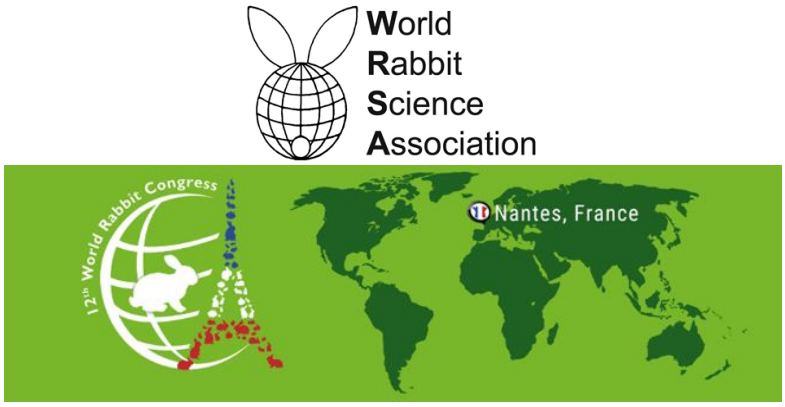

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QUALITY of PRODUCTS

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MEAT FROM RABBITS FED VEGETABLE DHA CAN BE AN IMPORTANT PART OF A DHA-ORIENTED HUMAN DIET

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ABSTRACT

The average individual intake of docosasahexanoique acid (C22:6 ω3 fatty acid, generally named DHA) by human populations is significantly lower than the recommendation of 250 mg/day, established to maintain the health situation of the population. In France for example the average intake is 137 mg/day. Because of the long half life of DHA in the organism, it is more accurate to consider the consumption per week than per day. With this way of expression, the recommendation and the average intake are respectively 1750 and 960 mg of DHA / week, meaning a deficit in this fatty acid of 790 mg / week. The target of this study, on the basis of the eating habits of the French population, is to propose a short list of modifications of the human diet in order to provide the 790 mg of DHA necessary to reach the weekly recommendation. A list of the DHA content of the main animal products included in the normal diet of French people is provided. The target of +790 mg additional DHA /week can be obtained through the products of rabbits, laying hens and broiler chickens fed diets supplemented with microalgae very rich in DHA. With products obtained from these animals, one rabbit meal per week (150 g) replacing a pork or a beef meal, provide 37% of the necessary additional DHA. Replacement of all eggs directly purchased by consumers (2.67 eggs/w) and all chicken meat consumed (365 g/w), with "DHA" products, provides respectively 24% and 23% of the necessary additional DHA. Consequently, rabbit meat, eggs and chicken meat issued from animal receiving feed with microalgae rich in DHA can supply 84 % of the missing DHA in the French diet for example. The last 16% can be provided by the addition to the normal diet of 50 g of rabbit pâté or 25 g rabbit liver per week. Besides this approach corresponding to the current alimentary habits in many countries, it is emphasized that coming back to the high rabbit meat consumptions (300 g/week) observed 30 or 50 years ago for some categories of the population, it is easier to solve the chronic DHA deficit of populations without using "DHA" chicken meat. Anyway, the inclusion in the weekly diet of meat produced by rabbits receiving vegetable DHA in their feed, can be an important way to decrease and compensate the chronic deficit in DHA of the population.

Key words : Rabbit, DHA, omega 3, fat, human diet

INTRODUCTION

In a previous review (Lebas et al., 2021), it was underlined that average individual intake of exogenous docosasahexanoique acid (C22:6 ω3 fatty acid, generally named DHA) by human populations, *e.g.* 137 mg/day in France, is significantly lower than the recommended value of 250 mg/d in European Union (Anses, 2016). However, it is highly desirable to reach the recommended intake to improve the health status of the population and reduce pathological risks such as cardiovascular troubles, insulin resistance, diabetes, obesity, metabolic syndrome, age related macular degeneration, depression or Alzheimer trouble. Reaching the recommended intake also improves cognition of young and old people (Swanson et al., 2012; Lebas et al., 2021). The only way for humans to obtain exogenous DHA is the consumption of animal products since higher plants are devoid of this long chain unsaturated omega 3 fatty acid. Among animal products, fish have significantly higher DHA content than terrestrial animals and are presently the main source of DHA for humans. But, fishing in the seas of the world cannot be increased to provide more DHA and in

addition quality of fishes and other marine products obtained by this way or by sea aquaculture is questionable because of seas pollution (Zambonino-infante, 2009).

DIETARY DHA SUPPLEMENTATION AND DHA CONTENT IN PRODUCTS

In France as in other countries, the DHA content of the standard terrestrial animal products is too low (5-15 mg/100g) to provide enough DHA according to the present consumption per person of these different products: for example, the intake of meat is about 50.9 kg per year (table 1), *i.e.*, 140 g/d after an approximate reduction by 20% of the purchased quantities (waste and lost) to obtain the quantity effectively ingested.

Table 1 : Terrestrial animal products consumed in France kg/habitant & / year in 2018 (calculated from FranceAgriMer data)

Type of animal	Carcass kg/year	% edible meat in a carcass	kg Meat purchased/year.
- Pork	31.9	67%	21.37
- Poultry *	29.7	80%	23.76
- Beef	23.1	72%	16.56
- Mutton	2.8	70%	1.96

* rabbit included 0.8 kg carcass/ year

Fortunately, the DHA content of farm animals products (meat but also eggs or milk) can be noticeably increased, without modification of the total lipids content, *via* the inclusion in their diet of cultivated micro-algae very rich in DHA : *e.g.* 18-28% of dry matter as DHA in *Schizochytrium* spp. (Lebas et al., 2021). Examples of DHA content in control animals products and after microalgae supplementation are given in table 2. This table presents only microalgae supplement levels that don't provoke problems of palatability (Lebas et al., 2021) and includes also values for other farm animal products such as eggs (in France 217 eggs/person and /year, of which 37% included in industrially transformed products), dairy products (in France 32.3 kg milk/ hab. &/year + 11.7 kg of cheese) and trout (in France 0,40 kg /hab. &/year).

Table 2 : DHA content in farm animals in 2 situations : standard products and products from animals that have received a DHA supplementation in their diet *via* the addition of microalgae (most generally *Schizochytrium* spp)

Species	Product	Control diet	Supplemented diet		*Increase of DHA in product after switch Control => Suppl. mg/100g product*
		DHA in product – mg/100 g	Vegetable DHA in animal feed % diet or g/day	**DHA in product mg/100 g**	
Rabbit	Whole carcass without liver	**19.4**	0.15%	**200**	*181*
	Foreleg	**19.4**		**200**	*181*
	Back with fat	**25.0**		**250**	*225*
	Defatted back	**5.0**		**50**	*45*
	Hindleg	**10.0**		**100**	*90*
	Liver	**50**		**470**	*420*
	Pâté	**20**		**240**	*220*
	Rillettes	**20**		**160**	*140*
	Sausage	**20**		**220**	*200*
Laying hen	Eggs	**58**	0.15%	**195**	*137*
Dairy cow	Milk	**0.2**	28 g/d	**12**	*11*
	Cheese	**1.0**		**60**	*59*
Pig	Pork meat	**4.5**	0.22%	**56**	*52*
Chicken broiler	Whole carcass	**15.6**	0.15%	**67**	*52*
	Breast with skin	**16.5**		**72**	*56*
	Leg	**15.3**		**62**	*47*
Trout [a]	Whole fish	**311**	1.38%	**699**	- [a]
	Fillet without skin	**57**		**166**	*109*
Cattle	Beef meat	**3.3**	18 g/d	**18**	*15*

- [a] : the whole trout is rich in DHA (with head, skin, ….) , but only the fillets are consumed.

HOW TO INCREASE EASILY THE DHA CONTENT OF HUMAN DIET

As previously mentioned (Lebas et al., 2021), the individual present daily DHA intake in the French population is only 137 mg/day on average, while the recommendation is 250 mg DHA/day. Because of the very long DHA half-life in organism, *e.g.* 2.5 years in the human brain (Bradbury, 2011), it seems logical to consider DHA intake on a weekly rather than a daily basis, as it was done since many years in various studies on human (Oh et al., 1991; Itomura et al., 2005; Swanson et al., 2012; Calder 2014). Recommendations based on a total per week are fully justified by the observations made in the rat, where the same quantity of DHA distributed in one time every week is better valued (+23% of retention) than after the distribution of small doses every day (Ghasemifard et al., 2015).

Thus, the current DHA intake of approximately 960 mg per week must be increased by 790 mg per week to reach the recommendation of 1750 mg of DHA per week. To reach easily this target, it is suggested to use products of the most efficient animals for the fixation of the dietary DHA *i.e.* rabbit meat (39%), chicken eggs (31%) and chicken meat (19%) (Lebas et al., 2021), providing also products with the highest DHA concentration expressed in mg/100 g edible product (table 2).

One of the proposed solution is first to replace every week one standard meal (150 g meat) of standard beef or of standard pork by a meal of rabbit produced with DHA microalgae to obtain an additional quantity of 295 mg of DHA, according to the values summarized in table 2. In addition, it is suggested to replace all the non ~~i~~ndustrially processed standard eggs (2.63 units of about 55 g per week) by eggs produced with DHA microalgae to obtain a supplementary quantity of 190 mg of DHA every week. Finally, the last suggestion to provide enough DHA is to use exclusively chicken meat provided by animal fed with DHA algae, without modification of the quantity *i.e.* 365 g/week. The switch from the standard type to the DHA fed broiler provides about 180 mg of supplementary DHA.

These three suggestions alone are able to provide 665 mg DHA per week and thus cover 84% of the additional DHA necessary to reach the objective of +790 mg DHA / week. The remaining 125 mg could be covered by 50 g / week of rabbit pâté or by 25 g of rabbit liver (less than half a liver per week). The global suggestion is summarized in the table 3.

Table 3. Suggestion of replacement or addition of animal products in order to provide 790 mg supplementary DHA / week

Type of modification during a week	Quantity	Additional DHA mg	% of the target
- One rabbit meal replacing 1 pork or beef meal	150 g	295	37%
- Replacement of eggs purchased by consumer (63% of the total eggs consumption)	2.67 eggs	190	24%
- Replacement of all the chicken meat	365 g	180	23%
- Addition of rabbit pâté *or* rabbit liver	50 *or* 25g	125	16%
Total		**790**	**100 %**

If the consumption of rabbit pâté or rabbit liver once a week seems too frequent for some people, it can be transformed into 100 g of paté and 50 of rabbit liver (about one liver) once per month. This suggestion is in agreement with the very slow turn-over of DHA in human organism (Bradbury, 2011)

It is also possible to reach the final target with other combinations using for example pork meat, cheese, eggs and trout, but they all are less efficient in the use of DHA available from microalgae production and imply the modification of a greater number of production systems, only 2 in the present proposition : rabbit and poultry (broilers and eggs) production. These conclusions are in agreement with those of a preliminary study (Colin et al., 2018).

Beside this alimentary strategy associating one weekly meal of “DHA enriched rabbit meat” with “DHA enriched eggs and broiler meat”, it can be noted that the increase of rabbit meat consumption up to 2 times / week (300 g) instead of one portion per week, enables by itself to bring 590 mg DHA / week and consequently 75 % of the current deficit in this fatty acid. Associated with this suggestion of doubling the rabbit meat intake, use of only DHA enriched eggs is sufficient to reach the target of +790 mg DHA/week, without resorting to chicken production.

The suggestion of a doubling rabbit meat intake may appear very high regarding the current consumption of rabbit meat in France and in many other countries, but it corresponds to a yearly average consumption of 15 kg rabbit meat / person / year, a level observed for some categories of the population in France in the 70's (Sinquin., 1976) or more recently in some places of the Mediterranean area (Colin et Lebas 1995). Coming back the consumption of rabbit meat existing some years ago, meat produced from rabbits receiving vegetable DHA in their feed, can be an important and simple way to decrease and compensate the chronic deficit in DHA of the population.

The methodology used in the current case to study the possibility to increase the DHA consumption in France could be easily applied to the situation of other countries. The only condition is to have an estimation of the DHA intake of the population. It is for example between 100 and 150 mg/day for many countries such as Australia, Belgium, Canada, Germany or USA, However the DHA intake is higher than the recommendation for some other countries like Japan or Norway (500 to 700 mg/day) where the fish consumption is very important (Astorg, 2007). But even these countries have to face the difficulties to maintain the current level of collect of marine resources and have to reduce the risks related to the heavy metals and persistent organic pollutants, present in all sea products.

CONCLUSION

As a conclusion, the DHA enriched rabbit meat is one efficient solution to decrease the DHA deficit of the population, particularly interesting in the countries where the consumption of this meat is popular.

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AN IMPORTANT PART OF A DHA-ORIENTED HUMAN DIET (O-08)
Colin M., Lebas F., Delarue J., Caillaud L., Van Lissum M., Prigent A.Y.

Copri

INTRODUCTION

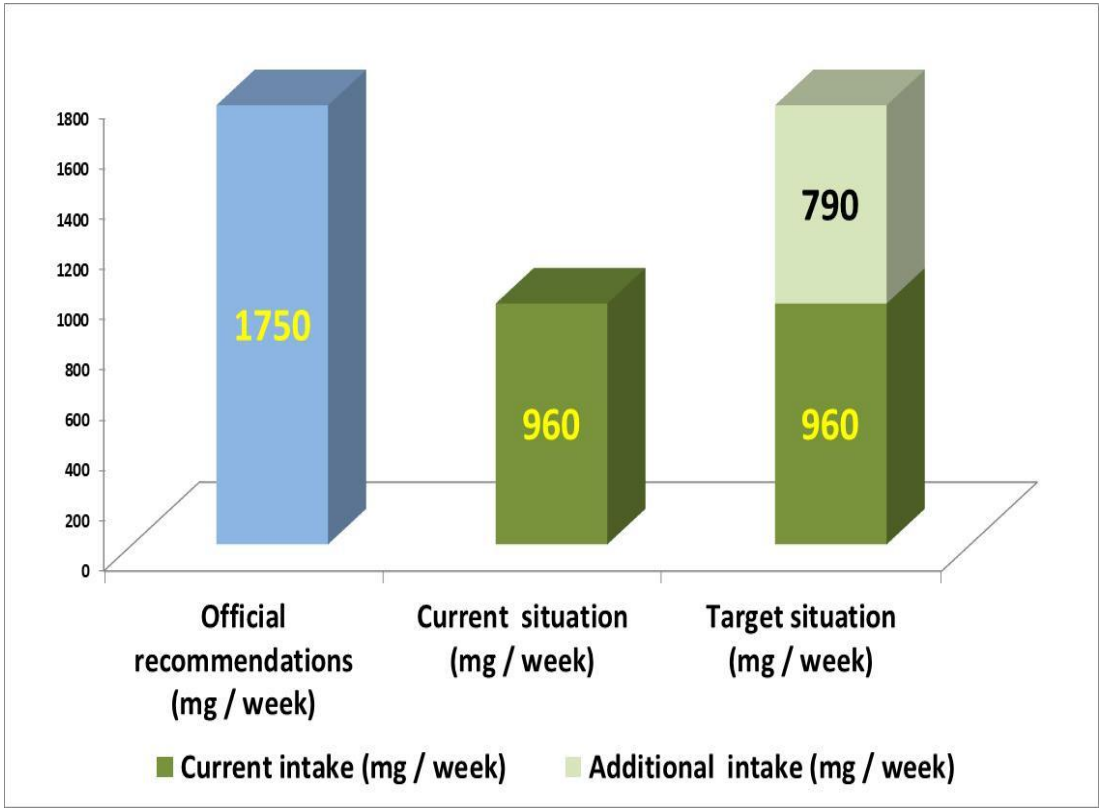
Average current intake of DHA by human populations lower than the official recommendations:

Current intake: 137 mg/day or **960 mg/week**

Recommendations: 250 mg/day or **1 750 mg / week**.

Target of this study

To propose simple modifications of the human diet providing weekly the additional 790 mg of DHA necessary to reach the recommendations



Dietary DHA supplementation and DHA content in products

Except the eggs, low level in DHA of the terrestrial animal products (meat, milk).

Increase this DHA level by incorporation of *Schizochytrium spp* in animal feed.

The rabbit is the terrestrial animal reaching the highest level of DHA in its meat.

The necessary 790 mg of additional ingested DHA can be supplied by DHA enriched rabbit meat associated with DHA enriched eggs.

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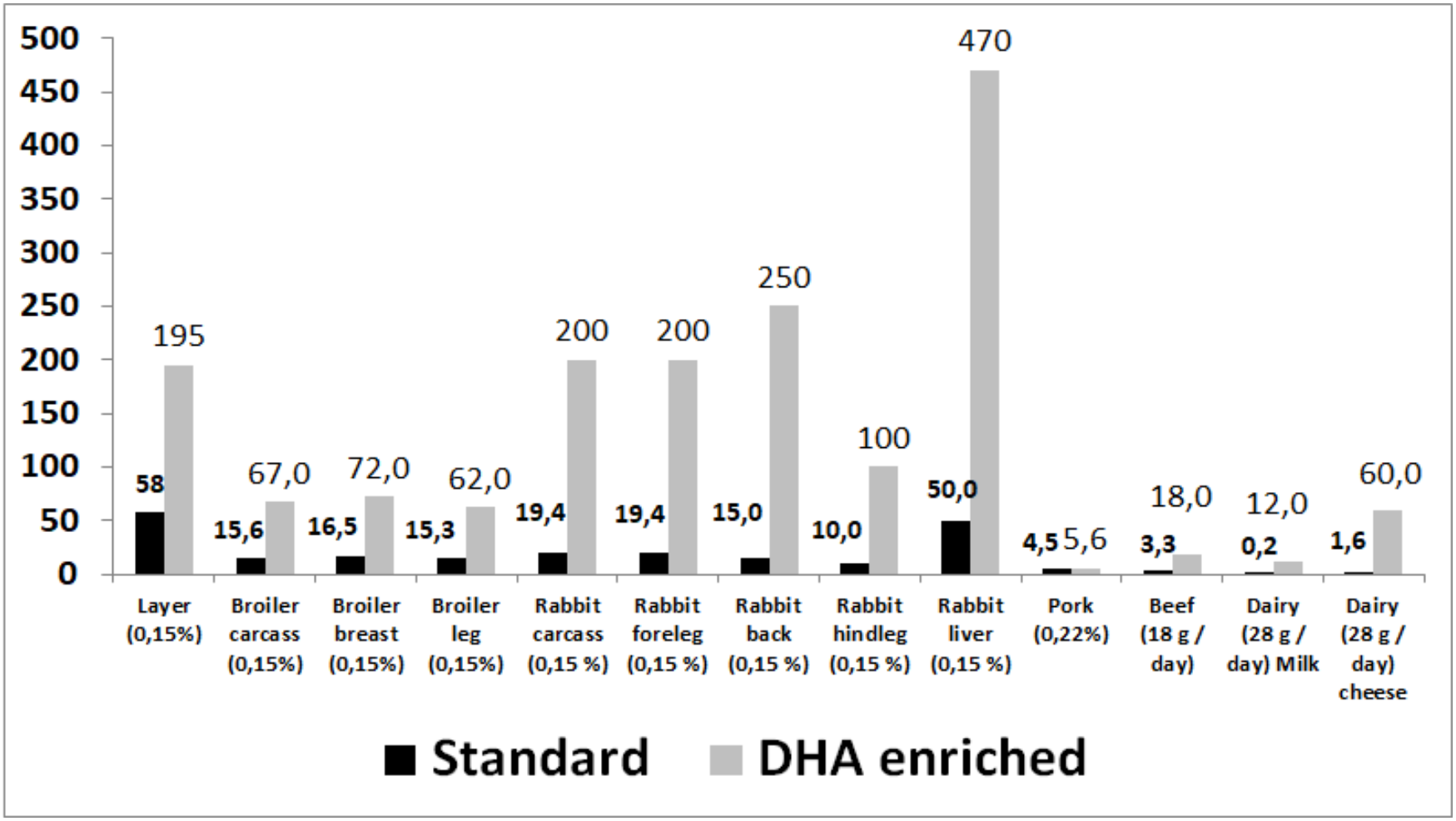
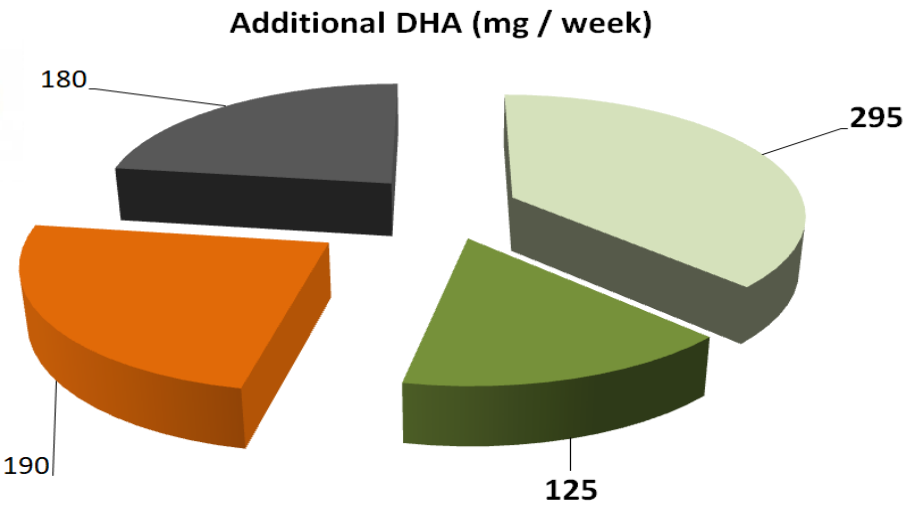
The rabbit is the terrestrial animal reaching the highest level of DHA in its meat.

DHA (mg / 100 grams)



Suggestion of human diet changes providing 790 mg additional DHA / week

- Substitution of 150 grams of pork of beef meat by the same quantity of DHA enriched rabbit meat.
- Replacement of standard eggs (3 per week) by DHA enriched ones.
- Replacement of standard broiler by DHA enriched one.
- Consumption of 50 grams of paté of enriched rabbit meat or liver.



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CONCLUSIONS

Possibility to cover the DHA human requirement eating **sufficient quantity of DHA enriched rabbit meat** and DHA enriched eggs

This alimentary strategy enables

- A strong increase of the rabbit meat consumption: **7,5 kg / habitant / year**.
- A limitation of the halieutic collect.

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Région Bretagne

FINISTERE
Penn-ar-Bed

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