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COMBINING ABILITY FOR QUALITY OF MAIZE FLOUR IN A 6–PARENT DIALLEL CROSS

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ABSTRACT

Whole maîze *(Zea mays L.)* grains from 15 F_1 hybrids obtained from a diallel cross of six maize cultivars consisting of one waxy and five non-waxy were ground into flour and used to prepare "tuwo", a thick porridge. "Tuwo" was prepared by heating a mixture of 10 g flour in 30 ml of water and evaluated for firmness, stickiness and time of gelatinization. Mean square for general combining ability (GCA) was highly significant for stickiness and firmness of "tuwo". Gelatinization time was highly significant for specific combining ability (SCA). Additive gene effects were substantially more important for firmness and stickiness, while gelatinization time was considerably influenced by non-additive genes. The waxy maize contributed more unfavourable GCA effects for softness and stickiness of "tuwo" than the remaining five cultivars.

***Key Words*: Firmness, gelatinization time, general combining ability, specific combining ability, stickiness, "tuwo".**

RÉSUMÉ

Les grains complets du maïs (*Zea mays* L.) provenant de 15 hybrides F_1 obtenus par croisement dialèle de 6 variétés dont un non farineux et 5 farineux sont réduits en farine pour la confection du "tuwo", une bouillie épaisse. Le tuwo, préparé en chauffant la mixture de 10 g de farine dans 30 ml d'eau a été évalué pour la fermeté, la viscosité et le temps de gelatinisation. La carré moyenne pour une aptitude de combinaison générale (GCA) a été hautement significative quant à la viscosité et la fermeté de "tuwo". Le temps de gelatinisation a été hautement significatif pour une aptitude de combinaison spécifique (SCA). Les effets des gènes additifs sont plus importants pour la fermeté et la viscosité, tandis que le temps de gelatinisation a été largement influencé par les gènes non additifs. Le maïs non farineux a contribué d'une manière défavorable aux effets GCA pour la douceur et la viscosité du "tuwo" que les 5 autres cultivars non farineux.

***Mots Clés*: fermeté, temps de gelatinisation, aptitude de combinaison générale, aptitude de combinaison spécifique, viscosité, tuwo**

INTRODUCTION

"Tuwo" is a local name to a dry milled cereal flour gel product which is a common food with only slight regional modifications from Senegal to Ethiopia (Scheuring *et al.*, 1982). In Nigeria, "tuwo" made from sorghum has been consumed more than that made from maize among people living in the north of the country, until recently when maize production acquired more popularity and acceptance.

Consumer acceptability of "tuwo" depends largely on its texture, i.e., firmness, stickiness and colour (Bello *et al.*, 1990). Since "tuwo" is eaten with hand dipped in a sauce, it is important that it should not be sticky to avoid clogging to the roof of the mouth and secondly that it should not be very soft to enable the ease of manipulation of "tuwo" between the thumb and the fore-fingures (Da *et al.*, 1982). Murty *et al.* (1982) observed that waxy grain samples produce fluid gels with low consistency, while grain flours from floury endosperm kernel have been reported to produce sticky "tuwo". When "tuwo" is stored over-night as commonly done by "tuwo" consumers, the textural behaviour of the porridge tends to be influenced by the cultivar used for its preparation (Da *et al.*, 1982).

The nature of gene action influencing the texture of thick porridges of maize has received little attention. Kaw and Cruz (1991) studied the degree of heterosis for flour gel consistency in rice using F_1 hybrids obtained from crossing 17 females with six male parents. The authors reported that a large number of the F_1 hybrids expressed considerable heterosis when compared with the mid-and -high parent values and concluded that non-additive gene effects were most predominant.

This study was designed to investigate the nature of gene action on the rheological property of maize "tuwo", a thick porridge flour meal.

MATERIALS AND METHODS

Six open-pollinated maize cultivars, namely Pool 16 SR, TZESR-W, BC 63, DMR-ESR-W, Pop. 49 SR (EV 8349-SR) and Celaya waxy were crossed in all possible combinations excluding reciprocals. A set of the 15 F_1's without parents and reciprocals were grown in the University of Benin Teaching and Research Farm during the 1991 crop year. The entries were grown in a randomized complete block design with three replicates. The plot size was a single row plot of 5 m length. The rows were spaced 75 cm apart. Plants in each row were spaced 50 cm with two plants $hill^{-1}$. Weeds were controlled by the application of 5.0 l ha^{-1} of primextra (atrazine + metolachlor) as a pre-emergence herbicide, and fertilizers were applied at the rate of 120 kg ha^{-1} N and 50 kg ha^{-1} P_2O_5 and K_2O, respectively.

When the plants were fully matured, the ears were harvested on row basis. The kernels were shelled and dried at 48°C ± 2°C. A 100 g sample of whole grain was taken from each hybrid, ground with a kitchen blender with two vertically placed carborundun grinding stones. The ground flour was sifted through a sieve of 0.35 mm mesh (BSS 410).

Preparation of "tuwo". "Tuwo" was prepared by the procedure described by Da *et al.*, (1982) with some modifications. Briefly, 10.0 g flour (dwb) was made into a slurry using 20 ml tap water. Ten ml of water was measured into a 150 ml beaker and heated over an electric burner until boiling. The flour slurry was poured into the boiling water and cooked for abourt 2–3 mins. The cooked "tuwo" was shared into two 10 ml beakers. "Tuwo" from the first beaker was evaluated for firmness after 1 hour as fresh "tuwo" and the second after 24 hr of storage at room temperature as stale "tuwo". "Tuwo" quality was evaluated for firmness, stickiness and time of gelatinization. Firmness and stickiness were subjectively evaluated on a scale of 1–5. In the case of firmness 1 = very firm and 5 = very sticky. Both variables were measured by taking a small portion of the prepared "tuwo" and manipulating it into a boll with the forefingers and thumb. The degree of adherence of the "tuwo" to the fingers in the case of stickiness and the ease to form a boll in the case of firmness were scored. Time (minutes) of gelatinization was recorded as the time between the onset of cooking of the slurry to the onset of gelatinization.

Data were analysed as a randomized complete block design. Genotypic mean squares were partitioned into general combining ability (GCA) and specific combining ability (SCA) according to the procedure of Griffing (1956) using one set of F_1 hybrids without parents and reciprocals.

RESULTS AND DISCUSSION

Differences among hybrids for firmness of "tuwo" after 1 hr of preparation (fresh "tuwo") were highly significant for general combining ability (GCA) but not significant for specific combining ability (SCA) (Table 1). For the 15 F_1 hybrids, firmness rating of fresh "tuwo" averaged 2.8 (Table 2). The GCA effects ranged from -0.42 for line 5 to 1.08 for line 6. The hybrid with the best "tuwo" rating (1.3) was a cross of line 3 x5. Both lines expressed the GCA effects and thereby expressing highly acceptable firmness characteristic. Mean squares for GCA were highly significant for firmness for overnight "tuwo" and not for SCA (Table 1). The GCA effects ranged between -0.47 for line 5 and 0.78 for line 6 (Table 3). The GCA effects for stale "tuwo" were similar to that of fresh "tuwo".

"Tuwo" otained from crosses involving line 6 (waxy) stored very poorly. Waxy maize cultivar appeared to have contributed more unfavourable genes for "tuwo" quality while line 5 contributed more favourable genes to good quality "tuwo". Scheuring *et al.* (1982) reported that waxy sorghum usually failed to form a gel.

The performance of the 15 hybrids averaged 4.2 for "tuwo" stickiness (Table 4). Highly significant mean squares for stickiness were observed for GCA while mean squares for SCA were not (Table 1). The GCA effects ranged from -0.83 for line 4 to 1.33 for line 6. Line 6 contributed more disproportionately to "tuwo" quality by increasing the stickiness value which is

TABLE 1. Mean square values for combining ability analysis for "tuwo" quality.

	Mean Squares			
Variables	GCA	SCA	Error	GCA/SCA
Firmness after 1 hr.	1.19*b	0.30	0.33	3.96
Firmness after 24 hr	0.76**	0.04	0.17	19.0
Stickiness	2.21**	0.40	0.28	5.53
Gelatinization time	5.80	12.16**	3.79	0.48

*b Significant at 1% level of probability

Degrees of freedom : GCA =5; SCA = 9; Error =28

TABLE 2. Hybrid means, array of means and general combining ability effects for firmness of "tuwo" after 1 hour

	Parents							
Parents	1	2	3	4	5	6	Array Means	GCA effect
1. Pool 16 Sr		2.7	2.7	2.7	2.0	3.7	2.8	-0.08
2. TZESR-W			2.7	2.7	2.3	3.3	2.7	-0.08
3. BC63				2.0	1.3	4.3	2.6	-0.25
4. DMR-ESR-W					2.7	3.0	2.6	-0.25
5. Pop. 49 SR						4.0	2.5	-0.42
6. Waxy							3.7	1.08

TABLE 3. Hybrid means, array of means, and general combining ability effects for firmness of "tuwo" after 24 hours

	Parents							
Parents	1	2	3	4	5	6	Array Means	GCA effect
1. Pool 16 SR		4.0	4.0	4.0	3.3	4.3	3.9	-0.31
2.TZESR-W		4.0	4.3	4.0	5.0	4.3	3.9	-0.31
3. BC 63			2.0	1.7	5.0	5.0	-0.08	
4. DMR-ESR-W					2.0	3.3	3.5	-0.83
5. Pot. 49 SR						4.7	3.8	-0.47
6. Waxy							4.8	0.78
Mean							4.2	

unacceptable to consumers. A cross of line 3x5 produced "tuwo" with the least stickiness. DMR-ESR-W contributed the most favourable gene effect to non-sticky "tuwo" by contributing the least GCA effect (-0.83).

The array means for gel time revealed that the average effect of line 2 across the hybrids was the least and closely followed by line 6 (Table 5). The GCA effects ranged from -1.78 for line 2 to 1.89 for line 3. Line 3 contributed most unfavourable to delay in gel time while line 2 contributed most favourably to quicker gelatinization time. Line 2 could be considered useful for the production of gel products where instant cooking is desirable. Line 6, waxy maize with a GCA value of -0.36 for gelatinization time appears to agree with the finding of Murty *et al.* (1982) who reported that waxy sorghum gelled earlier than non-waxy. Hybrids between lines (1x4) and (2x3) expressed the fastest gelatinization time (Table 6). Delayed gel time was observed in two hybrids of lines (1x3) and (3x4), respectively.

The preponderance of the variation due to GCA (Table 1) for firmness of stale "tuwo" indicates that additive genetic variance was more important than the non-additive gene effects. Similarly the significant mean squares due to GCA for firmness and stickiness of fresh "tuwo" suggest that the inheritance of both characters is controlled primarily by additive gene effects. This is, however, contrary to the findings of Kaw and Crux (1991) who reported that gel consistency in rice was controlled predominantly by additive genes. Improvement of "tuwo" texture (firmness and stickiness) can therefore be achieved using simple recurrent selection or recurrent full sib

TABLE 4. Hybrid means, array of means and general combining ability effects for stickiness.

	Parents							
Parents	1	2	3	4	5	6	Array Means	GCA effect
1. Pool 16 SR		3.0	3.7	1.7	3.0	4.0	3.1	-0.08
2. TZESR-W			3.0	3.3	2.7	4.3	3.3	0.17
3. BC 63				2.0	1.7	5.0	5.0	-0.08
4. DMR-ESR-W					2.0	3.3	3.5	-0.83
5. Pop. 49 SR						4.3	2.7	-0.50
6. Waxy							4.2	1.33
Mean							3.2	

TABLE 5. Hybrid means, array of means, and general combining ability effects for gelatinization time

	Parents							
Parents	1	2	3	4	5	6	Array Means	GCA effect
1. Pool 16 SR		35.0	40.3	31.0	39.0	34.0	35.9	-0.03
2. TZESR-W			32.3	38.3	33.7	33.3	34.5	-1.78
3. BC 63				41.0	37.3	36.3	37.4	1.89
4. DMR-ESR-W					32.7	35.7	35.7	-0.28
5. Pop. 49 SR						39.0	36.4	0.56
6. Waxy							35.7	-0.36
Mean							35.9	

TABLE 6. Specific combining ability effects for gelatinization time

	Parents					
Parents	1	2	3	4	5	6
1. Pool 16 SR		0.85	2.52	-4.65	2.85	-1.57
2. TZESR-W			-3.75	4.43	1.07	0.48
3. BC 63				3.48	-1.07	1.15
4. DMR-ESR-W					-3.37	0.35
6. Waxy						

family selection. The ration of GCA: SCA for gelatinization time was less than unity suggesting a preponderance of dominance gene effects. The highly significant mean square for SCA indicates that genetic progress from selection for gel time might be achieved using hybridization reciprocal recurrent selection.

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