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Quality indicators in nanche (Byrsonima crassifolia L.) fruits from Guerrero and Chiapas, Mexico

Abstract

The nanche (Byrsonima crassifolia) is a wild, rustic and native plant of Mexico and Central America,it adapts to different edaphic and climatic conditions. The objective was to analyze the quality indicators of the nanche fruits of Guerrero and Chiapas. Completely random samplings were carriedout in three and two localities of Guerrero and Chiapas, respectively, in 5 trees of each locality, collecting 50fruits per tree. The indicators analyzed were: fruit weight, fruit density, polar and equatorial diameter, oBrix, firmness, epidermis thickness, pulp weight, seed weight, luminosity, chromaticity and hue. The correlation between equatorial diameter/weight and lightness/chroma with r 2 of 0.93. Localities of Guerrero with greater statistical difference: Paso del Real was in weight, equatorial diameter; epidermis and seed. The fruits from Las Tunas were outstanding in oBrix, hue and seed weight, and those from San Jerónimo, Guerrero, recorded higher fruit density and equatorial diameter. The localities of Chiapas with the greatest statistical differences: Santo Domingo in density,polar diameter, firmness and pulp, and Mixiquito in fruit density and luminosity. It is concluded that the quality indicators of the nanche fruits collected in Guerrero and Chiapas have a wide distributionand decision making in the selection of trees with specific characteristics.

Keywords: Quality indicators, Byrsonima crassifolia, Guerrero, Chiapas

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Introduction

The nanche (Byrsonima crassifolia) is a wild, rustic and native plant of Mexico and Central America.[1] Data from the Agrifood and Fisheries Information System[2] cite Guerrero (3,500 t), Nayarit (986.6 t) and Michoacán (782.9t) as the entities with the highest production of this fruit. Nanche trees adapt to different edaphic conditions and with a wide distribution in climates, from warm subhumid (Aw) and semiwarm subhumid (A)C(w),[3] although the humid tropical is preferred. Nanche trees are used as living fences, they are also found along roads and stream banks, in backyards of houses as ornamental plants and in the Cañada de Alpoyeca and Huamuxtitlan, Gro., their cultivation interspersed between trees is incipient mango, mamey and citrus. Flowering begins in April and fruit ripening from June to October. Families with limited economic resources walk long distances to reach the sites where the trees in production grow and collect the ripe fruits. The collection is carried out in the mornings or afternoons,the physiologically mature fruits are cut from the branches and those that have fallen to the ground are gathered and deposited in buckets and later in wooden boxes to be transported to the collection and sale centers. The fruits are sold in regional markets[1] and by street vendors in the main cities. The fruits are consumed naturally due to their characteristics and properties, they are pulpy, yellow in color, strong aroma, bittersweet flavor and small drupes,[4] with content of soluble carbohydrates, fiber, minerals (Ca and P), Vitamin C and functional elements such as catechins, tannins and carotenoids.[5] The nanche fruit has the potential to be industrialized,[6] currently ice cream, fresh water, alcoholic beverages, fermented beverages, in syrup and jams are made, so its use is varied. Due to the above, the purpose of the study was to analyze the quality indicators of nanche fruits (Byrsonima crassifolia L.) collected in localities of the state of Guerrero and Chiapas. The indicators analyzed were fruit weight, fruit density, equatorial and polar diameter, pulp weight, epidermis weight, seed weight, total soluble solids (oBrix) and color (luminosity, chromaticity and hue).

Materials and methods

The nanche (Byrsonima crassifolia, L.) is a tree distributed in ecosystems and agroecosystems with different climatic, edaphic and altitude conditions in the state of Guerrero and Chiapas (Table 1). The sampling was carried out in localities of the municipality of Coyuca de Benítez and Benito Juárez, Gro., the climate is Awo warm subhumid, and Santo Domingo and Mixiquito, Chiapas, the average annual temperature of Tapachula Chis of 24.8ºC and rainfall 1200mm.

Table 1 Collection site of the nanche of the state of Guerrero and Chiapas, 2022

States	Municipality	Locality	msnm	Soiltexture
Guerrero	Coyuca de Benítez	Paso Real	90	Arenoso
	Benito Juárez	Las Tunas	10	Arenoso
		San Jerónimo	90	Arenoso
Chiapas	Unión Juárez	Santo Domingo	850	Limoso
	Tapachula	Mexiquito	640	Limoso

Experimental design: The collection was made in five Byrsonima crassifolia trees selected completely at random by locality in each entity. The trees were marked with paint for identification.From each tree, 50 mature fruits without physical damage were collected, placed in paper bags and labeled for identification. The bags were placed in a cardboard box to avoid damage and physical deterioration, and they were transported to the laboratory of the Faculty of Agricultural Sciences C- IV, of the Autonomous University of Chiapas. The collections were on June 26 and 27 and July 2, 2018, in both States, with hours from 6:00 a.m. to 5:00p.m in Figure 1.

Analyzed indicators: the collected Byrsonima crassifolia fruits were individually weighed on a digital scale, recording in grams (g). The density of the fruit was determined in a 100 mL test tube, 30mL of water were added, the fruit was introduced and the volume of displaced water was recorded,expressed in g/mL (g mL-1). The polar diameter

was measured with Vernier (Truper) from the peduncle to the apex and the equatorial diameter in its central part, the values were recorded in millimeters (mm). Firmness was determined with a Precision Scientific Universal Penetrometer of 0.4amps, model 73515 BF-02, the penetration cone was placed on the epidermis of the fruit in the equatorial zone, previously the apparatus system was activated for 15 seconds before taking the reading, which was expressed in Newton (nW). The epidermis was detached from the pulp with a dissection needle, which was inserted to detach the epidermis, without removing pulp, then it was weighed on a digital scale, the values were expressed in grams (g). The pulp was separated from the seed with a spatula, weighed on a digital scale and data was recorded in g. The seed was weighed ona digital scale and the data was expressed in g. The oBrix constitute the percentage of total soluble solid contained in the pulp of the fruit of Byrsonima crassifolia (nanche) and were determined with a Baunch & lomb model 39-45-01 hand refractometer, with values of 0 - 32 oBrix at 20 ºC. Juice was extracted from 10 fruits per tree with an extractor, the drop of juice was placed under the lens of the refractometer and the reading was taken. The color was determined with a manual spectrophotometer (X-ritemod. 3290®, USA) of the epidermis (peel) of ripe fruits. The color parameters L*, a* and b*, where L*, luminosity (0 = black and 100 = white); a* and b*, the rectangular color coordinates (+a =red, -a = green / +b = yellow and –b = blue). On the other hand, chroma or Chromaticity (C*) indicates purity, intense or vivid on a scale of 1 to 100, the latter value expressing greater purity (Patrón, 2010; Patrón et al., 2012); the saturation index (Chromaticity C* S = (a2 + b2)1/2 and hue (ºHue) (tan- 1(b/a) , with a manual spectrophotometer (X-ritemod. 3290®, USA).

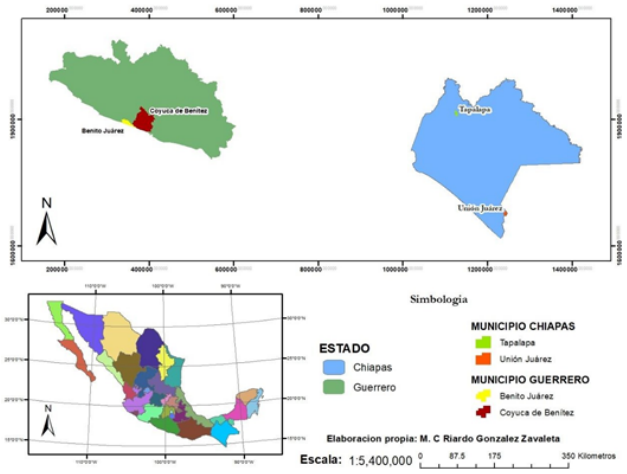

Figure 1 State of Guerrero and Chiapas, Mexico, where nanche fruits (Byrsonima crassifolia, L.) were sampled.

Statistical analysis: the indicators were analyzed with the statistical package SAS 9.0 (Statistical Analysis Software, NC, USA), a Pearson correlation matrix was determined, the correlation coefficients with r2 ≥ 0.75 and Pr < 0.0001 were selected, at these r2 performed simple linear regression by indicator and determined the Coefficient of Determination (R2); Finally, the quality indicators were statistically analyzed and the means were grouped with the Tukey multiple range test(α = 0.05%) to perform the corresponding interpretation.

Results and Discussion

Table 2 shows Pearson's correlation (r2), r2 ≥ 0.75 and Pr ≤ 0.0001; From these correlations, a linearregression, its determination coefficients (R2) and the generated models were determined. Fruit weight correlated positively with fruit density with r2 of 0.84 and R2 of 0.70, which indicates that 70% of the variability recorded in the density of the fruits (g mL-1) of Guerrero and Chiapas is explained by the weight of the fruit. The equatorial diameter correlated with the weight, density andpulp content, with r2 of 0.93, 0.79 and 0.80, with values of R2 = 0.87, 0.63 and 0.65 respectively, therefore, 87, 63 and 65% of variability in weight of the fruit, the density and pulp content are explained by the equatorial diameter of the fruits from Guerrero and Chiapas. The pulp content correlated positively with fruit density and weight, with r2 of 0.85 and 0.83 and R2 of 0.72 and 0.72respectively, therefore, 72% of the variability of the density and weight of the fruit are due to the content of pulp in the fruits collected in Guerrero and Chiapas. The luminosity correlated with chromaticity and hue or hue, with r2 of 0.93 and 0.78 and coefficient of determination (R2) of 0.87 and 0.61 respectively, that is, 87 and 61% of the chromaticity and Hue of the fruits of Guerrero and Chiapas were due to the luminosity attribute. The quality indicators in the nanche fruits were variablebetween locations in Guerrero and Chiapas. Quality indicators or attributes are important in productsfor industry and in the selection of germplasm with specific characteristics, for the production of seedlings in nurseries, reforestation and establishment of orchards.

Table 2 Pearson correlation coefficients and determination in quality indicators of Byrsonima crassifolia (nanche) from three locations in Guerrero and two in Chiapas, Mexico, 2022

Correlation	Statistical parameters			
	r^2	R^2	CV	Modelo
Fruit weight / density	0.8413	0.7078	13.7273	1.9109 + 0.3495x
Equatorial diameter / weight	0.9349	0.8741	3.6343	11.4164 + 1.8665x
Equatorial diameter / density	0.7942	0.6307	6.2236	14.9506 + 0.6586x
Equatorial diameter / pulp	0.8096	0.6555	6.0116	13.7893 + 1.9717x
Pulp / fruit density	0.8542	0.7296	17.3918	0.8129 + 0.2909x
Pulp / fruit weight	0.8383	0.7297	17.0257	0.8129 + 0.2909x
lightness / chroma	0.9343	0.8731	6.0991	17.7442 + 0.9012x
Lightness / tint or hue	0.7866	0.6187	10.5716	2.5574 + 0.8438x
Chroma/hue or hue	0.8429	0.7104	12.1537	-16.9449 + 0.9375x

Tukey's test (α<0.05) between states: Guerrero and Chiapas

In Table 3, it is observed that the weight of the fruit had significance with R2 of 20% of the variabilityof the fruits, it was determined that the fruits from Guerrero had more weight than those from Chiapas,with a difference of 0.46 g between the two. The fruits from Chiapas had higher density than those from the state of Guerrero, presenting R2 of 27% with a difference of 1.11 g mL-1 between them. The fruits from Chiapas had a greater polar diameter, that is, more elongated, with 0.75mm on average than those from Guerrero with R2 of 30 % variability. The equatorial diameter with R2 of 28% of the variability, indicates that at least one State presented different results, the fruits of Guerrerohad a greater equatorial diameter, they are rounder with 0.46 mm more than those of Chiapas. The Chiapas fruits had greater firmness with R2 of 68 % of the variability, the result is attributed to the time of collection and analysis of the fruits. The fruits from Guerrero presented greater epidermis with R2 of 47 % of the variation in the thickness of the shell, that is, the fruits from Guerrero are thicker than those from Chiapas. The fruits of Chiapas with R2 of 18% of the variability of the pulp,on average 0.38 g more pulp than those of the state of Guerrero. The state of Guerrero with R2 of 32% of the seed weight variability, on average was 0.18 g more than those of Chiapas, that is, the fruitsof Guerrero with larger seed size and less pulp. The fruits from Chiapas presented greater luminosity (L) with R2 of 33%

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of the variability of the fruits than those from Guerrero, that is, the fruits from Chiapas are more luminous than those from Guerrero. The fruits of Chiapas present a variability in the chromaticity or color purity with R2 of 27% compared to those of Guerrero. Hue is the dominant spectral color in degree of saturation, with R2 of 40% of the variability of the pigment in the fruits ofGuerrero compared to those of Chiapas. It is concluded that in weight, equatorial diameter, epidermis,seeds and hue, the fruits from the state of Guerrero presented a higher average than those from Chiapas, while those from Chiapas were higher in density, polar diameter, firmness, luminosity and chromaticity. The fruit indicators presented variability, perhaps related to the edaphic and climatic conditions.

Table 3 Coefficient of Determination R2 and separation of averages of quality indicators [Tukey(0.05)] of nanche fruits from locations in Guerrero and Chiapas, Mexico, 2022

				Locations				
Indicators	**R2**	**Guerrero**	**Chiapas**	**Guerrero Pasodel Real**	**San Jerónimo**	**Las Tunas**	**Chiapas Santo Domingo**	**Mexiquito**
Pf	0.20	4.01 a	3.55 b	4.39 a	3.96 cb	3.93 b		3.38 c
Df	0.27	4.56 b	5.67 a	4.42 b	5.51 a	3.74 c	5.70 a	5.64 a
Dp	0.30	15.52 b	16.27 a	15.79 b	14.96 c	15.80 b	16.36 a	16.17 ba
De	0.28	18.53 a	18.07 b	19.10 a	18.88 a	17.62 c	18.20 b	17.94 cb
Fi	0.68	7.82 b	9.61 a	8.29 c	7.59 d	7.60 d	10.19 a	9.02 b
Ep	0.47	0.08 a	0.07 b	0.10 a	0.06 d	0.08 b	0.07 cb	0.07 c
Pu	0.18	2.28 b	2.66 a	2.59 a	1.99 c	1.99 b	2.79 a	2.27 ba
Ps	0.32	0.56 a	0.38 b	0.57 a	0.50 b	0.61 a	0.42 c	0.34 d
Bx	0.39	11.46 a	11.69 a	10.78 b	11.17 b	12.44 a	11.19 b	10.78 b
L	0.33	57.82 b	63.06 a	62.08 b	52.70 d	58.66 c	58.66 cb	65.24 a
C	0.27	46.39 b	47.69 a	50.91 a	42.48 c	45.77 b	44.43 cb	50.96 a
H	0.40	71.09 a	65.36 b	75.24 a	64.08 c	73.94 a	63.52 c	67.19 b

Pf = fruit weight; Df = Fruit density; Dp = Pole diameter; De = Equatorial diameter; Fi = Firmness; Ep = Epidermis; Pu = pulp; Ps = Seed weight; Bx = Degrees Brix; L = Luminosity; Chromaticity; H = Hue

Grouping of averages (Tukey(0.05) of quality indicators in nanche fruits

Table 3 shows the Tukey test (α <0.05) of the quality indicators in nanche fruits collected in Guerrero and Chiapas. The fruit weight of Paso del Real, Gro., registered 4.39g, followed by Las Tunas with 3.93g, both localities of the Costa Grande de Gro., had greater weight than the fruits of the Chiapas localities. Fruit density was 5.70, 5.64 and 5.51g mL^{-1} in fruits from Santo Domingo and Mixiquito,Chiapas and San Jerónimo, Gro., respectively, being statistically similar, followed by Paso del Real,Gro., with 4.42 g mL^{-1}, finally Las Tunas, Gro, with the lowest record (3.74g mL^{-1}). The polar diameter in the nanche fruits from Santo Domingo, Chis., had 1.6mm more than those from San Jerónimo, Gro., that is, the fruits from Chiapas are a little more elongated than those from the state ofGuerrero. The equatorial diameter of the fruits from Paso del Real and San Jerónimo, Gro., are statistically similar, but the fruits collected in Las Tunas, Gro., registered the smallest equatorial diameter; the fruits from Santo Domingo and Mixiquito Chis., are intermediate, therefore, the fruits collected in Paso Real and San Jerónimo are rounder than those from Las Tunas, Gro., and Mixiquito,Chis. Firmness is an important quality attribute due to its relationship with the optimal maturity of the fruits. It turned out that those from Santo Domingo, Chiapas had greater firmness, followed by Mixiquito, Chis., while San Jerónimo and Las Tunas, Gro., reached less firm than those of Chiapas. Firmness values differ and could occur due to the difference in collection time and transfer for analysis in the laboratory at the University of Chiapas. The epidermis of the fruits from Paso del Real reached greater thickness (mm), followed by Las Tunas, Gro., while the fruits collected in San Jerónimo were smaller. The fruits from Santo Domingo, Chis., and Paso del Real, Gro., report higher pulp content, followed by Tunas, Gro., and San Jerónimo, Gro., presented the lowest pulp content. Las Tunas and Paso del Real, Gro., had a higher seed weight, followed by San Jerónimo, Gro., and Mixiquito, Chis, had a lower seed weight, therefore, the seeds of the fruit from the state of Guerreroare of larger in size and consequently heavier than those from Chiapas. The oBrix are related to the sweetness of the fruits, it turned out that Las Tunas, Gro., reached 12.44% of oBrix, therefore, they have 12.44 g of natural sugar per 100 g, while the rest of the locations are statistically similar and onaverage less than 1.66 g.

Another indicator is the luminosity or brightness, which is the amount of light emitted or reflected from the nanche fruit, a property related to the presentation of the product. 100% brightness indicates maximum purity and 0% is absolute black, Mixquito, Chis., reported 65.24 lumens, followed by Paso del Real, Gro., with 62.08 lumens; the lowest brightness or luminosity of the fruits corresponded to the collection of San Jerónimo, Gro. Chromaticity refers to the difference in degrees between a graycolor of the same luminosity and clarity: the Mexiquito, Chis and Paso del Real, Gro. collections showed 50.96 and 50.91, respectively, with intense and vivid color; the next value was 45.77 from Las Tunas, Gro., less intense or alive, and the fruits collected in San Jerónimo, Gro., recorded 42.48,the least intense of the 5 locations analyzed. The hue is the essential color property of the nanche fruits, the samples from Paso del Real and Las Tunas, Gro., resulted with 75.24 and 73.94 respectively, statistically similar, followed by Mixiquito, Chis., with 67.19; San Jerónimo, Gro., and Santo Domingo, Chis resulted with 64.08 and 63.52 respectively, statistically equal, with less nuance.

Discussion

Nanche fruits are available during two seasons of the year they have nutritional value and with the possibility of being industrialized and marketed. The uses are diverse,[7] they are used in traditional medicine and their antioxidant properties have been demonstrated[8] and their specific characteristics have been identified.[6] The weight of fruit in nanche is a quality indicator that was different between entities and collection locations. The fruits of Paso del Real, Gro., had 4.39 g and exceeded those of Mixiquito, Chis, with 1.01 g, (3.38g),

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however, the value is lower than those of Oaxaca with 4.65g.[5] The density of the fruits from Mexiquito, Chis., had 5.70 g mL-1, while in those from Las Tunas, Gro., it was 3.74 g mL-1.

Same letters without significant difference

The polar diameter in the fruits of Santo Domingo, Chis., was 16.36mm and 14.96mm in San Jerónimo, Gro., that is, 1.4 mm smaller in diameter, however, the values of this parameter in the fruitsof both entities are slightly smaller than those of Oaxaca with 16.9mm,[4] however Martínez-Moreno reports intervals of 1.82 to 2.63 cm, which are larger than those recordedin Guerrero and Chiapas; the equatorial diameter of the fruits from Paso del Real with 19.10 mm and San Jerónimo, Gro., with 18.88 mm are statistically similar, but different from the values recorded for fruits from Las Tunas, Gro., with 17.62 mm, while Santo Domingo and Miexiquito, Chis., are intermediate, but with a smaller equatorial diameter than those of Oaxaca with 19.66mm[4,6] report that the average equatorial diameter is 1.75 to 2.55 cm, while Medina-Torres et al. (2004) report diameters of 1.68 to 2.48 cm, values close to those of Guerrero and Chiapas, between polar and equatorial diameter, it is shown that the fruits collected in Paso del Real and San Jerónimo, Gro. they are more oval than elongated. The fruits of Santo Domingo, Chis., registered greater firmness, while those of Las Tunas, Gro. They were less firm. The epidermis of the fruits of Paso del Real, Gro., registered 0.10 mm while San Jerónimo with 0.06 mm,which shows variability in the thickness of the fruit shell, despite the proximity between the collectionsites and belonging to the same region of Costa Grande de Gro., while those of Chiapas were intermediate.

In pulp content, the fruits of Santo Domingo, Chis., with 2.79 g, show similarity with those of Paso del Real, Gro., 2.59 g, being the lowest value in the fruits of San Jerónimo and Las Tunas, Gro., 1.99g; These data are lower than those reported by Maldonado et al.[4] who report 4.16 g of pulpin Oaxaca, which coincides with Martínez-Moreno[6] who reports pulp thickness (mesocarp) with an interval of 4 to 7mm; Regarding the weight of the fruit pulp, it averaged from 2.26 to 6.32 g, which was slightly lower than that reported by Martínez-Moreno et al.[6] The seed weight ofthe fruits of Las Tunas, Gro., with 0.61 g and 0.57 g of Paso del Real, Gro., are statistically equal, while the weight of seed in the fruits of Mixiquito with 0.34 g, was the most low, despite such differences have the same average seed weight in both entities. Medina-Torres et al.[6] mentionsthat the weight of the fresh seed was in a range from 0.4 to 0.93g and the dry weight varied from 0.17 to 0.42g. These weights are similar to those recorded in Guerrero and Chiapas. On the other hand, Villachica indicates that of the total weight of the fruit, 64% is pulp, 25% corresponds to the seed and 11% to the shell. The Total Titratable Acidity (oBrix) of the fruits collected in Las Tunas, Gro., showed 12.44 % of oBrix while the rest of the communities had similar ranges and coincide with those reported by Maldonado et al.[4] with 11.76%. Regarding Guerrero and Chiapas, 11.46% and 11.69% oBrix were obtained, which are higher than those reported by López et al.[9] from 7.5 to 4.0, while Martínez-Moreno[6] report from 3.2 to 7.9 lower than those found in Guerrero and Chiapas. The luminosity of the fruits from the locations of Guerrero and Chiapas is less than 67.46 lumens reported by Maldonado et al.[4] Zaccari[10] reports that the luminosity and saturation of the color of the peel of the fruits decreased when the green color of the visual scale increased (L* 57.2 to 36.4; C*ab 41.4 to 15.9) in guava. The Chromaticity of the fruits of Mixiquito, Chis., and Paso del Real, Gro., was from 50.96 to 42.48, respectively, and San Jerónimo, Gro., was the one with the lowest chromaticity. Regarding the Hue of the fruits of Paso delReal and Las Tunas, Gro., they registered a higher hue with 75.24 to 73.94 respectively and San Jerónimo, Gro., and Santo Domingo, Chis., had a lower hue.[11-15]

Conclusion

The nanche (Byrsonima crassifolia L.,) is a seasonal fruit that has physical and chemical properties that vary between localities and states. The quality indicators in the fruits collected in the states of Guerrero and Chiapas have a wide distribution and variation as shown by the coefficients of determination. The fruits collected in localities of the state of Guerrero had greater weight while the fruits of Chiapas are more elongated, compared to those of Guerrero that are rounder. Chiapas fruits had greater firmness. The epidermis is thicker in the fruits from Guerrero, while the fruits from Chiapas are morefleshy or contain more pulp. In oBrix, in both states they have the same sweetness. In Luminosity and Chromaticity, the Chiapas fruits are different from the Guerrero ones and in Hue the Guerrero fruits were higher.

Although there is no extensive and up-to-date bibliography on this crop, the fruit is of great commercial interest since, due to its bittersweet taste, it can be consumed fresh, but it is also used in products such as soft drinks, liqueurs and jams, as some examples. Therefore, it is intended that this research can be used for decision making for the sale and processing of the product for marketing purposes.

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None.

Conflicts of interest

The authors declare no conflicts of interest regarding the publication of this paper.

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