,1 M, and gelatin. Materials for analysis include standard capsaicin powder and ethanol.

The equipment needed is a blender (Philips), a 60 mesh sieve, baking sheet, analytical scales, aluminum cups, syringe, 250 ml volume beaker glass, hot plate stirrer, magnetic stirrer, thermometer, 100 ml measuring cup, stainless steel filter, aluminum foil, Whatman paper no. 42, oven, and double beam UV-Vis spectrophotometer.

B. Experimental Design

The design used in this study was a complete randomized design (RAL) with a treatment of variations in gelatin concentration (b / v) on the volume of solvent as follows.
P0 = No addition of gelatin
P1 = 2% gelatin (2 g gelatin in 100 mL solvent)
P2 = 4% gelatin (4 g gelatin in 100 mL solvent)
P3 = 6% gelatin (6 g gelatin in 100 mL solvent)
Each treatment was repeated 5 times so that 20 experimental units were obtained.

C. Sample Preparation

The encapsulated suspension consists of 1.5 g of alginate, 1 g of red pepper powder and 100 mL of distilled water. The concentration of gelatin addition is 2%, 4% and 6%. Making red chili powder encapsulation begins by inserting 100 mL of distilled water into a 250 mL volume beaker glass and then stirring using a hot plate stirrer on a scale of 5 continuously. The suspension is then allowed to stand for 30 minutes at room temperature. Then stirred using a magnetic stirrer (without heating) continuously. Alginate is introduced in the suspension, waited until homogeneous for 10 minutes. Put 1 g of ground red pepper and wait until homogeneous for 15 minutes. Next, an encapsulated suspension of powdered red pepper is inserted in the syringe. Prepared 100 ml of $CaCl_2$ 0.1 M and stirred with a magnetic stirrer continuously. The encapsulated suspension of red chili powder is dripped on the $CaCl_2$ solution so that granules or breads are produced. Stirred the suspension for 5 minutes and then filtered using a stainless steel sieve. Breads are placed on a baking sheet with an aluminum foil base and put in the oven with a temperature of 40-50 ° C for 5 hours.

D. Parameters

Yield

The encapsulated yield of red chili powder is calculated based on the ratio of the encapsulated weight of the red chili powder produced and the weight of the coating material used and multiplied by 100%. The encapsulate of red chili powder and the total coating material that has been weighed are then calculated using the following equation [11].

$$Yield\ (\%) = \frac{Encapsulate\ weight\ (g)}{Weight\ of\ coating\ material(g)} \times 100\%$$

Water Content

The moisture content is determined gravimetrically by drying in an oven at 100°C to constant weight. Oven the aluminum dish for 20 minutes then put in the desiccator for 15 minutes. Next, 2 g of encapsulated red chili powder weighed and then put in an aluminum dish and placed in the oven for 24 hours. Next it is placed in a desiccator for 15 minutes and weighed. The moisture content of encapsulated red chili powder can be calculated through the following equation. starting weight, final weight [12]

$$Water\ Content\ \ (\%) = \frac{starting\ weight - final\ weigt}{starting\ weight} \times 100\%$$

Solubility

The encapsulated solubility of red chili powder is carried out by gravimetric method based on the weight of residue left on the filter paper. Filter paper is dried in the oven for 30 minutes at 105°C, then weighed as much as 1 g of sample and dissolved in 100 ml distilled water and filtered. Next, the filter paper along with the residue is dried in the oven for 1 hour at 105°C. After that, the sample is placed in a desiccator for 15 minutes and then weighed. The determination of the percentage of solubility can be calculated using the following equation[13].

$$Solubility\ \ (\%\ ) = \frac{Final\ weight - filter\ paper\ weight}{\frac{100 - moisture\ content}{100}} 100\%$$

Capsaicin Content

a. Preparation of Standard Stock Solutions

A total of 10 mg of standardized capsaicin was put into a 100 mL measuring flask. Then 50 mL of ethanol was added and sonicated for 5 min. The solution is then added ethanol until it reaches the limit mark on the measuring flask resulting in a final concentration of 100 μg/mL *[14]*.

b. Manufacturing of Capsaicin Standard Curves

Various concentrations of standard capsaicin solutions of 20, 40, 60, 80, and 100 μg/mL are prepared by taking specific volumes of the stock solution (5, 10, 15, 20 and 25 mL) into a 25 mL measuring flask. Each measuring flask then added ethanol to the limit mark and measured its absorbance using a double beam UV-Vis spectrophotometer at a wavelength of 280 nm *(14)*

c. Sample preparation

A total of 0,25 g of powdered encapsulates are dissolved in 25 ml of absolute ethanol and then filtered to produce filtrate. The resulting filtrate is then applied with distilled water until it reaches the limit mark of a measuring flask of 50 mL. successfully capsaicin encapsulated is calculated based on the content of capsaicin encapsulated (CE). The total capsaicin content in red chili capsules (CT) was measured by dissolving 0,1 grams of red chili capsule powder in absolute ethanol and marked until it reached the limit mark of 100 mL flask. From each sample, 5 mL was taken and analyzed using a spectrophotometer with a wavelength of 280 nm *[15]*.

Color

Measure the color of encapsulated red peppers using a color reader. Before measuring the color of encapsulated red peppers, the color reader is calibrated first. Color measurement is read on parameters L*, a*, b* by 3 different points. L* indicates the brightness of black (0) to white (100). A* depicts a red-green color with a positive A* value indicating it appears red, and a negative A* value means it appears green. While b* depicts yellow-blue colors with positive b* values indicating yellow colors and negative b* indicating bluish hues *[16]*

Encapsulation Efficiency

Encapsulation efficiency (EE) is calculated by comparing the successfully capsaicin content with the total capsaicin content in the encapsulate using absolute ethanol as solvent [17]. The encapsulation efficiency can be calculated through the equation:

$$EE(\%) = \frac{Capsaisin\ Levels\ Encapsulated}{total\ capsaisin\ encapsulate\ levels} \times 100\%$$

Data Analysis

The data obtained from the test results were analyzed using ANOVA fingerprints at 1 % and 5% level of significance. If the data obtained are significantly different, then continue with Duncan's New Multiple Range Test (DNMRT) at a significance level of P<0,05.

III. RESULT AND DISCUSSION

A. Product Description

Red chili powder encapsulate is a product that is processed using an encapsulation technique with a coacervation method consisting of a core ingredient in the form of red chili powder and a coating material in the form of gelatin (**Table 1**).

TABLE 1.
PRODUCT DESCRIPTION ENCAPSULATED RED CHILI POWDER

Gelatin Concentration (%)	**Product Description**	**Product Pictures**
0%	Solubility : 76,36% Capsaicin content: CC: 200 μg/g; CT: 4,913 μg/g Encapsulation Efficiency: 41,63% Yield : 60,42% Color : L*43,29; a*15,46; b*21,06 Water Content : 18,32%	
2%	Solubility : 70,18% Capsaicin content: CC: 230 μg/g; CT: 6,669 μg/g Encapsulation Efficiency : 35,60% Yield : 63,56% Color : L*43,24; a*16,38; b*21,54 Water Content : 16,88%	
4%	Solubility : 77,67% Capsaicin content: CC: 260 μg/g; CT: 5,362 μg/g Encapsulation Efficiency: 43,76% Yield : 66,86% Color : L*43,30; a*14,92; b* 21,74 Water Content : 16,32%	
6%	Solubility : 83,35% Capsaicin content: CC: 190 μg/g; CT;9,496 μg/g Encapsulation Efficiency: 22,59% Yield : 69,60% Color : L*45,16; a*16,22; b*22,46 Water Content : 15,94%	

Noted: l* (brightness); a* (redness); b* (yellowish); cc (capsaicin encapsulated content); ct (total capsaicin content).

B. Encapsulated Yield of Red Chili Powder

Based on variety analysis, it shows that the encapsulated yield of red chili powder with the addition of gelatin concentration has a very real influence on the yield (F<0,05). The encapsulated yield of red chili powder with the addition of gelatin concentration is presented in **Table 2.**

TABLE 2.
YIELD OF ENCAPSULATED RED CHILI POWDER WITH ADDITION OF GELATIN CONCENTRATION

Gelatin Concentration (%)	Yield (%)
0%	60,42±0,78^{a}
2%	63,56±2,36^{b}
4%	66,86±0,96^{c}
6%	69,60±0,51^{d}

Noted: Numbers accompanied by the same lowercase letters show no significant difference according to the DNMRT test at a significance content of 5%.

Yield has an important role in evaluating the efficiency and effectiveness of a process. The higher the yield achieved, the more efficient the process applied (18). The higher concentration of gelatin causes the yield value to increase, in general, an increase in the ratio of the core material to the polymer will increase the amount of yield and the efficiency of the encapsulation [19]. Based on DNMRT further tests, the yield at 6% concentration showed a significant difference in 0%, 2%, and 4% concentrations. The highest yield is found at a concentration of 6%, and the lowest yield at a concentration of 0% without coating material is 60,42%. According to [20], the greater the number of encapsulations the greater the yield of encapsulated products. This is because the number of encapsulants plays a role in the yield of encapsulated products. Meanwhile, water and flavor components evaporate during the drying process and play a small role in the yield of the encapsulated product. The difference in yield in the encapsulation of red chili powder is caused by the treatment of giving gelatin with different contents. With the addition of different gelatin, it means an increase in the total solids contained in the gelatin, so as to increase the total solids encapsulated red chili powder. The high concentration of adding encapsulant ingredients will increase the total yield of red chili powder encapsulation [21].

C. Red Chili Powder Encapsulate Color

Research data and analysis of gelatin concentration as a coating agent against discoloration of red chili powder capsules L*, a* and b*. The results of variance analysis showed that the values of L* (brightness), a* (reddish) and b* (yellowish) in red chili powder did not have a significant difference (F>0,05) with the addition of gelatin concentration, listed in **Table 3**.

TABLE 3.
COLOR (L*, a*, b*) ENCAPSULATE OF RED CHILI POWDER WITH ADDITION OF GELATIN CONCENTRATION

Gelatin Concentration (%)	Value			Color	Description
	L*	a*	b*		
0%	43,29±0,76	15,46±0,71	21,06±0,46		Dark moderate orange
2%	43,24±0,63	16,38±1,77	21,54±0,65		Dark moderate orange
4%	43,30±1,34	14,92±1,73	21,74±1,09		Dark moderate orange
6%	45,16±2,05	16,22±0,64	22,46±0,55		Dark moderate orange

Noted: Numbers accompanied by the same lowercase letters show no significant difference according to the DNMRT test at a significance level of 5%.

Based on the data obtained, it was found that the average encapsulated brightness content ranged from 43 to 45. This indicates that encapsulates tend to have lower brightness contents because their average value is below 50. In this context, a value of 100 indicates a completely bright color. The highest L* value was recorded at a concentration of 6% with a value of 45,16 while the lowest at a concentration of 4% was 43,30. The factor that affects the content of brightness is the yellow color of the coating material which tends to give the impression of brightness in the encapsulate. Gelatin is naturally transparent or nearly transparent when dissolved in water. When gelatin hardens, it forms a gel that is also transparent. This means that the gelatin does not have a color significant enough to change the color of the product on encapsulation.

The increase in brightness is influenced by the increasing concentration of gelatin in each treatment. Increased concentration of white gelatin affects the brightness content of encapsulation products. The higher the concentration of gelatin added, the higher the brightness content in the encapsulated product of red chili powder.

D. Water Content

The results of variety analysis showed that gelatin as an encapsulant material caused changes. A very noticeable effect on the water content of red chili powder encapsulation (P <0,05). Increased gelatin contents cause this difference. The higher the gelatin content, the less water in it. This is due to the fact that the encapsulation process takes longer to achieve granular form in products with a higher gelatin concentration than in products with a lower gelatin concentration. As a result, the evaporation of products with higher concentrations of gelatin will take longer, which in turn will result in higher moisture content. **Table 4** shows the average results of water content (%) encapsulation testing with various gelatin concentration treatments.

TABLE 4.
WATER CONTENT OF RED CHILI POWDER ENCAPSULATES WITH THE ADDITION OF GELATIN CONCENTRATION

Gelatin concentration	water content (%)
0%	18,32±0,28^{c}
2%	16,88±0,57^{b}
4%	16,32±0,50^{ab}
6%	15,94±0,43^{a}

noted: Numbers accompanied by the same lowercase letters show no significant difference according to the DNMRT test at a significance level of 5%.

It can be seen that the concentration of gelatin has an effect on the water content of the encapsulated encapsulate of red chili powder. Based on DNMRT follow-up tests, the gelatin concentration of 2% did not show a significant difference to the gelatin concentration of 4% but was significantly different from the gelatin concentration of 0%, 2% and 6%. It was noted that the highest water content at 0% gelatin concentration with a value of 18,32% while the lowest water content at 6% gelatin concentration with a value of 15,94%. This is in accordance with the results of research that has been carried out and meets the characteristics of gelatin, namely the maximum water content of 16%.

Based on these data, it can be observed that the increase in gelatin concentration causes the water content in the encapsulate to tend to be lower. This water content drops significantly in proportion to the increase in gelatin concentration. This is because gelatin can increase total dry matter solids. So, the amount is Less water evaporates, causing an increase in concentration. Therefore, the concentration of gelatin will decrease the water content of red chili powder encapsulation. The higher the total solids content, after drying, to some extent, the evaporation rate will be higher, as a result of which the moisture content of the material becomes lower.

Water content is very important in maintaining the quality of foodstuffs [24]. The normal aroma of various food products within a few months if the product contains moisture content. Food products with a moisture content above 5% will experience clumping when stored. Under certain conditions, the clot will be large and become so hard that it can only be broken by a hammer. Physical appearance will be very different from normal including color changes.

E. Solubility

Research data and analysis of various solubilities of red chili powder encapsulates with the influence of gelatin concentration as a coating material. The results of fingerprint analysis showed that the solubility of red chili powder encapsulates with the addition of gelatin concentration had a very significant difference (P>0,05). The encapsulated solubility of red chili powder with the addition of gelatin concentration is presented in **Table 5.**

TABLE 5.
SOLUBILITY OF ENCAPSULATED RED CHILI POWDER WITH THE ADDITION OF GELATIN CONCENTRATION

Gelatin Concentration (%)	Solubility%
0%	76,36±1,40[ab]
2%	70,18±5,71[a]
4%	77,67±5,14[b]
6%	83,35±5,40[b]

Noted: Numbers accompanied by the same lowercase letters show no significant difference according to the DNMRT test at a significance level of 5%.

In **Table 5**, It can be seen that the concentration of gelatin has an effect on the encapsulated of red chili powder solubility. Based on the DMRT test, gelatin concentrations of 6% showed significant differences in concentrations of 0, 2 and 4%. The highest solubility was recorded at a concentration of 2% with a value of 12,71%. The results showed that the addition of 2% gelatin as an encapsulant to the encapsulation of red chili powder had the best solubility value than other treatments. This is in accordance with who states that the greater the solubility value indicates that the more soluble a material is in the solvent. Solubility is expressed in terms of the maximum amount of solute dissolved in a solvent at equilibrium. Solubility is affected by the encapsulated material of a product.

The water content in the encapsulate can also affect solubility. High water content makes encapsulates difficult to dissolve in water. This is related to the fact that encapsulates that have high water content tend to stick to each other due to water molecules so that no pores are formed and encapsulates cannot absorb large amounts of water. High moisture content can also cause encapsulates to have a narrow surface to moisten because the encapsulated grains are larger which causes the grains to stick together.

F. Capsaicin Encapsulated Content

Research data and analysis of various contents of capsaicin encapsulated red chili powder with the influence of gelatin concentration as a coating material. The results of fingerprint analysis showed that capsaicin contents in red chili powder encapsulates with the addition of gelatin concentration had a very significant difference (F>0,05). The capsaicin encapsulated content of red chili powder with the addition of gelatin concentration is presented in **Table 6.**

TABLE 6
CAPSAICIN ENCAPSULATED CONTENT OF RED CHILI POWDER WITH THE ADDITION OF GELATIN CONCENTRATION

Gelatin Concentration (%)	CE (µg/g)	CT (µg/g)
0%	200±0,04	4,913±0,053[a]
2%	230±0,03	6,669±1,294[a]
4%	260±0,04	5,362±0,164[a]
6%	190±0,01	9,496±2,358[b]

Noted:
- Numbers accompanied by the same lowercase letters showed no significant difference according to the DNMRT test at a significance level of 5%.
- CE indicates the content of capsaicin encapsulated.
- CT indicates the total content of capsaicin.

In **Table 6**, It can be seen that the concentration of gelatin affects the contents of capsaicin encapsulated (CE) and the total capsaicin (CT) contents of encapsulated red chili powder. Based on DNMRT follow-up tests, at capsaicin encapsulated (CE) contents gelatin concentrations of 0%, 2%, 4% and 6% did not show a significant difference. It was noted that the highest contents of capsaicin encapsulated (CE) at 2% and 4% gelatin concentrations were 0.23 mg/g while the lowest contents of capsaicin encapsulated (CE) at 6% gelatin concentrations were 0.19 mg/g.

At total capsaicin (CT) contents, gelatin concentrations of 0%, 2%, 4% and 6% differed significantly, it was noted that the highest total capsaicin (CT) contents at 6% gelatin concentrations with a value of 9,496 µg/g, while the lowest total capsaicin (CT) contents at 0% concentrations of 4,913 µg/g.

In the food industry, gelatin generally acts as a geller, foam former, thickener, plasticizer, emulsifier, to improve texture and become a binder. In the process of making cakes, cheese, yogurt, ice cream, milk, bread, sausages, butter, candy, marshmallow, chocolate and agar to use more gelatin.

The spicy taste of chili is due to the presence of a substance caused by capsaicin. The capsaicin content in chili acts as an appetite stimulant. Capsaicin stimulates the endorphin hormone which gives a pleasurable effect, so that when someone eats food seasoned with chili, they tend to increase their portion of food.

G. *Encapsulation Efficiency*

Encapsulation efficiency describes the percentage of capsaicin successfully protected in the capsule. The higher the encapsulation efficiency indicates that the coating ability to coat the core material is better. The results of fingerprint analysis showed that the encapsulation efficiency in red chili powder encapsulates with the addition of gelatin concentration had a very significant difference ($p>0,05$). The encapsulation efficiency of red chili powder encapsulation with the addition of gelatin concentration is presented in **Table 7.**

TABLE 7
EFFICIENCY OF ENCAPSULATION OF RED CHILI POWDER WITH ADDITION OF GELATIN CONCENTRATION

Gelatin Concentration (%)	Encapsulation Efficiency%
0%	41,63±8,56[b]
2%	35,60±6,88[b]
4%	43,76±6,05[b]
6%	22,59±10,21[a]

Noted: Numbers accompanied by the same lowercase letters show no significant difference according to the DNMRT test at a significance level of 5%.

The highest encapsulation efficiency was recorded at 4% gelatin concentration with a value of 43,76% while the lowest encapsulation efficiency was recorded at 6% gelatin concentration with a value of 22,59%. The decrease in encapsulation efficiency occurs due to the excessive total amount of solids in the encapsulation of red chili powder, especially gelatin as an encapsulation ingredient. An increase in excessive gelatin concentration can inhibit the encapsulation process of capsaicin compounds causing many capsaicin compounds to be uncaptured. It is important to pay attention to the amount of encapsulation material in order to achieve optimal encapsulation efficiency.

An increase in encapsulant concentration or a greater ratio between core material and encapsulant has an impact on decreasing encapsulation efficiency. This is due to an increase in emulsion viscosity along with an increase in total solids which decreases the encapsulation efficiency value.

Some parameters that affect the value of encapsulation efficiency include low polymer solubility in solvent, high polymer concentration, solvent evaporation rate and microcapsule hardening rate. Encapsulation efficiency refers to the proportion of active substances trapped in a capsule compared to the total active substances and varying core loading and binding agent's microcapsules ratio to wall materials affected the characteristics of the microcapsules [22-25]. Thus, the total capsaicin compounds do not affect the encapsulation efficiency but are influenced by the amount of capsaicin compounds successfully encapsulated.

IV CONCLUSION

Research concluded that the concentration of gelatin as a coating agent affected the characteristics of red chili powder encapsulation such as the yield, water content, solubility, capsaicin content and encapsulation efficiency, but it does not affect the color of red chili powder encapsulation. Gelatin coating material with a concentration of 4% is the best concentration treatments with a yield of: 66,86%; the color value of L*43,30; a*14,92; b*21,74 respectively; water content: 16,32%, solubility value: 83,35%; capsaicin content: CE: 260 μg/g; CT: 5,362 μg/g; encapsulation efficiency: 43,76. The research discovered that a gelatin concentration of 4% can be used as a coating material that enhances the encapsulation characteristics of powdered red chili.

CONFLICT OF INTEREST

Authors declare no conflict of interest to disclose.

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