

Preservation of Shellfish Undulate Venus (*Paphia undulata*) by Canning with Different Treatments

Nadia A. Abd-El-Aziz

Meat and Fish Technology Research Department, Food Technology Research Institute, Agriculture, Research Center, Alexandria, Egypt
Email: dr.nadiaahmed@yahoo.com

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Abstract

Our study investigated preservation Undulate venus (*Paphia undulata*) by canning via three treatments that are canned raw, canned smoked and canned cooked as a healthy product with high nutritional value. Results reported that edible meat of *Paphia undulata* was free from Cu, Pb and Cd as a result of washing process. There was significantly ($p < 0.05$) higher in moisture content of canned raw compared with other tow treatments of canned smoked and canned cooked of *Paphia undulata*, and there was significantly reduction of protein content ($p < 0.05$) in tow treatments of canned smoked and canned cooked compared with the canned raw. Significant different ($p < 0.05$) in fat content was canned raw $<$ canned smoked $<$ canned cooked. On the other side, the three treatments of canned shellfish *Paphia undulata* had significant difference ($p < 0.05$) in content of ash and carbohydrates content. Canned smoked of shellfish *Paphia undulata* showed the lowest value of pH. All treatments of canned shellfish *Paphia undulata* were rich in minerals where canned raw treatment was higher in Ca, Fe, Zn, Mg, and Mn. While canned smoked had minerals content lower than canned raw. Lightness (L^*) had slightly difference between all treatments of canned shellfish *Paphia undulata*. Reduction on lightness and redness was noticed at the same time in all treatments of canned shellfish *Paphia undulate*, canned raw had the highest value of lightness (L^*), and redness (a^*). Canned smoked had the highest value of hardness followed by canned raw then canned cook. Slightly significant difference ($p < 0.05$) was noticed between three treatments in sensory properties, data showed that all panelists preferred canned cooked than raw canned and canned smoked, degree of canned cooked was excellent.

Keywords

Shellfish, *Paphia undulata*, Canning, Smoking

1. Introduction

Shellfish are animals that dwell in water and have a shell or shell-like exterior. We can divide shellfish into two groups: first are crustaceans and second are mollusks. Crustaceans are invertebrates with segmented bodies, protected by hard shells made of chitin, and include shrimp, lobster, crayfish, crab, and krill. Mollusks are invertebrates with soft bodies, divided into foot and visceral section. Clams, scallops, oysters, and mussels are examples of mollusks. Shellfish are rich in protein, and healthy fats, contain high amounts of certain micronutrients, including vitamins and minerals such as iron, zinc, magnesium, inorganic phosphate, sodium, potassium, selenium, iodine, and also other nutrients. Regularly eating shellfish may increase immunity, and promote brain and heart health [1] [2].

Shellfish to be eaten raw are very high risk products, some of these hazards are specific for shellfish and are related to the environment where the animals are captured, and may contaminate with pathogens bacteria. The consumption of shellfish (such as crab, shrimp, and krill, etc) as an important nutritional source is increasing globally [3]. Nevertheless, shelf-life of shellfish is normally limited, mainly associated with the microbial growth and quality deterioration over the whole supply chain [4].

Undulate venus (*Paphia undulata*) is an abundant marine shellfish resource, which widely cultured and it sold at a low price and high economic benefit. *Paphia undulata* is a good source of protein, consisting of approximately 68.77% crude protein “dry weight basis” [5]. *Paphia undulata* was content with high proteins especially essential amino acids which consider an essential source of nutrients for many people, especially in developing countries [6].

Contaminate shellfish with toxic heavy metals, such as mercury (Hg), cadmium (Cd), and lead can cause adverse health effects [7]. Processed shellfish products must get rid of pathogenic organisms but if the processing treatment is not adequate to eliminate them, many cases of botulism are associated with this product which subjected to inadequate thermal treatment [8].

Shellfish meat is frequently eaten raw in some European countries. For this purpose, the whole live oyster is subjected to cleansing process for 36 h in recirculated seawater and is treated with ultraviolet light or for 48 h in chlorinated seawater in static tanks with a change of water after 24 [9].

Canning is an important, safe method of food preservation when practiced properly. The canning process includes placing foods in jars and heating them to a temperature that destroys microorganisms that could be a health hazard or cause the food to spoil. Also, canning inactivates enzymes that could cause the food to spoil. Raw seafood may contain microorganisms that cause food poisoning. These bacteria are destroyed by heating the seafood before eating. On the other hand, canning provides a shelf life that typically ranges from one to five years [10] [11].

Smoking of meat and meat products is one of the oldest processing methods

in food preservation. Smoke not only gives special taste, colour and aroma, but also enhances preservation due to the dehydrating, bactericidal and antioxidant properties of smoke [12].

Therefore, this study aimed to produce a healthy product with high nutritional value, rich in mineral, free from heavy metals and bacterial hazard by canning Undulate venus (*Paphia undulate*) with tree treatment to extend its shelf life and preserve the quantities of corruption.

2. Material and Methods

2.1. Material

Fresh tomato, green pepper, onion, garlic and celery, refined fine iodized common salt, spices blend mixture white, red and black pepper, cumin, paprika, corn oil, tomato sauce, natural smoke concentrate (Meat and Fish Technol. Res. Dept, Agriculture Research Center), fresh shellfish [undulate venus (*Paphia undulata*)], was obtained from Alexandria fish market, and cans were obtained from a local market, Alexandria city, Egypt. All reagents and chemicals used in this study were an analytical grade

2.2. Methods

2.2.1. Technological Methods

Preparation of shellfish: Undulate venus (*Paphia undulata*) was washed and cleaned of mud and dirt by a water, To get the best quality product, raw shellfish (should be alive until use) so we were looked for tightly closed shells. If the shells are gaping open or don't close when we wash them or put them in cold water, we discard the shellfish, the *Paphia undulata* was subjected to a cleaning process by the method suggested by [13] for clams and mussels. then *Paphia undulata* soaked in tap water for 8 h with changing water every one hour, to get rid of heavy metals, then washed to remove mud, drained, steamed at 100°C for 10 minutes, cooled at room temperature, during this process the shells open up and shucking becomes easy, and separation edible meat from shellfish the meat was washed well to free it from grit and dirt.

Smoking of *Paphia undulate*: edible meat of soaked (*Paphia undulate*) was smoked by liquid smoke solution (natural smoke concentrate: water as 1:1 v/v), since the edible part of (*Paphia undulata*) was soaked and sprayed by liquid smoke solution each 5 min. The smoking process was carried out in a smoking kiln (AFOS, MK2, Torry mini & maxi smoker, England) at 70°C for 1hr then the samples were obtained and cooled.

Seafood soup preparation: (*Paphia undulata*) after washed and soaked in water cooked with ingredients fresh tomato, green pepper, onion, garlic, celery, salt, spices blend mixture white, red and black pepper, cumin, and paprika, at 100°C for 15 min.

Canning of *Paphia undulate*: three treatments of canning shellfish (*Paphia undulata*) were prepared 1) raw edible meat of *Paphia undulata* canned in 2%

sodium chloride solution with 8% tomato sauce as filling media (canned raw), 2) smoked edible meat of *Paphia undulata* canned in 2% sodium chloride solution as filling media (canned smoked), 3) canned cooked edible meat of *Paphia undulata* as seafood soup. filling media was soup, (canned cooked), all treatment were blanched in 100 g and packed with different filling media in lacquered cylinder tin cans of dimensions (h = 11 cm, diameter = 6.5 cm) considering leave head space. Cans were crimped and sterilized at 121 °C for 20 min.

2.2.2. Analytical Method

1) Physicochemical properties: The colour values, lightness (L^*), redness (a^*) and yellowness (b^*), of food samples were evaluated using a Hunter Lab Ultra Scan, VIS model, colorimeter (USA). The instrument was standardized during each sample measurement with a black and white tile ($L^* = 94.1$, $a^* = 1.12$, $b^* = 1.26$). Mean of five readings of each colour index of Hunter scale (L^* , a^* , b^*) were recorded [14].

Texture Profile Analysis (TPA) of canned shellfish was performed using TA-XT 2 Texture meter (Texture Pro CT3 V1.2, Brookfield, Middleboro, USA) as described by [15]. Force time deformation curves were obtained during applying a 5 kg load cell, at a 1 mm/s cross head speed. The following texture attributes were calculated hardness.

2) Chemical analysis:

Proximate composition: Moisture, crude protein, crude fat and ash contents canned shellfish were determined according to [16], while carbohydrates were calculated by difference.

pH was determined using pH meter type MVX100 Beckman (USA) at room temperature ($22^\circ\text{C} \pm 3^\circ\text{C}$) as described in [16].

Heavy metals: Pb, Cd and Cu concentration in canned shellfish sample were determined after digestion using ICP-OES according to the method of [17].

Minerals determination: Ca, Fe, Zn, Mg and Mn were determined using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-OES) according to standard method US EPA Method 200.7 and US EPA Method 6010 C.

2.2.3. Sensory Evaluation

Colour, texture, taste, odour and overall acceptability of canned shellfish were organoleptically evaluated using 10 trained panelists from, Food Science and Technology Department, Faculty of Agriculture, Alexandria University. They were asked to rate their acceptabilities of canned shellfish products according to nine point scale, ranging from the like extreme 9 to dislike extreme 1 point as described by [18].

2.2.4. Statistical Analysis

Data was statistically analyzed using Statistical Package for Social Sciences (SPSS) software version 22. The level of significant difference was determined at $P \leq 0.05$. Mean \pm Standard Deviation (SD) of mean was used.



Canned raw



Canned smoked



Canned cooked

3. Results and Discussion

3.1. Chemical Composition

3.1.1. Heavy Metals Concentration

Table 1 showed the concentration of Cu, Pb and Cd (mg/kg) in *Paphia undulata*, in fresh shellfish *Paphia undulata* and after soaking in tap water and washing before canning process. Results reported that edible meat of *Paphia undulata* were free from Cu, Pb and Cd as a result of washing process that get rid all traces of Cu which found in edible meat before washing. [19] showed that edible tissues of wild-caught crab, were detected some toxic elements above the standard of food safety. this therefore might pose a threat to human health. [20] reported that soaking oyster meat with epigallocatechin-3-gallate after washing with slightly acidic electrolyzed water could be stored for 13 days with good quality both microbiological and physico-chemical properties under cold storage.

[21] showed that the levels of cadmium in samples of fish and meat products analyzed ranged from 0.77 to 1.04 µg/100 (mean: 0.91 µg/100 g), this is below the codex committee on food additives and contaminants [22] draft guideline of 0.5 mg Cd/kg. Cadmium may accumulate in the human body and may induce kidney dysfunction, skeletal damage and reproductive deficiencies Lead is known to induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular disease in adults, [23]. Copper is essential for good health but very high intakes can cause health problems such as liver and kidney damage [24]. The upper tolerable intake level of copper for children (1 - 3 years old) and males/females (19 - 70 years old) is 1 and 10 mg/d, respectively [25].

3.1.2. Proximate Composition

Table 2 showed that moisture content of shellfish canned were ranged form 71.46% to 74.33% It was significantly higher in canned raw than other tow treatment canned cooked, and canned smoked, was the lowest in moisture content, this attributed to different treatment before canning. canned raw was highest moisture content because it was not exposed to smoking and cooking process which due to reduction of moisture value [26] reported that smoking caused reduction in moisture content due to muscle dehydration. [27] showed that the proximate compositions of cooked meats crab were not much different according to the species, which contained 76.9% - 80.7% moisture.

On dry weight basis, the three treatments of canned shellfish (*Paphia undulata*) were considered rich in protein 73.67%, 68.64%, and 60.63% in canned raw, canned smoked and canned cooked respectively, There was significantly reduction of protein content ($p < 0.05$) in smoked and cooked treatments, this mean that shellfish (*Paphia undulata*) a good source of protein and these reduction in protein content attributed to heat effect in smoking and cooking process. In addition proteins can react directly with reactive oxygen formed during drying and smoking processes, whereas heat due to degradation of protein in canned cook comparison with the canned raw. Canned smoked shellfish (*Paphia undulata*)

Table 1. Heavy metals concentration (mg/kg) in edible meat of (*Paphia undulata*) as row material before canning.

Heavy metals	Concentration (mg/kg) Wwb*		Maximum Permissible level (mg/kg)	Recommended by
	Zero time	After washing and soaking		
Copper (Cu)	6.16	N.D***	30.0	FAO (1992)
Lead (Pb)	N.D	N.D	2.0 0.1	FAD (2001) (EOSQC, 1993)
Cadmium (Cd)	N.D	N.D	3.0 1.0	FAO (1992) EOSQC (1993)**

* Wet weight basis; **Egyptian Organization for Standardization and Quality Control (EOSQC, 1993).

Table 2. Proximate composition, and pH of canning (*Paphia undulata*).

Component (%)	Canned raw	Canned smoked	Canned cooked
Moisture	74.33 ± 0.56 ^a	71.46 ± 0.30 ^c	72.29 ± 0.16 ^b
Crude protein	73.67 ± 0.11 ^a	68.64 ± 0.16 ^b	60.63 ± 0.15 ^c
Crud fat	8.49 ± 0.34 ^c	9.23 ± 0.16 ^b	14.96 ± 0.14 ^a
Ash	8.68 ± 0.22 ^c	12.39 ± 0.10 ^b	19.59 ± 0.22 ^a
Carbohydrate*	9.16 ± 0.06 ^b	9.74 ± 0.22 ^a	4.82 ± 0.18 ^c
Total caloric value (kcal/100 g)	407.73	396.66	397.12
Percentage of protein calories to total cal.	18.07	17.34	15.26
pH value	5.03 ± 0.07 ^b	4.53 ± 0.01 ^c	5.47 ± 0.02 ^a

Data as mean ± SD. Means in the same column sharing the same letters are not significantly different at $P \leq 0.05$ level.

was higher protein content than canned cooked shellfish (*Paphia undulata*) as a results of high temperature of cooking process.

[5] showed that *Paphia undulata* contains higher protein contents, especially sarcoplasmic protein and myofibril protein, and it's a good source of protein, consisting of approximately 68.77% crud protein (dry weight basis). [28] reported that the protein content of all investigated oyster samples varied from 44.5% to 51.2% DW. There were no significant differences between species, locations and harvesting time.

In general, shellfish has higher protein contents than fin fish. Unlike vertebrates, raw shellfish muscle, in addition to myosin and other myofibrillar proteins, also contains the protein, paramyosin up to 19% (w/w) [29].

Seafood is an excellent source of proteins and contains all essential amino acids and the proteins are easily digested; most proteins show a digestibility above 90% [30] Shellfish proteins have PER values that are slightly above that of casein, the major milk protein [31]. Shellfish proteins provide all the essential amino acids for maintenance and growth of the human body [32]. Shellfish and other seafood are good sources of branched chain amino acids and taurine, which act beneficially on glucose metabolism and also blood pressure [33]. This mean that shellfish (*Paphia undulata*) which canned with different treatment in this study is considered a healthy and safety food for human consumption.

Fat content was 8.49%, 9.23% and 14.96% in canned raw, canned smoked and canned cooked, respectively. Significant different ($p < 0.05$) in fat content was found as a result of smoking process which cause decrease in moisture content therefore increasing in fat content canned smoked was noticed, while more increasing fat noticed in canned cooked *Paphia undulata* due to using corn oil in preparing seafood soup by *Paphia undulata* as a filling media of canned cooked. Heat treatments such as boiling and steaming, in general, have little impact on proximate composition of shellfish [34]. Shellfish items have low crude lipid contents, generally up to 2% (w/w), the lipid contents of several shellfish have appreciable proportions of n-3 (omega-3) long-chain polyunsaturated fatty acids PUFAs [35] on the other hand the three treatments of canned shellfish *Paphia undulata* had Significant different ($p < 0.05$) in content of ash and carbohydrates content were (8.68%, 12.39% and 19.59%) and (9.16%, 9.74%, and 4.82%) in treatment canned raw, canned smoked and canned cooked respectively. Effect of heat treatment and ingredients which added to canned cooked noticed clearly in ash and carbohydrate content. [36], the raw red snow crab (body and leg muscles mix) consisted of 87.1% moisture, 10.6% protein, 0.3% lipid and 1.8% ash on w/w.

The contents of carbohydrate including dietary fiber in shellfish tissue are low. Carbohydrate varies from 1.3% in cooked lobster meat to 2% to 3% in oyster, and the green mussel [37]. Total calories value for canned shellfish (*Paphia undulata*) were 407.73, 396.66 and 397.12 Kcal/100 g of food and the percent protein derived calories were 18.07%, 17.34%, 15.26% for canned raw, canned smoked and canned cooked respectively. This mean the canned product rich in protein content with low total calories due to their low lipid and carbohydrate contents [2].

3.1.3. pH

pH value for canned shellfish *Paphia undulata* canned raw, canned smoked and canned cooked was 5.03, 4.53, and 5.47, respectively. the low value of pH in canned raw contribute to tomato sauce as a filling media which added to shellfish *Paphia undulata* but canned smoked this low pH as a result to smoking process and producing smoke compounds such as organic acids which cause reduction in pH value. Cooking process and present of ingredient which added to shellfish behind increase of pH in canned cooked shellfish *Paphia undulata*.

During smoking there is a reduction in water activity and in pH values as a result of heating, drying and deposition of some bactericidal compounds present in the smoke (phenol, derivatives, aldehydes and organic acids). These changes lead to the inactivation of enzymes and microorganisms responsible for deterioration, thus increasing the shelf life [38]. The pH value of fresh (*Laubuka dadiburjori*) fish was 6.8. Drop off pH value after canning process to 5.9 in canned fish [39]. The higher pH values observed in canned samples may be due to the formation and accumulation of some dibasic amino acid as a result of breakdown and proteolysis of proteins during heat treatment [40].

3.1.4. Mineral Content

Data in **Table 3** showed that three treatments of canned shellfish *Paphia undulata* were rich in minerals and canned raw treatment was higher in Ca, Fe, Zn, Mg, and Mn 81.19, 10.35, 8.94, 30.74, and 0.85 mg/100 g respectively. While canned smoked had minerals content lower than canned raw 79.18, 8.83, 4.85, 23.55 and 0.63 mg/100 g respectively, at the same time canned cooked was the lowest in content minerals as 75.68, 9.79, 4.71, 25.52 and 0.61 mg/100 g respectively. This mean that a slightly reduction in minerals content noticed as a result of smoking and cooking process. The levels of manganese (Mn) in the all samples ranged from 0.61 to 0.85 mg/100 g. National Research Council of Canada (NRC) has recommended that the safe and adequate daily intake levels for manganese that range from 0.3 to 1 mg/day for children up to 1 year, 1 - 2 mg/ day for children up to age 10, and 2 - 5 mg/ day for children 10 and older. While, the upper may intake level of manganese for children (1 - 3 years old) and males/females (19 - 70 years old) is 2 and 11 mg /day respectively [25]. Daily intake of small amounts of manganese is needed for growth and good health in humans otherwise loss of manganese can cause nervous system problems.

The results in **Table 3** showed that the iron (Fe) concentrations in all samples ranged from (8.83 to 10.35 mg/100 g) so that fish is a major source of iron for adults and children. Iron deficiency causes anemia. The recommended dietary allowance of iron for infants and males/females 51 - 70 years is 11 and 8 mg/day, respectively [25].

The data obtained that the zinc contents of samples were ranged from 4.71 to 8.94 mg/100 Zinc is an essential element in human diet. Too little zinc can cause problems, however too much zinc is harmful to human health [24]. The upper tolerable intake level of zinc for children (1 - 3 years old) and males/females (19 - 70 years old) is 0.2 and 1 mg/day, respectively [25]. Zinc helps in immune functions, healing of wounds, development of bones, and the cell membrane structure and functions. Zinc also may have a protective effect against atherosclerosis because of its anti-inflammatory and antioxidant functions [41]. Shellfish minerals contain microelements (sodium, potassium, calcium phosphate and magnesium, iron, selenium zinc and manganese [42]. Minerals are essential to human health, which cannot be synthesized by our body and have to be taken in from external environment [43]. Therefore, content of mineral element in fishery product is important for us to evaluate its nutritional quality [44].

Table 3. Minerals content (mg/100 g) of canned (*Paphia undulata*).

Minerals mg/100 g	Canned raw	Canned smoked	Canned cooked
Ca	81.19	79.18	75.68
Fe	10.35	8.83	9.79
Zn	8.94	4.85	4.71
Mg	30.74	23.55	25.52
Mn	0.85	0.63	0.61

3.2. Physicochemical and Sensorial Properties

Colour: The colour of the product plays a pivotal role in the acceptability of the food product. Results in **Table 4** showed that lightness (L^*) had slightly different between all treatments. Canned shellfish *Paphia undulata* reduction on lightness and redness was noticed at the same time in all treatments of canned shellfish *Paphia undulata*. Canned raw had highest value of lightness (L^*), and redness (a^*) 47.02 and 12.76 respectively, compared with other treatments, and had lowest value of yellowness value 13.26 compared with canned smoked and canned cooked. Canned smoked had lowest value of lightness (L^*) 43.46 and highest value of yellowness (b^*) 21.29 as a result of smoking process which change the colour of shellfish to golden yellow, so that canned smoked had low value of redness (a^*) 7.91 compared with canned raw. Canned cooked had value of lightness (L^*) was 44.36, redness (a^*) 6.59 and yellowness 15.24. It had lowest value of redness (a^*) compared with other treatments due to the ingredient which added in cooking process. Higher decrease in redness a^* values were reported for canned tuna with vegetables due to deposition of pigments migrated from vegetables. [45]. In muscle tissue, high temperature could induce the modifications of optical characteristics, which contributed to the changes in color [46]. These changes might be increased with prolonged cooking time. Also, increased lightness for cod fillets with increasing temperature and time, treated Atlantic mackerel had an increased L^* with increasing temperature [47].

Texture Data in **Table 4** reported texture of the three treatment of canned shellfish *Paphia undulata* as a hardness parameter that highest value noticed in canned smoked 123 g followed by canned raw with hardness value 109 g and canned cooked with hardness value 54 g. The increase in the hardness upon thermal processing could be attributed to the heat treatment which reduces the water content of meat thereby improving the firmness of the meat [48]. And could be attributed to the loss of binding properties of connective tissue due to thermal denaturation of protein [49].

Sensory properties: According to sensory evaluation panelists accepted all treatments of canned shellfish *Paphia undulata* (**Table 5**). The degree of the preference of colour, odour, taste, texture and overall acceptability was very good and excellent. Slightly significant difference ($p < 0.05$) was noticed between three treatments, data showed that all panelists prefer canned cooked than raw canned

Table 4. Colour and texture characteristics of canned *Paphia undulata*.

Parameter	Canned raw	Canned smoked	Canned cooked
<u>1-Colour</u>			
Lightness (L^*)	47.02	43.46	44.36
Redness (a^*)	12.76	7.91	6.59
Yellowness (b^*)	13.26	21.29	15.24
<u>2-Texture</u>			
Hardness (g)	109	123	54

Table 5. Sensory properties of canned *Paphia undulata*.

Sensory properties	Canned raw	Canned smoked	Canned cooked
Odour	8.0 ± 0.94 ^b	8.2 ± 1.13 ^b	9.0 ± 0.00 ^a
Colour	8.5 ± 0.70 ^a	8.3 ± 1.15 ^a	9.0 ± 0.00 ^a
Taste	8.1 ± 0.87 ^b	8.4 ± 0.51 ^b	9.0 ± 0.00 ^a
Texture	8.2 ± 0.91 ^{ab}	8.0 ± 0.94 ^b	8.9 ± 0.31 ^a
Appearance	8.0 ± 0.94 ^b	8.3 ± 0.82 ^{ab}	8.9 ± 0.31 ^a
Overall Acceptability	7.9 ± 1.19 ^b	8.0 ± 0.94 ^b	8.9 ± 0.31 ^a

Data as mean ± SD. Means in the same column sharing the same letters are not significantly different at $P \leq 0.05$ level.

and canned smoked, degree of canned cooked was excellent, followed by canned smoked and the last one was canned raw. Smoking cause changes in the sensory characteristics such as flavor, texture, aroma and color.

In addition golden yellow, and cooked shellfish as seafood soup and canned with soup as a filling media resulted excellent taste, odour and colour.

4. Conclusion

The above data confirmed the successful production canned shellfish *Paphia undulata* as a new product and preservation of shellfish *Paphia undulata* by canning with different treatment as raw smoked and cooked. New product was safety, and healthy, and high protein and minerals content and with excellent sensory properties.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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