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The stability of nutritional composition and physical traits of chicken patty containing oyster mushroom packed with biodegradable and non-degradable packaging materials

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Abstract

Extensive use of synthetic-based polymer plastic as packaging medium to pack food products has led to serious environmental problems due to their total non-biodegradability property. The stability of nutritional composition and physical traits of chicken patties containing oyster mushroom packed with biodegradable and non-degradable packaging materials were studied. The chicken patties containing oyster mushroom were packed with either biodegradable plastic (BP), paper box (PB) or non-biodegradable high density polyethylene (HDPE). Generally, there were no significant (P>0.05) different in all nutrient analyzed except for carbohydrate after 6 months of storage for chicken patties packed with different types of packaging. The chicken burger packed with both BP and PB packagings were able to retain the moisture and fat without jeopardizing the diameter reduction and cooking yield during storage. There were no differences in all nutrient analyzed after 6 months of storage of chicken patties packed with either biodegradable packagings (BP and PB) or non-degradable packaging. In addition, frozen storage does not significantly affect the concentration of of β-glucan in both BP and PB packagings. In summary, these results indicate that biodegradable packagings applied in packing chicken patty frozen for 6 months were effective in controlling the microbial growth and provide wholesomeness and safety to the chicken patty containing oyster mushroom.

Introduction

Environmental issues are becoming increasingly important to the ecological conscious consumer. Widely use of synthetic packaging plastics has led to serious environmental problems due to their total non-biodegradability property. Globally, there are about 30-50% of plastics made from hydrocarbon are used for packaging (Braun *et al*., 2006). Presently, consumer awareness and demand may trigger the use of bio-based packaging materials as an alternative to materials produced from non-renewable resources. Biologically the bio-based packaging is defined as packaging containing raw materials originating from agricultural sources such as starch, bio-derived monomers and other agricultural by-products materials.

Natural biopolymer, such as starch, is excellent degradable polymers that can be applied to substitute the hydrocarbon plastic materials (Waha *et al*., 2011). The skins of the tropical fruits are said suitable to produce the film for making plastic as they are high in carbohydrates and protein (Zhong *et al*., 2011). Presently, in many European countries, there is rising urgency on the packaging industry to develop environmentally sustainable materials. Furthermore, use of biodegradable packaging materials has the greatest potential in countries where landfill is the main waste management tool (Petersen *et al*., 1999). Biodegradable packaging produced from agricultural origin macromolecules provide a supplementary and sometimes essential means to control physiological, microbiological, and physicochemical changes in food products (Guilbert *et al*., 1997).

Agricultural by-products from fruits and plants are seen to be a potential raw ingredient not only in processing of degradable plastics but it also being formulated in cultivation of oyster mushroom. Saw dust, rubber wood tree, rice straw and other agricultural by-products have been used in the preparation of medium nutrient for growing mushroom. Until now, edible mushrooms are cultivated and consumed as food or food ingredients in various food preparation and processed food products. This fungus is cultivates

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on a decayed organic material and produce edible portion on the various surface of the substrate.

It is purported that by replacing meat based ingredients with oyster mushroom into patty formulation, a saving on ingredient cost is purportedly can be achieved. Recently, we studied the colour, textural properties and cooking characteristics of chicken patty added with *Pleuratus sajor-caju* (Wan Rosli *et al*., 2011). In addition, the incorporation of oyster mushroom as non-meat ingredient with the focus to enhance the nutritional composition and dietary fibres while reducing formulation cost in processed food product such as beef patty was successfully developed (Wan Rosli and Solihah, 2012).

Even though the absolute substitution with eco-friendly packaging films to wrap goods or commodities is just almost impracticable to achieve, at least for specific applications like food packaging, the use of degradable plastics should be the future. Therefore, there are necessitating efforts to be taken in overcoming these situations. One of the alternatives has been considered to increase the use of natural biodegradable polymer in packing food items.

To the best of our knowledge, biodegradable packaging has commanded great attention, and numerous projects are under way in this field. Application of biodegradable packaging plastic in wrapping processed food products including processed meat-based items such as beef or chicken patty are not widely practiced in Malaysia. In addition, there are scanty research and development efforts being conducted in this area. Processed meat products such as beef and chicken patties are amongst the most popularly consumed processed meat products in many parts of the world (Yilmaz *et al*., 2002; Gok *et al*., 2011; Brewer, 2012) including Malaysia. Some of the reasons for such wide popularity are their affordable cost, availability in different tastes and longer shelf life. Thus, the present study aims to investigate the effect of biodegradable plastic packaging on the nutritional composition and physical traits of chicken patty containing oyster mushroom (*Pleurotus sajor-caju*) during frozen storage for 6 months.

Materials and Methods

Preparation of biodegradable packaging

Preparation of biodegradable plastic was followed Rohani *et al*. (2010). Sago starch obtained from the Land Custody Development Authority (LCDA), Sarawak (Malaysia) was dried in a vacuum oven for 24 h at 80°C. The sago granular sizes ranged from 9 to 35 μm, with an average granule size of 20 μm was used. The biodegradable plastic mixture was prepared by premixing sago starch in powder form with 35 wt% liquid glycerol (Ajax Chemicals, Malaysia) in a kitchen blender with a capacity of 200 g. The mixture was considered ready when the starch was fully covered with the liquid glycerol after mixing for 5 min. In case of insufficient mixing, manual mixing was used with spatula. The mixture was kept in a dry place for 24 h at room temperature. After the process, the compound was melt-mixed using heated two-roll mills at 150°C for 10 min (Rohani *et al*., 2010).

Chicken patty formulation

The patties were prepared followed the formulations described by Wan Rosli and Solihah (2012) with slight modification. The modification was done on the partial replacement of ground chicken breast with oyster mushroom at 25% in the patty formulation. The chicken breast used in the present formulation is fulfilling Malaysian Food Act 281 and Regulations 1983 (FoodAct, 1983). The manually formed finished chicken patties were either packed with normal high density polyethylene (HDPE) plactic (control), biodegradable plastic (BP) or paper box (PB) before being stored in a freezer at -18^{o}C while waiting for further analysis. The HDPE plastic was complementary donated by Juara Rasa Maju Sdn Bhd (Bukit Angkat, Kajang, Selangor, Malaysia) while PB was purchased from Mahjasa Sdn Bhd (local supplier near Kota Bharu district of Kelantan, Malaysia). Biodegradable plastic packaging was prepared according to Rohani *et al*. (2010) as described above. Oyster mushroom was prepared in Nutrition Laboratory of the School of Health Sciences, Universiti Sains Malaysia Health Campus. Chicken breast cut was purchased from local wet market. Other dry materials were purchased from local suppliers.

Processing of chicken patty

The chicken breast was manually cut using a utility knife and minced using food processor (Panasonic MK-5076). The minced chicken was stored at –18^{o}C until processing time. Meanwhile, isolated soy protein was blended with water and shortening at a ratio of 1:5:5 using a Hobart mixer (N-50 Canada). The emulsion prepared (called pre-emulsion) was kept in a chiller (2-5^{o}C) until ready for use. Salt was added to the frozen minced chicken and mixing was carried out using a Hobart mixer for 3 minutes. Water mixed with spices, potato starch and oyster mushroom were added and mixed for another 2 min. The pre-emulsion was then added and mixing continued for another 2 min. The finished chicken

meat batters were then weighed into 70g portions, and then manually stamped to produce a uniform chicken patty. The raw chicken patties were then frozen in a freezer at –18°C.

Nutrient composition analyses

Nutrient analyses were conducted using AOAC (1996) for moisture, ash, protein by nitrogen conversion factor of 6.25 [Kjeldahl method, (AOAC, 1996) and crude fat content using the semi-continuous extraction [Soxhlet] method (AOAC, 1996). In this method, a homogenous ground sample (3g for each) was dried in an oven at 105°C until constant weight was achieved. The difference between the initial weight and constant final weight after drying was considered as the moisture lost. Therefore, this difference was recorded as moisture content of the sample.

Total ash content was determined by dry-ashing method, i.e. by incinerating a known quantity of dried food sample (0.5g for each) in a muffle furnace at temperature 500 – 600°C until constant weight is obtained (AOAC, 1996). In other nutrient, total carbohydrates were calculated by the difference: total carbohydrates = 100 – (g moisture + g protein + g fat + g ash).

β-glucan analysis

To determine β-glucan, mixed-linkage beta-glucan procedure was used. This assay procedure adapted from Megazyme International Ireland Limited (Megazyme, 2008). In this method, samples were suspended and hydrated in buffer solution with pH 6.5. Then, they were incubated with lichenase enzyme and were centrifuged (Hettich–Universal 32R). The aliquot from centrifuged sample was then hydrolysed with beta-glucosidase. After that, Glucose Determination Reagent (GOPOD Reagent) was added and the samples were incubated again in water bath (Memmert – WB29) before measuring the absorbance using spectrophotometer (Perkin Elmer – Lamda EZ150). The absorbance was measured at 510 nm for each reaction against the reagent blank. The calculations of β-glucan in all samples were using Mega-CalcTM.

Total microbial count

The procedures for total microbial count or total plate count (TPC) were follow the method outlined by Pinero *et al*.(2008). Patty samples were homogenized in a waring blender prior analysis. Ten grams of sample and 90 ml of sterilized maximum recovery diluents (BDH, UK) were inserted into a 400 ml sterile stomacher bag (Inter Science, France). The sample was homogenized by using a stomacher (Inter Science, France) for 2 minutes. The homogenized sample (1 ml) was pipette into a sterilized 15 ml centrifuge tube (Falcon, USA) that had been priorily filled with 9 ml of maximum recovery diluents. A 10 fold serial dilution was performed ranging from 101 to 105 of dilution factor. To determine the total plate count, 100 ul of each dilution tube performed was pipetted on total plate count petry film (3M Petry Film, USA). The petry film was incubated at 35°C for 24 to 48 hours. The numbers of colony was expressed as colony forming unit (CFU) per ml. The analysis was carried out in triplicate.

Cooking procedure

Chicken patties were thawed at 4°C for 12 h. Chicken patty samples were then cooked on a in a pan-fried electric skillet (Model KX-11K1, Sharp Corporation, Japan) for 7-8 min until an internal temperature of 72 ± 1°C was achieved.

Cooking yield

Cooking yield of chicken patties was determined by measuring the weight of six patties for each treatment/batch and calculating weight differences for patties before and after cooking, as follows (El-Magoli *et al*., 1996):

$$\text{Cooking yield (\%)} = \left(\frac{\text{cooked weight}}{\text{Raw weight}} \times 100\right)$$

Moisture and fat retention (%)

The moisture and fat retention values represent the amount of moisture and fat retained in the cooked product per 100 g of raw sample, These values were calculated according to the following equations (El-Magoli *et al*., 1996).

$$\text{Moisture retention (\%)} = \frac{(\text{percent yield} \times \text{\% moisture in cooked patties})}{100}$$

$$\text{Fat retention (\%)} = \frac{(\text{cooked weight} \times \text{percent fat in cooked chicken patties}) \times 100}{(\text{raw weight} \times \text{percent fat in raw chicken patties})}$$

Diameter reduction (%)

Change in chicken patties' diameter was determined using the following equation:

$$\text{Diameter reduction (\%)} = \frac{\text{raw chicken patties diameter} - \text{cooked chicken patties diameter}}{\text{raw chicken patties diameter}} \times 100$$

Statistical analysis

Data obtained were tested for significance using ANOVA and Duncan Multiple Range Test with SPSS (SPSS, 2009), Version 18. All measurements were conducted in triplicate (n=3). Significant level was established at $P \leq 0.05$.

Results and Discussions

Nutrient composition

The nutrient analyses of cooked chicken patties packed with different type of packaging materials are shown in Table 1. Generally, there were no significant (P>0.05) different in all nutrient analyzed except for carbohydrate after 6 months of storage for chicken patties wrapped with different types of packaging. In addition, there were also no significant different (P>0.05) in all nutrients content for all types of packaging. After 6 months of storage, all chicken patties recorded protein, fat and ash content ranging from 19.8 – 21.4%, 15.0-15.9% and 1.9-2.2% respectively. On the other result, all chicken patties recorded moisture content ranging from 41.9-42.6% after 6 months of storage. These values were comparable with our previous result (Wan Rosli and Solihah, 2011; 2012).

Carbohydrates were among predominant macronutrients and ranged from 16.67 – 17.68% (Table 1) in cooked chicken patties containing mushroom packed with different types of packaging. After 6 months of storage all chicken patties recorded carbohydrate content ranging from 19.41 – 20.22 % and significantly (P <0.05) higher than all patties stored at 0 month. These values were not significant (P>0.05) among all treatments. The present data are supported with the previous works done by other scientist. Barros *et al*. (2007) have reported that carbohydrates content of cooked parasol mushroom (Macrolepiota procera) was 16.40 g/100g and 80.38 g/100g in the corresponding dried sample. Cooking may promote a loss of nutrient due to interactions among constituents, chemical reactions, and solubility in cooking medium and thermal degradation (Manzi *et al*., 2004).

The significant increment in carbohydrate content after 6 months of storage may be associated with the reduction of concentration of both fat and protein (Table 1) during storage. The reduction of these nutrients may be due to the oxidation of lipid and protein in the chicken patties upon storage. Other reason is perhaps may be due to the disassociation of glucolipids and glycoproteins present in chicken patties that releasing monosaccharide during frozen storage. Similar findings have been reported previously in fish during frozen storage at -20°C where both protein and lipid oxidized during up to 13 months (Baron *et al*., 2007).

Table 1. Nutritional composition of chicken patty containing oyster mushroom packaged with different packaging materials

Nutrient Composition	Storage time (months)	Control	Degradable Plastic (BP)	Paper box (PB)
Moisture (%)	0	^{p}42.25+0.23^{a}	^{p}42.49±0.22^{a}	^{p}43.76+0.19^{a}
	6	^{p}42.64±0.18^{a}	^{p}42.25+0.59^{ab}	^{p}41.93±0.56^{b}
Protein (%)	0	^{p}21.20±0.11^{a}	^{p}22.49±0.22^{a}	^{p}21.20±0.11^{a}
	6	^{p}19.82±0.60^{b}	^{p}21.39±1.35^{a}	^{p}20.22±0.70^{b}
Fat (%)	0	^{p}16.78±0.55^{a}	^{p}16.31±0.27^{a}	^{p}15.23±0.41^{a}
	6	^{p}15.13±0.94^{a}	^{p}15.04±0.05^{a}	^{p}15.68± 0.69^{a}
Ash (%)	0	^{p}2.09±0.18^{a}	^{p}2.04±0.04^{a}	^{p}2.32±0.23^{a}
	6	^{p}2.19±0.18^{a}	^{p}1.91±0.09^{a}	^{p}1.98±0.15^{a}
Carbohydrate	0	^{q}17.68±0.10^{a}	^{q}16.67±0.09^{a}	^{q}17.49±0.13^{a}
	6	^{p}20.22±0.12^{a}	^{p}19.41±0.08^{a}	^{p}20.19±0.11^{a}

$^{a-b}$ Mean values within the same row bearing different superscripts differ significantly (P<0.05)
$^{p-q}$ Mean values within the same column bearing different superscripts differ significantly (P<0.05)

Table 2. Cooking characteristics of chicken patty containing oyster mushroom packaged with different packaging materials

Cooking Attributes	Storage time (months)	Control	Degradable Plastic (BP)	Paper box (PB)
Cooking yield	0	^{p}83.67±0.45^{a}	^{p}84.89±1.08^{a}	^{p}83.16±0.88^{a}
(%)	6	^{p}84.98±1.17^{a}	^{p}83.66±0.08^{ab}	^{p}82.34±0.78^{b}
Moisture	0	^{p}64.75 ± 1.64^{a}	^{p}65.27±1.05^{a}	^{p} 65.42±1.03^{a}
retention (%)	6	^{p}64.71±0.60^{b}	^{p}66.10±0.66^{a}	^{p}64.99±0.66^{ab}
Fat retention (%)	0	^{p}89.21±1.54^{a}	^{p}89.04±0.33^{a}	^{p}88.06±1.78^{a}
	6	^{p}88.84±0.54^{a}	^{p}88.67±1.87^{a}	^{p}89.01±0.85^{a}
Diameter	0	^{p}6.38±1.03^{a}	^{p}6.33±1.37^{a}	^{p}6.73±0.37^{a}
reduction (%)	6	^{p}7.34±0.64^{a}	^{p}7.33±1.57^{a}	^{p}7.68±0.02^{a}

$^{a-b}$ Mean values within the same row bearing different superscripts differ significantly (P<0.05)
^{p} Mean values within the same column bearing different superscripts differ significantly (P<0.05)

Physical traits

Physical characteristics of chicken patties packed with different packaging materials are presented in Table 2. Cooking yield of HDPE (control) recorded the highest cooking yield (85.0%) after 6 months of storage followed by biodegradable plastic (BP) and paper box (PB). Both BP and PB recorded 83.7 and 82.3% cooking yield. Even though BP recorded had slightly lower cooking yield than control but it was not significant (P>0.05). The present result indicated that both BP and PB packaging were able to retain moisture and fat content without affecting the diameter reduction and cooking yield during storage. Unchanged cooking yield recorded after storage for 6 months was detected in both control and BP treatments may probably due to the ability of mushroom used in the formulation who consist of hydrocolloidal fibre to create a tridimensional matrix, holding not only water, but also fat added to the formula, avoiding losses of fat and water during cooking (Inglett *et al*., 2005).

On the other result, it was clearly observed that there were no difference (P>0.05) in both moisture and fat losses after storage for 6 months in all chicken patties wrapped with BP, PB and HDPE (control). These findings may probably due to the moderate

amount of fat content (around 15%) used in the present formulation (Wan Rosli and Solihah 2012). Higher fat content around 29-30% in the common patty formulation will lead to the losses of higher percentage of fat during cooking. This situation may probably due a low density meat protein matrix, along with a high fat content in the formulation. This is in agreement with previous research (Suman and Sharma, 2003) who studied the effect of grind size and levels on the physico-chemical and sensory characteristics of low-fat ground buffalo meat patties. The results of moisture retention of all chicken patties packed with different packaging materials were similar with the trend of cooking yield. The moisture retention was stable after 6 months of storage.

Dietary fibres increased cooking yield because of their high ability to keep moisture and fat in the matrix. This finding is supported by the previous work of (Aleson-Carbonella *et al*., 2005) on the incorporation of lemon albedo fibres in beef patty formulation. Similar findings were documented by (Mansour and Khalil, 1999) (Turhan *et al*., 2005), who have utilized wheat fibres and hazelnut pellicles, respectively in beef patty formulations.

Percentage of diameter reduction was observed slightly increased in all treatments from 6.3-6.7% (0 month) to the values ranged from 7.3-7.7% after 6 months of storage. Even though the diameter reduction values of all treatments were seen increased in line with storage times, but it were not significant ($P<0.05$). This cooking trait values in patties packed with PB and BP were also not significantly different ($P> 0.05$) with control after storage. These findings were similar to the study done by Pinero *et al*. (2008) who reported that there were no significant in diameter reduction of low-fat patty containing oat's soluble fibre and control. The retention of the size and shape of chicken patty during cooking could be due to the binding and stabilizing property of oyster mushroom fibre, which held the meat particle together and resisted changes in the shape of the product (Wan Rosli and Solihah, 2012).

In the present study, the percent of cooking yield during cooking was comparatively higher than the other study. For example, previous study reported that cooking loss of grilled and fried beef patties contained 9-30% of fat were ranging from 22 – 36% (Sheard *et al*., 1998) and Pinero et al. (2008), who reported the cooking loss of 25 and 29% respectively in beef patties incorporated with oat fibres. This present study only used 15% fat in patty formulation and the cooking loss was less than 20% as compared to Sheard *et al*. (1998). From this result, it can be suggested that cooking loss increased proportionally with fat content in patty formulation. As the fat content increases, the mean free distance between fat cells decreases, raising the likelihood of fat coalescing and then leaking from the products. Thus, high fat products tend to lose large amounts of fat during cooking whilst low fat meat products lose relatively little fat (Tornberg *et al*., 1989). Processed meat manufacturers have commonly introduced several modifications in an attempt to offset the detrimental effects of reducing the fat level. In this regard, carbohydrates and fibre have been successful in improving cooking yield and enhancing texture (Gok *et al*., 2011).

Table 3. Beta-glucan and microbial contents of chicken patty containing oyster mushroom packed with different packaging materials

	Storage time (months)	Control	Degradable Plastic (BP)	Paper box (PB)
Beta-glucan	0	$^{p}0.63\pm0.13^{a}$	$^{p}0.77\pm0.10^{a}$	$^{p}0.64\pm0.02^{a}$
(g/100g)	6	$^{p}0.54\pm0.17^{b}$	$^{p}0.74\pm0.02^{a}$	$^{p}0.58\pm0.07^{b}$
Total microbial	0	$^{p}4.79\pm0.09^{b}$	$^{p}4.75\pm0.06^{b}$	$^{p}5.30\pm0.03^{a}$
count (log CFU/ml)	6	$^{q}5.95\pm0.02^{a}$	$^{p}4.80\pm0.06^{c}$	$^{p}5.60\pm0.01^{b}$

$^{a-b}$ Mean values within the same row bearing different superscripts differ significantly ($P<0.05$)
$^{p-q}$ Mean values within the same column bearing different superscripts differ significantly ($P<0.05$)

Total microbial content

On total microbial content, patty wrapped with PB significantly ($P<0.05$) recorded slightly higher value of total microbial content (5.30 log CFU/ml) as compared to patties packed with both BP and control packagings at 0 month of storage (Table 3). Chicken patty packed with BP recorded the lowest total microbial content (4.75 log CFU/ml) but not significantly different as compared to control (4.79 log CFU/ml). This finding perhaps be due to the ability of sago starch-based ingredient formulated in the packaging plastic which exhibits potential antimicrobial property in protecting food stuff from microbial infections (Bajpai *et al*., 2011). After 6 months of storage, all patties recorded higher content of total microbial content ranging from 4.80 -5.95 log CFU/ml) compared to 0 month of storage. However, there were no differences ($P<0.05$) recorded for microbial content in all chicken patties packed with both BP and PB before and after storage for 6 months.

In the present study, microbial counts in all treatments were found to be within the limits as documented by Pinero *et al*. (2008) and Sachindra *et al*. (2005). In spite of the higher moisture retention caused by oyster mushroom dietary fibre added into patty formulation, it appears that their addition did not alter the microbial stability upon freezing. However, comparisons with other related studies are difficult due to differences in raw materials such as protein types, soy-based isolates, formulations used and other non-protein ingredients. These results

indicate that biodegradable plastic and paper box applied in packing chicken patty frozen for 6 months were effective in controlling the microbial growth and provide wholesomeness and safety to the chicken patty.

β-glucan content

During 0 month of storage, both chicken patties packed with BP and PB had β-glucan value in the range of 0.64-0.77 g/100g and not significantly ($P>0.05$) different (Table 3) compared to control patty (0.63 g/100g). During this stage, chicken patty packed with BP recorded slightly higher value of β-glucan content (0.77 g/100g), but it was not significantly different ($P>0.05$) with other treatments. On the other result, after 6 months of storage, all chicken patties packed with different types of packaging materials recorded slightly reduction of β-glucan content. It was clearly observed that chicken patty packed with BP recorded the highest concentration of β-glucan (0.74 g/100g) after 6 months of storage. This value however was significantly higher than chicken patty packed with both PB (0.58 g/100g) and control (0.54 g/100g). In summary, frozen storage does not significantly affects the concentration of of β-glucan in both BP and PB packagings.

Previously, freezing was found to affect β-glucan solubility. Frozen storage of oat bran muffins significantly lowered β-glucan solubility over time, using *in vitro* extraction simulating human digestion (Beer *et al*., 1997). In addition, freeze-thaw cycle reduced the solubility of β-glucan in oat bran muffins by 9% to 55% of the fresh values (El Khoury *et al*., 2012). However, there was no such discussion on the effect of β-glucan incorporated in processed meat-based products during freezing.

Conclusions

The present result indicated that both biodegradable plastic and paper box were able to retain moisture and fat content without affecting the diameter reduction and cooking yield during storage. There were no different in all nutrient analyzed except for carbohydrate after 6 months of storage of chicken patties packed with either biodegradable, paper box or non-degradable packaging. Frozen storage also does not significantly affect the concentration of of β-glucan in both BP and PB packagings. This study indicates that biodegradable plastic and paper box applied in packing chicken patty frozen for 6 months were effective in controlling the microbial growth, unchanged physical traits while providing wholesomeness and safety to the chicken patty.

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