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Effect of Process Conditions on the Quality Parameters of Colombian Arepa with Egg During Vacuum Frying

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Abstract

The aim of this research was to study the effect of process conditions on the quality of vacuum fried arepa with egg. In the first instance, a rotatable composite central experimental design (DCC-R) was carried out, consisting of four factorial points, four axial points and five central points for a total of 13 experimental units. The factors with their respective levels were: (X1) = temperature (160°C, 170°C and 180°C) and (X2) time (300s, 360s and 420s). The response variables were: moisture (%), oil (%), instrumental colour (L, a* b*) and sensory perception: general acceptability, colour, odour, greasy and crunchiness. Vacuum frying was then carried out in a GASTROVAC using a pressure of 30 kPa and a product/oil ratio of 1:10. The results of the moisture content were not such different and the temperature and frying time were not factors that influenced this parameter. In contrast, the percentage of oil showed different results, with higher oil absorption at lower temperatures. The most notable case was observed at 160°C (300s) and 170°C (445,853s), the latter being higher by 40.04%. Statistical differences are observed for parameter L at temperatures of 180°C with 184°C, 170°C, 160°C and 156°C. Differences are also evident in the colour a* values at temperatures of 160°C with 170°C, 180°C and 156°C; and 180°C with 156°C, 184°C and 160°C.

For chromatic b* values, statistical differences between low and high temperatures were observed; that is, temperature was not an indicative factor for differences.

Keyword: Moisture and oil content, instrumental color L, a*, b*

1. Introduction

Arepa with egg is one of the most popular and recognized fried foods in the Colombian Caribbean Region. It is prepared mainly with yellow corn dough, which is added water and sodium chloride to soften and flavor. Today it is a gastronomic trend and is part of the ancestral culture, due to its high consumption [1].

In the Colombian Caribbean Coast, the most recognized snack products are the arepas with eggs, empanadas and carimañolas, the former are fried directly from the corn dough and contain more oil than other popular products. This fried food has become over the years a typical gastronomic dish of cities such as Cartagena de Indias, Barranquilla and municipalities such as Luruaco (Atlántico), where it is catalogued as an invaluable heritage of culture and identity. There is currently a special safeguard plan in this area to protect and preserve the expressions of traditional cuisine. In addition, every year in this municipality the arepa con huevo festival is held with the purpose of creating routes to visit the Atlantic Ocean. The processing of the egg arepa is carried out by atmospheric frying, which is prepared by hand and the quality of the product is not controlled during the thermal process. Atmospheric deep-fat frying is the most common and used method, defined as a process in which foods are cooked by immersion in edible oil or fat and heated above the boiling point of the water. This is done at high temperatures under atmospheric pressure conditions, resulting in surface darkening and many adverse effects [2]. It is a fast and convenient technique for the production of foods with sensory properties preferred by consumers, including a typical flavor, colour and crunchy surface. In addition, new compounds are formed and these are responsible for the physical and chemical changes in frying oil [3].

It is similar to other heat processing practices and can change the nutritional value of the respective product. To improve this purpose, with respect to surface burns, high oil absorption and very rigid texture, vacuum frying may be an option for producing fruits, vegetables and other food matrices such as low oiled egg arepa and desired color, flavor and sensory texture characteristics. Vacuum frying is defined as the process carried out under pressures well below atmospheric levels, preferably below 50 Torr (6.65 kPa) [4]. The lower pressure reduces boiling points of oil and moisture in food. It has some advantages that include: i) it can reduce the oil content of the fried product, ii) it can preserve the natural color and

flavors of the product due to low temperature and oxygen control during processing, iii) it has fewer adverse effects on the quality of the oil [5].

As a result, in Colombia, as in many developing countries, there has been a steady increase in the consumption of fried products, due to the great sensory qualities of fried products that include taste, appearance and texture. In addition, it is a quick and convenient method of preparing food [6, 7]. The required characteristics of the arepas (final water content, yellow color and texture) are the result of raw material properties and processing. Vacuum frying is an interesting way to use this food matrix, whose transformation of corn is of great importance for many people throughout the Caribbean Coast and the interior of the country as food and as a source of income. Likewise, no studies have been reported that analyze in detail the quality parameters during the vacuum frying process of the egg arepa, therefore, the objective of this research was to study the effect of the process conditions on the quality of the vacuum fried arepa with egg.

2. Methodology

2.1 Formulation and elaboration of the product

Arepas were made from pre-cooked corn dough of the yellow caricaceous variety, which contained 59% moisture and was supplied by a company located in the city of Cartagena de Indias (Colombia). At reception, the doughs were stored under refrigeration conditions at 4°C. The traditional techniques observed by traders and sellers of the product in the municipality of Luruaco (Atlántico) were used and modified with a single frying stage according to the method of production in a well-known restaurant in the city.

The formulation used was standardized by preliminary tests at the IDAA laboratory from the University of Cartagena and taking into account the recommendations of a chef expert in fried food processing. Sodium chloride was added to the dough to give it flavor, as well as water at 28°C to soften its structure slightly and form the circular plates; this was homogenized in its entirety for 7 min. Immediately the product was molded with dimensions of 10 cm in diameter and 2.5 cm thick. In this research, a circular mould suitable for this purpose was used, which had a concave area to place the dough and add the hen egg.

2.2 Experimental design

The vacuum frying process of the arepas with egg was carried out using a rotatable composite central design (CCD), consisting of four factorial points (-1 +1, +1 +1, +1 -1, -1 -1 -1), four axial points (-α 0, 0 α, α 0, 0 -α) and five central points, for a total of 13 experimental runs. The factors with their respective low, intermediate and high levels were: (X1) = temperature (160 °C, 170 °C and 180 °C) and (X2) time (300s, 360s and 420s). The response variables were: moisture

(%), oil (%), instrumental colour (L*, a* b*) and sensory perceptions were general acceptability, colour, odour, greasy and crunchiness. The results were expressed as the mean with their respective standard deviation and compared using variance analysis (ANOVA) and multiple comparison tests through Tukey's HSD test with a 5 % significance level. The statistical program Statgrapichs Centurion 16.1.15® Version 16.0 in Windows 8 was used. The coded experimental design matrix used in frying of arepa with egg is shown in Table 1.

Table 1. Coded design matrix

Variable	Encoder symbol	Range and Levels				
		α_1= - 1.4241 (axial)	-1 (low)	0 (central)	+1 (high)	α_2= +1.4241 (axial)
Temperature (°C)	X_1	155.85	160	170	180	184
Time (s)	X_2	275.14	300	360	420	445.85

2.3 Vacuum frying process

Vacuum frying of arepas with eggs was carried out in the GASTROVAC (International Cooking Concepts, Barcelona) with measures: 40 × 26 × 46 cm, maximum capacity of 10.5 L and 220 V voltage, developed at the Polytechnic University of Valencia. The working pressure in the frying process was 30 kPa, at which the boiling water temperature was 90°C, temperature deltas of 50°C, 60°C and 70°C were used, so that the frying temperatures used were 160°C, 170°C and 180°C, with a time of 300s, 360s and 420s. First, the oil was heated to the set frying temperature, samples were placed in the basket, the lid closed and the vacuum pump was activated. When the equipment reached the desired working pressure, the basket was lowered and immersed in hot oil. Once the frying time was over, the basket was lifted, the pump was left on for one minute and then turned off, the vacuum was broken and the equipment was turned off, removing the samples from it. The ratio of the product/oil was 1:10, after which the arepas were drained in a basket of mesh.

2.4 Determination of moisture and oil content

The moisture content of arepas with egg (g water g-1 solids) was calculated by oven drying at 105 °C to steady weight, Method 925.10 – [8]. The oil content (g oil g^{-1} dry solids) was made by gravimetry using the method of extraction with light petroleum in the Soxhlet equipment, Method 920.39 [8]. The measurements were made in each treatment and expressing the data as the average with its standard deviation.

2.5 Color evaluation

Color changes were analyzed on the outside of the arepas with egg, using a CR-5 laboratory reflectance colorimeter (tristimolo Konica Minolta Sensing), with D65 illuminant and a 10° tone angle for the observer. Parameters were assessed in CIEL*a*b space for L* brightness (light 100° and dark 0°), chromaticity a* (red (+) and (-) green) and b* (yellow (+) and (-) blue.

3. Results

Table 2 shows that at temperatures of 160°C and frying times of 300s and 420s, the weight loss went from 13.76 % to 16.84 %, respectively. In contrast, during frying at 170°C at different times, it was observed that the longer the frying time (445.85s), the greater the weight loss was by 23.85%. The same was evident at higher temperatures, with similar weight loss. This was done to standardize the weights of the arepa with egg, and so during frying all samples did not report significant differences very high, in order to have no differences by weight and influence the absorption of oil and other variables studied.

Table 2. Weight loss of the arepa with egg

Experimental design			**Weights of arepas with huevo - 5 min cooling**			
Treatments	Time (s)	Temperature (°C)	Before frying (g)	After frying (g)	Difference (g)	% Weight loss
1	360 (0)	155.85 (-1.4142)	212	183	29	13.68
2	300 (-1)	160 (-1)	218	188	30	13.76
3	420 (+1)	160 (-1)	196	163	33	16.84
4	275.147 (-1.4142)	170 (0)	187	151	36	19.25
5	445.853 (+1.4142)	170 (0)	213	168	45	21.13
6	360 (0)	170 (0)	203	166	37	18.23
7	360 (0)	170 (0)	209	170	39	18.66
8	360 (0)	170 (0)	183	147	36	19.67
9	360 (0)	170 (0)	191	154	37	19.37
10	360 (0)	170 (0)	184	146	38	20.65
11	300 (-1)	180 (+1)	186	152	34	18.28
12	420 (+1)	180 (+1)	204	159	45	22.06
13	360 (0)	184 (+1.4142)	193	153	40	20.73

Table 3 shows the controlled variables (time and temperature) and the response variables (moisture and fat). In the case of moisture, at 160°C and times of 300s and 420s, the percentage of this parameter decreased by 5.33%. However, at 180°C and similar times, the difference was not noticeable. On the other hand, at

lower and higher temperatures, there was no marked statistically significant difference. In general, temperature was not the most influential factor on moisture. Torres et al., [1] detailed that the moisture content behaved linearly, decreasing considerably with the increase in temperature. In addition, above 130°C the arepas with egg had greater moisture loss, being different from what was found in this study. This variation can be explained by the concept of equivalent thermal force, since the pressure drop in the system results in a lower boiling water temperature and therefore lower frying temperatures. Research made by Moreira et al., [9], observed that moisture loss and oil absorption rates were faster during the first 15s of frying, and became constant as frying continued; moisture loss rate increased as temperature increased. The effect of temperature on oil absorption was not significant during the first 15 s of frying, although the final oil content was higher for fried tortilla chips at 190°C than at 150°C.

Table 3. Moisture and fat content of arepa with egg

Time (s)	Temperature (°C)	Moisture (%)	Fat (%)
360 (0)	156 (-1.4142)	55.19	30.20
300 (-1)	160 (-1)	58.31	20.72
420 (+1)	160 (-1)	55.20	31.26
275.147 (-1.4142)	170 (0)	55.56	32.59
445.853 (+1.4142)	170 (0)	58.28	34.56
360 (0)	170 (0)	60.53	30.24
360 (0)	170 (0)	56.11	28.42
360 (0)	170 (0)	53.75	33.18
360 (0)	170 (0)	54.00	32.11
360 (0)	170 (0)	54.29	34.11
300 (-1)	180 (+1)	50.68	34.25
420 (+1)	180 (+1)	55.56	31.81
360 (0)	184 (+1.4142)	54.28	27.53

With regard to the fat content, at a lower temperature the oil absorption was higher than at a higher temperature (184°C). In contrast to 160°C and times of 300s and 420s, the oil percentage was higher by 53.65 points. Different results were evidenced at 170°C when analyzing the smallest and longest frying time, with a difference of 5.7 points. The most notable case was observed at 160°C (300s) and 170°C (445,853s), being higher by 40.04%. The oil content in fried foods has been linked to the initial moisture content [10], pre-frying treatment [11], structural changes during the process [12] and cooling time. Garayo and Moreira [13] pointed out that the oil content was related to the percentage of moisture

in potato chips. Instead Bouchón [14] indicated that oil absorption was mainly associated with food microstructure. Kawas and Moreira, [15], reported that the tortilla chips had an initial and final moisture content of 42.0 ± 0.2% (wb) and 2.0 ± 0.1% (wb), respectively, being very different from those found in the arepa with egg.

The total final oil content after 60s of frying was 23.6 ± 0.1% (wb). These chips absorbed approximately 9.5 ± 0.2% (wb) of oil during frying, reaching 17.6 ± 0.2% (wb) values during cooling. About 34% of the total oil content (i. e. 9.5 ± 0.2% wb) was absorbed by the chips during frying, and about 69% of the total oil (i. e. 17.6 ± 0.2% wb) was the internal oil content after cooling. The rest (8.9% wb) was oil that remained on the chip surface. The tortilla is one of the few foods that can be compared to the arepa with egg, because it is made with cornmeal; however, it is a single flat plate of specific thickness and homogeneous structure that presents such different changes in moisture content and oil absorption.

In the frying of tortillas made from cornmeal, Moreira et al., [9] demonstrated that the distribution of the size of the developed pore was the main factor in oil absorption. There was possibly greater development of porosity as temperature increased, which influenced the formation of surface crust and prevented the absorption of excessive oil from the product. Yamsaengsung et al., [16] reported that moisture loss during frying in pre-treated potatoes led to changes in the microstructure that influenced the oil absorption rate. Zhang et al., [17] studied the potato frying process and reported that the initial moisture content had no significant effect on oil absorption. Similarly Gazmuri and Bouchon [18] indicated that oil absorption was not clearly related to the amount of moisture lost, but rather to changes in the microstructure of the gluten and wheat starch-based product. This would explain the behavior of these variables responses observed in egg arepas in this research.

Table 4 shows the average of the color coordinates L*, a*, b* of the vacuum fried arepa with egg. Statistical differences are observed for parameter L* at temperatures of 180°C with 184°C, 170°C, 160°C and 156°C, this denotes that the temperature had a greater effect on the brightness of the arepas with egg when was observed yellow, characteristic color of this food matrix. Differences are also evident for the colour value a* at temperatures of 160°C with 170°C, 180°C and 156°C; and 180°C with 156°C, 184°C and 160°C. The most significant change was observed at lower temperatures compared to higher temperatures and longer times. For chromatic value b*, statistical differences between low and high temperatures were observed; i. e., temperature was not an indicative factor for differences.

The results of color change in vacuum dipped fried egg arepas were similar to those reported by Esan et al., [19] in yellow sweet potatoes, which indicated that color reactions accelerated with low water activity in the microstructure of the chips

during frying. Likewise, researches carried out by Karcabey et al., [20], reported that during the optimization of the frying of carrot slices, brightness was significantly reduced with the interaction of time and temperature factors, which was attributed to non-enzymatic browning reactions (Maillard), caramelization and chemical oxidation of phenolic compounds.

Table 4. Average color coordinates of the arepa with egg

Time (s)	Temperature (°C)	L*	a*	b*
420	180	44.51±0.95^{a}	12.5±0.68^{ab}	38.02±1.51^{a}
300	180	44.7±3.06^{ab}	12.07±1.08^{a}	39.35±2.96^{ab}
360	170	45.47±1.37^{abc}	13.7±0.11^{cdef}	41.48±0.47^{bcd}
360	170	45.62±2.35^{abcd}	12.84±0.55^{abc}	40.55±1.80^{ab}
420	160	46.56±035^{abcde}	14.81±0.13^{g}	40.92±0.46^{bc}
360	170	46.61±0.12^{abcde}	12.95±0.92^{abc}	41.09±1.00^{bcd}
360	184.142	46.89±1.70^{bcdef}	13.32±0.35^{bcde}	40.74±0.60^{b}
300	160	47.67±0.49^{cdef}	13.41±0.10^{bcdef}	39.85±0.24^{ab}
360	170	47.83±0.32^{def}	14.21±0.16^{efg}	43.63±1.16^{de}
275.147	170	48.35±1.72^{ef}	12.98±0.39^{abc}	44.44±0.78^{e}
360	170	48.9±1.70^{f}	14.33±0.35^{fg}	44.68±1.30^{e}
444.853	170	49.07±0.18^{f}	14.02±0.76^{defg}	44.66±1.30^{e}
360	155.858	49.16±1.05^{f}	13.18±0.29^{bcd}	43.4±3.14^{cde}

The arepas with egg showed a bright yellow color; despite the high oil content they reported, they did not become opaque or dark on the surface. In contrast Dueik et al., [21] showed different results in carrot chips; they claimed that dark color was mainly associated with non-enzymatic browning reactions. Similarly Dueik et al, [22] In matrices formulated with gluten, starch, insoluble fibre and pregelatinized corn starch, they established that the time-temperature factors of the frying process had a significant influence on color changes and final luminosity, which was attributed to the non-enzymatic browning reactions on the surface, which were catalyzed by low water activity at higher temperature. On the other hand, Shyu et al., [23] observed that the color of carrot chips decreased as time and frying temperature increased. Indicating that from 100ºC the color changes became evident, a fact attributable to the instability of the carotenoids. Similar results on color changes found Shyu and Hwang [24] when processing apple chips at 90°C and 110°C and 5min and 30min. In general, the golden colour has been indicated as a characteristic and very significant attribute of the quality of fried products and is decisive in sensory acceptance. Torres et al., [1] reported that the addition of sesame paste to the egg arepa affected brightness and color change, being darker with higher paste content. However, temperature was the most

prevalent factor in the development and formation of Maillard reaction-derived components.

4. Conclusions

The temperature and frying time were not factors that influenced the moisture percentage of the arepa with egg, whereas for the oil content the first one predominated, being higher at lower temperature. For the brightness, statistical differences are observed at temperatures of 180°C with 184°C, 170°C, 160°C and 156°C, different case was for the chromatic value b* where these factors were not clear to establish differences at lower or higher temperatures. Vacuum frying is an alternative to obtain egg arepas with suitable quality and acceptability characteristics.

References

[1] J. D. Torres, D. Acevedo and P.M. Montero, Efectos de la Fritura al Vacío en los Atributos de Calidad de Arepa con Huevo, *Información Tecnológica*, **28** (2017), no. 1, 99-108. https://doi.org/10.4067/s0718-07642017000100010

[2] O.R. Akinpelu, M.A. Idowu, O.P. Sobukola, F. Henshaw, S.A. Sanni, G. Bodunde and L. Munoz, Optimization of processing conditions for vacuum frying of high quality fried plantain chips using response surface methodology (RSM), *Food Science and Biotechnology*, **23** (2014), no. 4, 1121-1128. https://doi.org/10.1007/s10068-014-0153-x

[3] R. Bou, J.A. Navas, A. Tres, R. Codony and F. Guardiola, Quality assessment of frying fats and fried snacks during continuous deep-fat frying at different large-scale producers, *Food Control*, **27** (2012), no. 1, 254-267. https://doi.org/10.1016/j.foodcont.2012.03.026

[4] Y. Nunes and R.G. Moreira, Effect of Osmotic Dehydration and Vacuum-Frying Parameters to Produce High-Quality Mango Chips, *Journal of Food Science*, **74** (2009), no. 7, E355-E362. https://doi.org/10.1111/j.1750-3841.2009.01257.x

[5] P. García-Segovia, A.M. Urbano-Ramos, S. Fiszman and J. Martínez-Monzó, Effects of processing conditions on the quality of vacuum fried cassava chips (Manihot esculenta Crantz), *LWT-Food Science and Technology*, **69** (2016), 515-521. https://doi.org/10.1016/j.lwt.2016.02.014

[6] H. Wu, S.A. Tassou, T.G. Karayiannis and H. Jouhara, Analysis and simulation of continuous food frying processes, *Applied Thermal*

Engineering, **53** (2013), no. 2, 332-339.
https://doi.org/10.1016/j.applthermaleng.2012.04.023

[7] S. Karimi, M. Wawire and F.M. Mathooko, Impact of frying practices and frying conditions on the quality and safety of frying oils used by street vendors and restaurants in Nairobi, Kenya, *Journal of Food Composition and Analysis*, **62** (2017), 239-244.
https://doi.org/10.1016/j.jfca.2017.07.004

[8] AOAC., Association of Official Analytical Chemists. Official Methods of Analysis. 19th ed. AOAC. Arlington. VA, USA, 2012.

[9] R.G. Moreira, X. Sun and Y. Chen, Factors affecting oil uptake in tortilla chips in deep-fat frying, *Journal of Food Engineering*, **31** (1997), no. 4, 485-498. https://doi.org/10.1016/s0260-8774(96)00088-x

[10] R. Moreira and X. Sun, Simultaneous heat and mass transfer during the deep fat frying of tortilla chips, *Journal of Food Process Engineering*, **18** (1995), no. 3, 307-320. https://doi.org/10.1111/j.1745-4530.1995.tb00369.x

[11] M.H. Gamble, and P. Rice, Efect of pre-fry drying on oil uptake and distribution in potato chip manufacture, *International Journal of Food Science and Technology*, **22** (1987), 535-548.
https://doi.org/10.1111/j.1365-2621.1987.tb00519.x

[12] J.K. Lee, *Effects of Processing Conditions and Maize Varieties on Physicochemical Characteristics of Tortilla Chips*. PhD Thesis, Texas A & M University, College Station, 1991.

[13] J. Garayo and R. Moreira, Vacuum Frying of Potato Chips, *Journal of Food Engineering*, **55** (2002), no. 2, 181-191.
https://doi.org/10.1016/s0260-8774(02)00062-6

[14] P. Bouchon, Understanding oil absorption during deep-fat frying, *Advances in Food and Nutrition Research*, Elsevier, Vol 57, 2009, 209-234.
https://doi.org/10.1016/s1043-4526(09)57005-2

[15] M.L. Kawas and R.G. Moreira, Characterization of product quality attributes of tortilla chips during the frying process, *Journal of Food Engineering*, **47** (2001), no. 2, 97-107.
https://doi.org/10.1016/s0260-8774(00)00104-7

[16] R. Yamsaengsung, C. Rungsee and K. Prasertsit, Simulation of the heat and mass transfer processes during the vacuum frying of potato chips, *Songkla-*

nakarin Journal of Science and Technology, **30** (2008), no. 1, 109-115.

[17] T. Zhang, J. Li, Z. Ding and L. Fan, Effects of Initial Moisture Content on the Oil Absorption Behavior of Potato Chips during Frying Process, *Food and Bioprocess Technology*, **9** (2016), no. 2, 331-340. https://doi.org/10.1007/s11947-015-1625-6

[18] A.M. Gazmuri and P. Bouchon, Analysis of wheat gluten and starch matrices during deep-fat frying, *Food Chemistry*, **115** (2009), no. 3, 999-1005. https://doi.org/10.1016/j.foodchem.2009.01.020

[19] T.A. Esan, O.P. Sobukola, L.O. Sanni, H.A. Bakare and L. Munoz, Process optimization by response surface methodology and quality attributes of vacuum fried yellow fleshed sweetpotato (Ipomoea batatas L.) chips, *Food and Bioproducts Processing*, **95** (2015), 27-37. https://doi.org/10.1016/j.fbp.2015.03.008

[20] E. Karacabey, Ş.G. Özçelık, M.S. Turan, C. Baltacioğlu and E. Küçüköner, Optimization of Microwave-Assisted Predrying and Deep-Fat-Frying Conditions to Produce Fried Carrot Slices, *Journal of Food Process Engineering*, **40** (2017), no. 2, 1-11. https://doi.org/10.1111/jfpe.12381

[21] V. Dueik, P. Robert and P. Bouchon, Vacuum frying reduces oil uptake and improves the quality parameters of carrot crisps, *Food Chemistry*, **119** (2010), no. 3, 1143-1149. https://doi.org/10.1016/j.foodchem.2009.08.027

[22] V. Dueik, O. Sobukola and P. Bouchon, Development of low-fat gluten and starch fried matrices with high fiber content, *LWT-Food Science and Technology*, **59** (2014), no. 1, 6-11. https://doi.org/10.1016/j.lwt.2014.04.036

[23] S.L. Shyu, L.B. Hau and L.S. Hwan, Effects of processing conditions on the quality of vacuum-fried carrot chips, *Journal of the Science of Food and Agriculture*, **85** (2005), no. 11, 1903-1908. https://doi.org/10.1002/jsfa.2195

[24] S.L. Shyu and L.C. Hwang, Effects of processing conditions on the quality of vacuum fried apple chips, *Food Research International*, **34** (2001), no. 2, 133-142. https://doi.org/10.1016/s0963-9969(00)00141-1

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