Suitability Evaluation Of Pro Vitamin A And Quality Protein Maize QPM In Southern Guinea Savannah Of Nigeria

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ABSTRACT

Although maize supplies the calories for the resource poor farmers in southern guinea savannah of Nigeria, it is however low in protein and vitamin A, thus resulting in marasmus and nyctalopia (night blindness) respectively for people who consume it without supplements. Therefore, base on the need to establish the adaptability of pro vitamin A and quality protein maize QPM in this agro ecology, this research was initiated. To this end, six (6) pro vitamin A and four (4) QPMs were evaluated at the Teaching and Research Farm of Kwara State University, Malete, Ilorin using randomized complete block design in three (3) replicates. Two (2) seeds were sown at 25 x 75 cm inter and intra row spacing respectively and later thinned to one. Weeds were controlled with herbicides and supplemented with manual weeding. The yield obtained ranged from 1.46 to 5.06 t/ha with TZE Q143 having the highest yield with lysine and tryptophan contents of 5.67 and 14.0µg/100g respectively. Thus TZE Q134 has the potential of filling the food and nutritional gap of the rural populace. Also, there is high variability in yield, protein and pro vitamin A contents of the lines, hence great potential for genetic improvement through breeding.

Key words: QPM, Pro-Vitamin, Maize, food, nutritional gap

1. INTRODUCTION

Maize (*Zea mays L.)*, belonging to the grass family Poaceae, is one of the most predominantly cropped cereals globally (IITA 2009) partly as a result of its high adaptability and productivity (Anupama *et al.,* 2005). It is a household crop for most sub-Saharan Africans including Nigeria (Zalkuwi *et al.,* 2010), choice food crop for more than 900 million resource-poor consumers, 120-140 million deprived farming household and about 35% the of underfed children worldwide (CIMMYT and IITA, 2010). Maize means life in the developing world as its value cannot be overstated as it has potential to mitigate the present food insecurity and alleviate poverty. It is projected that by 2025, maize would have become the world favorite food crop as its demand would double (CIMMYT and IITA, 2010). Maize contains carotenoids and phenolic compounds as antioxidants, selenium, zinc, manganese and copper as cofactors for antioxidant or betaine, choline and folate as indirect antioxidants (Hänsch and Mendel, 2009). Although maize has macro- and micronutrients required for humans, the normal maize lacks essential amino acids such as lysine and tryptophan important in the synthesis of proteins by the body (Vivek *et al.,* 2008). Millions of people most especially in third world countries, get their protein and calorie supplies from maize (Mbuya *et al*., 2011), consequently become malnourished as a result of lack of these essential amino acids in maize (Rosegrant *et al*., 2001). QPM has 30-80% more lysine and tryptophan in the whole grain than normal maize (Vasal, 2001). It contains virtually twice as much usable protein as the normal maize with protein bioavailability that equals milk casein and yields 10% more grain than the traditional varieties of maize (Nuss and Tanumihardjo, 2011).

Recent QPM research focuses on its adaptability to various agro-ecologies (Krivanek *et al*., 2007). Also, development of high-yielding QPM varieties is ongoing (Sofi *et al*., 2009) and it is predicted that by 2020, about 30% of maize area will be under QPM genotypes (Gill, 2008). It is predicted that improvement and adoption of QPM could augment the nutritional status of food and feed maize products (Bhatnagar *et al*., 2004).

This study was therefore conducted to assess yield and nutritional qualities of some QPM and pro vitamin A lines in the southern Guinea savanna ecology of Nigeria. The objectives of the study are therefore:

- To evaluate the yield potential of QPM and pro-vitamin A maize varieties in the southern guinea savanna agro-ecology.
- To determine the lysine and tryptophan contents of QPM.

2. MATERIALS AND METHODS

2.1 EXPERIMENTAL SITE

This research was carried out at the Teaching and Research Farms of Kwara State University, Malete located at Latitude 8˚ 30' N, 8˚ 36' E and Longitude 4˚ 31' N, 4˚33' E and about 345m above the sea level in the Southern Guinea Savanna of Nigeria. The experimental site has been previously used to grow various crops ranging from cereals to legumes. It was left to fallow for 24 months before used for this study.

2.2 PLANTING MATERIALS

Six (6) pro-vitamin A and four (4) QPMs were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, and a local check (Pambo) was obtained from the farmers' source. The maize varieties used for this study are listed in Table 1.

2.3 EXPERIMENTAL LAYOUT AND FIELD PREPARATION

The Six (6) Pro-vitamin A, four (4) QPM and local check (Pambo) were sown using randomized complete block design (RCBD) in three (3) replicates. Land clearing was carried out mechanically. Sowing was done on the 22nd of July 2015at a spacing of 75 cm x 25cm inter and intra row spacing respectively. Two seeds were planted per stand, drilled 3-4cm deep. The seedlings were thinned to a plant per stand two weeks after sowing to provide a uniform plant population and reduce plant-plant competition.

2.4 WEED MANAGEMENT

In order to prevent competition for nutrients (such as water and light) between the crops and the weed, the weeds were controlled at the pre-emergent state using a mixture of gramozone (paraquat) and premextra (Atrazine 223 g/L + Metolachlor 277 g/L). It was later supplemented by hand weeding to control weeds.

2.5 FERTILIZER APPLICATION

For good growth and high yield, maize plants need to be supplied with adequate nutrients particularly nitrogen, phosphorus and potassium. NPK 15:15:15 fertilizer was applied to the plot at the second week of planting and urea was also added at the sixth week of planting.

2.6 DATA COLLECTION

2.6.1 POST-PLANTING DATA COLLECTION

Average Plant Height (cm)

Measurements were made on selected plants from the soil surface to the last trifoliate leaf and were recorded in centimeters (cm).

Average Number of Leaves

The number of leaves on the selected plants were counted and their means were recorded.

Average Leaf Area (Cm^2)

Leaf areas of the selected plants were estimated as L x B x 0.75 where

L= length of the leaf along the mid rib (cm)

B= widest width of leaf (cm) and 0.75 as correction factor (Carleton, 1965).

Days to 50% Tasselling

The number of days from sowing date to the days when 50% of the plants started tasselling was computed.

Days to 50% Silking

The number of days from sowing to the days when 50% of the maize cobs started silk emergence was computed as average days of silking.

Days to Anthesis

The number of days from sowing to the days when 50% of the tassels has started shedding pollens

Anthesis Silking Interval (ASI)

This is difference between days to 50% anthesis and silking

Husk Cover rating

The number of husk cover damage per plant stand was computed as average number of husk cover damage per stand. They were graded based on how good or damaged their husk cover was. They were scored with excellent, very good, good, fair and poor using 5,4,3,2, and 1 for coding the grades respectively.

Stay Green

The numbers of days that the plants were able to maintain their greenness after physiological maturity .They were graded based on how greenish or faded they were. They were scored with excellent, very good, good, fair and poor using 5,4,3,2, and 1 for coding the respective grades.

Logging

The rate at which the plants in each replicate fall off was computed as logging. They were graded based on firmed or how logged their stems were. The plants were scored using excellent, very good, good, fair and poor as the grading parameters, using 5,4,3,2, and 1 for coding the respective grades

Grain Yield Per Plant

The yield obtain from each plant per line was computed as grain yield per plant in tons/hectare.

3. DATA ANALYSIS

All data collected were summarized and statistically analyzed for analysis of variance and correlation analysis and mean values separated with Duncan's Multiple Range Test. All data were analyzed using Plant breeding (PB) tools.

4. RESULTS

Table 1 shows the characteristics of the maize sown. The maturity class of the lines ranged from intermediate to late maturing material with both white and yellow endosperm.

Mean values for vegetative growth parameters such as plant height, leaf number, leaf area of the 11 maize varieties are presented in table 2. At 4 weeks after sowing, the maize varieties were not significantly different from each other in terms of growth. They had average plant height of 26.26 cm with PVA SYN 19 F_2 being the most vigorous with height of 32.77 and TZE recorded the least (22.17cm). Average number of leaves per plant for the 11 maize varieties was 7.17. The number of leaves however ranged between 6.61 and 8.53 for TZE Q1 27 and PVA SYN 9 F_2 respectively. The leaf area of the maize plants at this week ranged between 35.45cm^2 for TZE Q1 34 and 108.22cm^2 for pambo while the average leaf area across the 11 maize varieties is 60.07cm^2 (see table 2). The mean value at 6 weeks after sowing for plant height (cm), number of leaves per plant and leaf area of 11 different maize varieties differed significantly from each other. On the average, at 6-weeks after sowing, maize had plant height of 67.21cm, about 9 leaves per plant, and 52.36cm^2 leaf area. At this week, pro-vitamin A maize varieties show vigorosity for the highest value for number of leaves and leaf area. Also and 8 and 10 WAS, the maize varieties differ significantly from each other with PVA SYN 17 F_2 having average height of 159.63cm, about 12 leaves and 406.79cm^2 leaf area.

Table 2 also shows the peak of growth stage, 10WAS, maize varieties differ significantly from each other. The maize varieties on the average have 157.57cm as plant height, about 14 leaves and 163.94cm^2 leaf area, with pambo the local check being most vigorous having plant height of 184.8cm, about 15 leaves and laf area of 215.03cm^2.

Table 3 shows correlation analysis between the plant heights, leaves numbers and leaf areas fortnightly from week 2-10, some of which were significantly correlated. From the table, there was significant ($p<0.05$) positive correlation between the plant heights; and the leaf area (0.53), stay green (0.33) and number of leaves at week 10. There was however a significant ($p< 0.05$) negative correlation between grain yield; plant height (-0.33) and tryptophan level (-0.34). Also, number of leaves correlated positively with stay green (0.46) while it correlated negatively with leaf area at 10 WAS. From the table, there was negative significant correlation between logging and husk cover damage (-0.76) and stalk damage (-0.62) Also, there was positive significant ($p<0.05$) correlation between the stem breakage and the husk cover (0.35).

Table 4 Shows the mean value for logging, husk cover damage, shoot breakage, anthesis silking Interval, yield and the days to 50% tasselling, silking and anthesis. For the days to 50% tasselling and anthesis, all the 10 advanced breed tassel and also shed their pollens almost at the same period but they were significantly ($p<0.05$) different from the local check. Also, the yield of all the varieties on the average amount to 2.93 t/ha with TZE Q1 34 (5.06 t/ha) having the highest yield.

Table 5 Shows the analysis of variance (ANOVA) for the levels of lysine and tryptophan of the maize varieties. On the average, the mean for lysine is 8.58 while that of tryptophan is 7.39 with PVA SYN 9 F_2 showing the highest significant ($p<0.05$) level for both lysine (15 µg/100g) and tryptophan (26 µg/100g) content. In contrast, pambo shows the least lysine (4 µg/100g) and tryptophan (µg/100g) contents.

5. DISCUSSION

5.1 VEGETATIVE PARAMETERS IN MAIZE

Characterization of the 11 selected maize varieties for vegetative characters (plant height, number of leaves and leaf area) at 6, 8 and 10 WAS revealed highly significant ($p<0.05$) differences attributable to genotypic difference among them. The wide variability exhibited by these varieties suggests there is room for selection from the collection. It was observed from this preliminary study that the local check tend to have higher tendency for height which make it to have greater tendency to be lodged. This indicates that plants that showed superiority for height tend to have more number of leaves and larger leaf area and hence more of photosynthesis per unit. The vigorosity of pambo might be as a result of being adapted to the zone. The relative low yield of pambo might be as a result of being open pollinated variety area (Kutka, 2011). In contrast, the QPM hybrids show dwarfism for plant height which made them to be less prone to lodging and consequently rodent attack.

5.2 YIELD POTENTIAL IN MAIZE

Since the goal of this study is to evaluate the yield potential of QPM and pro-vitamin A maize varieties in the southern guinea savanna agro-ecology where the study was conducted, it observed from the preliminary study that these maize varieties physiologically thrive well in this zone. The yield of all the varieties on the average amount to 2.93 t/ha about the national average (IITA, 2009). TZE Q1 34 was the highest yielding with 5.06t/ha. The superiority of QPM hybrids over PVA SYN F_2 and pambo could be as a result of heterosis exhibited by hybrids and segregation shown by OPVs (PVA SYN F_2 and pambo) (Kutka, 2011, Shushay, 2014 and Ofori *et., al.* 2015). The yield obtained in this study is higher than the average 1.3t/ha obtainable in sub Saharan Africa (IITA, 2009).

5.3 LYSINE AND TRYPTOPHAN CONTENTS IN MAIZE

From this study, QPM and Pro-Vitamin A genotypes evaluated were generally of considerable lysine and tryptophan contents. The best hybrids for amino acid contents (PVA SYN 9 F_2, PVA SYN 17 F_2 and TZE Q1 27) had percentage lysine and tryptophan advantage of 30% and above compared with the pambo which mean that, though, these maize varieties physiologically thrive well on the field with the pambo having the highest plant height but, the genetic component is less significant ($p<0.05$) when compared with those of the advance breeding lines that have lower plant height. This is similar to the study of Bello *et., al* (2009) who concluded that the advanced maize varieties show superiority for protein contents when compared with the local checks.

6. CONCLUSION AND RECOMMENDATION

There were significant differences across the 11maize varieties in plant height (cm), number of leaves, leaf area (cm^2), days to 50% tasselling, days to 50% silking, days to 50% anthesis, anthesis silking interval logging, husk cover damage, shoot breakage and yield.

The wide range in the data observed for most of the traits and the significance in their correlation and means obtained showed the presence of genetic variability for traits study, Therefore, these traits can be improved through breeding.

Conclusively, TZE Q1 34 and TZE Q1 20 are the best suitable varieties in this area in terms of yield. While for higher lysine and tryptophan content, PVA SYN 9 F_2 and PVA SYN 19 F_2 were discovered to be of more nutritional quality when compared to every other variety with the local check having the least of the nutritional quality.

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Table 1: List of eleven (11) maize varieties with their source and colour

Maize varieties	Source	Colour	Maturity group	Class	Type
TZE QI 20	IITA	White	Early	Ept. hybrid	QPM
TZE Q34	IITA	White	Early	Ept. hybrid	QPM
TZE QI 27	IITA	White	Early	Ept. hybrid	QPM
TZE QI 25	IITA	White	Early	Ept. hybrid	QPM
Pro-Vitamin A Synthetic 1 F_2,	IITA	Yellow	Medium/late	population	Pro vitamin A
Pro-Vitamin A Synthetic 9 F_2	IITA	Yellow	Medium/late	population	Pro vitamin A
Pro-Vitamin A Synthetic 10 F_2	IITA	Yellow	Medium/late	population	Pro vitamin A
Pro-Vitamin A Synthetic 11 F_2	IITA	Yellow	Medium/late	population	Pro vitamin A
Pro-Vitamin A Synthetic 17 F_2	IITA	Yellow	Medium/late	population	Pro vitamin A
Pro-Vitamin A Synthetic 19 F_2	IITA	Yellow	Medium/late	population	Pro vitamin A
Pambo	Market	Yellow	Medium/late	population	Normal endosperm

Ept- experimental hybrid, QPM- quality protein maize.

Table 2: Trends in Vegetative growth; plant height (cm), number of leaves, leaf area (cm^2) of maize varieties at 4, 6, 8 and 10 weeks after sowing (WAS)

Variety	Plant height	No of Leaves	Leaf Area	Plant height	No of leaves	Leaf Area	Plant height	No of leaves	Leaf Area	Plant height	No of leaves	Leaf Area
	.....4 WAS.....			.....6 WAS.....			.....8 WAS.....			.....10 WAS.....		
PVA SYN 11 F_2	26.60^{a}	7.20^{a}	58.73^{b}	69.50^{ab}	8.66ab	56.12^{ab}	114.80^{bcd}	11.67ab	116.43^{ab}	162.43^{abc}	13.67^{abc}	199.44^{ab}
PVA SYN 10 F_2	27.27^{a}	6.90^{a}	63.26^{b}	72.33^{ab}	9.00ab	63.25^{a}	122.63^{abc}	11.33ab	124.88^{ab}	172.47^{abc}	13.67^{abc}	182.83^{ab}
PVA SYN 9 F_2	28.80^{a}	8.53^{a}	61.25^{b}	74.70^{ab}	8.67ab	57.38^{ab}	124.77^{abc}	11.67ab	114.56^{ab}	174.47^{abc}	14.00^{ab}	157.55^{ab}
PVA SYN 1 F_2	25.97^{a}	7.10^{a}	60.01^{b}	68.96^{ab}	9.00ab	56.91^{ab}	116.47^{bc}	11.67ab	114.85^{ab}	162.93^{abc}	13.67^{abc}	162.71^{ab}
PVA SYN 17 F_2	31.50^{a}	6.77^{a}	56.12^{b}	74.06^{ab}	9.33a	46.45^{ab}	159.63^{a}	12.00ab	406.79^{a}	172.30^{abc}	13.67^{abc}	169.62^{ab}
PVA SYN 19 F_2	32.77^{a}	7.30^{a}	57.85^{b}	74.66^{ab}	9.33a	57.28^{ab}	125.13^{abc}	11.67ab	105.09^{ab}	176.27^{ab}	14.00^{ab}	158.08^{ab}
TZE Q1 20	23.63^{a}	6.87^{a}	37.26^{b}	44.30^{c}	8.67ab	43.64^{b}	73.60^{d}	10.67ab	70.74^{b}	102.87^{d}	12.67^{c}	118.04^{b}
TZE Q1 27	24.97^{a}	6.67^{a}	53.97^{b}	65.06^{b}	9.00ab	47.03^{ab}	108.50^{cd}	12.33a	100.89^{ab}	151.10^{c}	13.67^{abc}	155.99^{ab}
TZE Q1 34	22.17^{a}	7.43^{a}	35.45^{b}	51.33^{c}	9.33a	43.79^{b}	85.53^{cd}	11.00ab	77.18^{b}	119.93^{d}	13.67^{abc}	120.83^{bc}
TZE Q1 25	22.80^{a}	6.77^{a}	68.64^{b}	65.56^{ab}	9.00ab	53.70^{ab}	109.73^{bcd}	11.00ab	112.16^{ab}	153.73^{bc}	13.33^{bc}	163.26^{ab}
PAMBO	22.37^{a}	7.33^{a}	108.22^{a}	78.90^{a}	8.00b	50.45^{ab}	131.50^{ab}	12.00ab	168.50^{ab}	184.8^{a}	14.67^{a}	215.03^{a}
Mean	26.26	7.17	60.07	67.21	8.91	52.36	115.66	11.55	137.46	157.57	13.70	163.94
CV(%)	13.70	7.20	31.50	15.70	4.40	12.40	19.70	4.30	67.60	16.00	3.52	17.60

Figures with the same letters in a column are not statistically different.

Table 3: Correlation analysis of vegetative, reproductive and quality parameters of the maize lines from 4-10 weeks after planting

	ASI	SG	SB	L	HC	Yld	PH4	LN4	PH6	LN6	PH8	LN8	PH10	LN10	TRP	LYSI	LA4	LA6	LA8	LA10
ASI	1																			
SG	-.06	1																		
SB	-.30*	.39*	1																	
L	-.05	-.69**	-.62**	1																
HC	.27	.45**	.35*	-.76**	1															
Yld	-.07	.05	.03	-.03	.06	1														
PH4	.15	-.17	-.03	-.03	-.03	-.14	1													
LN4	.16	.06	-.09	-.28	.40*	.28	.02	1												
PH6	.16	.33*	-.15	-.22	.04	-.33*	.35*	.12	1											
LN6	.32*	-.43**	-.35*	.44**	-.19	.23	.03	-.19	-.12	1										
PH8	.13	.18	-.20	-.04	-.05	-.29*	.21	-.02	.75**	.12	1									
LN8	-.02	.19	-.01	-.17	-.09	-.24	.26	.04	.56**	-.02	.43**	1								
PH10	.17	.33*	-.16	-.22	.05	-.33*	.37*	.12	.99**	-.13	.75**	.55**	1							
LN10	-.04	.46**	.18	-.26	.13	-.14	.07	.06	.52**	-.20	.39*	.15	.53**	1						
TRP	.23	.02	-.20	.03	-.05	-.34*	.21	.30*	.40*	-.14	.28	.10	.42**	.25	1					
LYSI	.06	-.07	-.31*	.23	-.27	-.26	.28	.20	.41**	-.11	.26	.13	.44**	.27	.90**	1				
LA4	-.02	.63**	.09	-.50**	.33*	.14	-.04	.16	.41**	-.05	.20	.06	.41**	.34*	.06	.02	1			
LA6	.06	-.06	-.23	.06	-.14	.13	.25	.12	.33*	.15	.08	-.09	.35*	.09	.27	.32*	.51**	1		
LA8	-.15	.06	-.13	.06	-.06	-.10	.24	-.20	.19	-.06	.10	-.03	.21	.19	-.24	-.01	.23	.18	1	
LA10	-.24	.36*	-.04	-.01	-.24	-.26	.15	-.40*	.55**	-.09	.27	.24	.53**	.29	.09	.17	.41**	.44**	.29*	1

*and ** indicate significant differences at P<0.05 and P<0.001, respectively while ns indicate non significant

Figure attached to traits represents number of weeks after planting. ASI- anthesis silking interval, SG- stay green, lodging, HC- husk cover, PH- plant height, LN- number of leaves, LYS- lysine content, TRP- tryptophan content and LA- leaf area.

Table 4: Mean values variability for Yield (t/ha) and other characters measured at reproductive stage

Variety	%50T	% 50S	%50 A	L	HC	SB	ASI	YLD
PVA SYN 11 F_2	55.00^{b}	64.7^{b}	66.0^{e}	4.33^{a}	4.33^{ab}	4.67^{ab}	1.33^{ab}	1.48
PVA SYN 10 F_2	53.33^{b}	63.8^{b}	68.0^{bcde}	4.67^{a}	4.33^{ab}	4.00^{b}	4.33^{abc}	3.40
PVA SYN 9 F_2	52.33^{b}	65.0^{b}	69.7^{cd}	4.67^{a}	4.00^{b}	4.00^{b}	4.67^{abc}	2.66
PVA SYN 1 F_2	52.67^{b}	62.7^{b}	68.3^{bcd}	4.33^{a}	4.33^{ab}	4.33^{ab}	5.67^{a}	1.46
PVA SYN 17 F_2	53.67^{b}	63.3^{b}	67.7^{cde}	4.67^{a}	4.33^{ab}	4.00^{b}	4.33^{abc}	1.50
PVA SYN 19 F_2	56.00^{b}	64.3^{b}	69.3^{bc}	4.33^{a}	4.33^{ab}	4.67^{ab}	5.00^{ab}	2.15
TZE Q1 20	53.33^{b}	65.3^{b}	68.0^{bcde}	4.67^{a}	4.33^{ab}	4.67^{ab}	2.67^{abc}	4.62
TZE Q1 27	56.67^{b}	66.0^{b}	67.0^{de}	4.67^{a}	4.00^{b}	4.67^{ab}	1.00^{c}	2.69
TZE Q1 34	51.33^{b}	64.7^{b}	68.3^{bcd}	4.67^{a}	4.33^{ab}	4.33^{ab}	3.67^{abc}	5.06
TZE Q1 25	53.00^{b}	65.0^{b}	70.0^{b}	4.67^{a}	4.33^{ab}	4.00^{b}	5.00^{ab}	3.91
PAMBO	70.76^{a}	73.7^{a}	77.0^{a}	3.00^{b}	5.00^{b}	5.00^{a}	3.33^{abc}	2.68
Mean	55.28	65.32	69.03	4.43	4.33	4.39	3.73	2.93
CV%	9.7	4.5	4.2	0	6.0	8.2	40.7	35.83
SED (Df=10)								0.30

Table 5: Mean values for lysine and tryptophan (µg/100g) contents of the 11 maize varieties

Variety	Lysine	Tryptophan
PVA SYN 11 F_2	8.33^{ab}	19.33^{abc}
PVA SYN 10 F_2	13.33^{a}	24.33^{ab}
PVA SYN 9 F_2	15.00^{a}	26.00^{a}
PVA SYN 1 F_2	10.00^{ab}	21.00^{abc}
PVA SYN 17 F_2	5.33^{bc}	10.67^{c}
PVA SYN 19 F_2	14.67^{a}	25.33^{ab}
TZE Q1 20	4.67^{b}	10.67^{abc}
TZE Q1 27	4.67^{b}	17.33^{abc}
TZE Q1 34	5.67^{b}	14.00^{abc}
TZE Q1 25	8.67^{ab}	13.33^{abcd}
PAMBO	4.00^{abc}	9.33^{d}
Mean	8.58	17.39
CV%	48.55	35.70

Figures with the same letters in a column are not statistically different