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PROCESSING PROPERTIES OF GRAINS FROM SOME MAIZE CULTIVARS INTRODUCED ON-FARM IN THE S UDANO SAHELIAN ZONE OF CAMEROON

By

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ABSTRACT

Maize grains from twenty three cultivars developed by research and produced at farm level were evaluated for chemical composition and their ability to produce flour and grit after removal of panicle in wet and dry processes. Sixteen cultivars used for this evaluation were developed by the breeding program of the Institute of Agricultural Research for Development (IRAD) of Cameroon.

The remaining seven originated from CIMMYT, West and Central Africa Maize Network (Wecaman), Ghana and Congo. Flour and grit were produced in wet and dry processes with samples of 10 kg of grains from each cultivars using available machinery at village level. Wet process of the grains included the removal of the panicle, soaking for 3 hours, drying on the mat for 2 hours, milling, drying of the flour and sieving through different mesh sizes (400 to 800 microns). For the dry milling, whole or pealed grains were simply processed in a hammer mill and the flour fractions separated as with wet milling.

Results indicated some variation in the proximate composition with nine cultivars exhibiting protein contents above 8%. High protein cultivars were in order hybrids 88094X87036, 87036XExp$_1$24, Acid soil pool yellow, 88094XM131XExp$_1$24, 87084XM131XExp$_1$24, Drought pool yellow, Drought pool white, Kassaï SR, Tuxpeno sequia and BSR 81.

PCA analyses revealed that protein and fat contents as factors accounted for over 80% of intra cultivar variability related to chemical composition. Four major similarity groups of cultivars emerged as striga tolerant with high starch contents, the soft endosperm cultivars, the high fat and high protein cultivars.

Flour and grit yields were cultivar and treatment dependant. Wet milling produced higher flour yields while grit yields were higher when dry milling of pealed grains was done for all cultivars. Cultivars that demonstrated good ability for grit production were ATP SR-Y, Acid soil pool yellow, Drought pool yellow and the hybrids. All cultivars exhibited their ability and suitability for different end uses and this should be taken into account when embarking on large scale maize production.

Key words: maize, cultivars, composition, flour, grits, wet milling,

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APTITUDES TECHNOLOGIQUES DES GRAINES DE QUELQUES CULTIVARS DE MAÏS (ZEA MAIZE) INTRODUITS EN MILIEU PAYSAN DE LA ZONE SOUDANO-SAHELIENNE DU CAMEROUN

RESUME

Les graines de maïs de 23 cultivars développés par la recherche agricole et produites en milieu paysan étaient évaluées pour leur composition chimique et leur aptitude à la production de la farine et du grit ou semoule de maïs. Seize cultivars évalués provenaient du programme de sélection de l'Institut de Recherche Agricole pour le Développement (IRAD, Cameroun) et sept autres provenaient du CIMMYT, du réseau Ouest Africain pour le maïs (WECAMAN), du Ghana et du Congo. Ces graines en échantillons de 10Kg par cultivars étaient soumises à la mouture sèche et humide après que la panicule et le germe aient été enlevés avec les dégermeurs.

Pour la production du grit en mouture humide les grains dégermés, étaient trempés pendant 3 heures, séchés par étalage sur des nattes pendant 2 heures suivi de la mouture, du séchage de la farine et du tamisage à travers des mailles de 400 à 800 microns. Par mouture sèche, les grains entiers ou dégermés étaient directement soumis à la mouture et la farine séchée et fractionnée.

Les résultats montrent des variabilités importantes dans la composition chimique. Plusieurs cultivars (9) ont des teneurs en protéines supérieures à 8% en base sèche et sont respectivement les hybrides 88094X87036, 87036XExp$_1$24, Acid soil pool yellow, 88094XM131XExp$_1$24, 87084XM131XExp$_1$24, Drought pool yellow, Drought pool white, Kassaï SR, Tuxpeno sequia et BSR 81.

Les teneurs en matière grasse et protéine comme facteurs expliqueraient 80% des variabilités observées. Un regroupement à partir de ces facteurs d'affinité donne plusieurs groupes dont un groupe de cultivars tolérants au *striga* et riche en farine, un groupe à endosperme tendre, un groupe de faible teneur en matière grasse et un groupe de cultivars riches en protéine.
Les rendements de farine et semoule obtenus étaient liés aux traitement et type de cultivars utilisés. La mouture humide améliore des rendements en farine alors que la mouture sèche favorise la production du grit indépendamment des cultivars. Les différents cultivars testés ont montré des aptitudes différentes à la transformation ce qui doit être pris en compte pour des productions à grande échelle.

Mots clés: maïs, cultivars, composition, farine, semoule, mouture humide,

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INTRODUCTION

Industrial users of maize constitute the largest clients of maize producers. In developing countries where industrial demand for maize is constantly increasing, they import substantial quantities of maize. Their choice is guided by high quality and standards of the maize grains concerned in terms of protein and starch contents as well as technological attributes.

For economically acceptable grit production, a minimum yield of 40 to 45% is required with less than 1% fat content. House wife for domestic consumption preferred fine maize flour with about 88% of its particles measuring less than 500 microns [1]. Poultry feed mills prefer yellow maize with high protein and riboflavin contents.

These observations suggested that there is a need to breed for variety targeted to a given end product such as flour production, protein content, grit yields etc…Continuous efforts of research institutions resulted in the development of many maize cultivars suitable to various agro ecological zones of West and Central Africa [2]. Breeding and selection were based on agronomic features like length of maturing cycle (short, intermediate and long); drought, striga or soil acidity tolerances and disease resistance.

Grain characteristics such as colour, texture, and acceptance by farmers were also considered. Over 20 maize cultivars were released to farmers [3]. However, major differences in physico-chemical characteristics of corn kernels and their relationship with the quality of dry-milled maize flour had been reported [4]. This work was intended to evaluate the grains of some selected maize cultivars produced on farmer's fields for their ability for quality flour and grit production.

MATERIALS AND METHODS

Maize grains: Sixteen cultivars used for this evaluation were developed by the breeding program of Institute of Agricultural Research for Development (IRAD) of Cameroon. The remaining seven originated from CIMMYT, West and Central Africa Maize Network (Wecaman), Ghana and Congo (Table 1).

Quality seeds of those cultivars were planted on 0.25 ha plots on farm following recommended agronomic practices. Production conditions were those normally practiced by farmers and no attempt was made to use isolation techniques to ensure quality and genetic purity of the cultivars produced. Maize grains encountered on local markets are produced under these very conditions. At maturity, maize was allowed to dry on the field, then manually harvested, shelled and the grains used.

Flour and grits were produced in wet and dry processes [5] with 10 kg of grains from each cultivars using available equipments (Gondard peeling machine and hammer

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mill) powered by electric engines. Wet process of the grains included the removal of the panicle, soaking for 3 hours, drying on the mat for 2 hours, milling, drying of the flour and sieving through different mesh sizes (400 to 800 microns). For the dry milling, whole or pealed grains were simply processed in a hammer mill and the flour fractions separated as with wet milling.

Chemical analyses
The AOAC methods were used [6]. Samples were taken for : dry matter by the atmospheric oven method, fat by Soxhlet hexane extraction, total protein by the kjeldahl method and total fibber by extraction. Total starch was estimated from the differences between dry matter and the rest of the constituents.

Statistical analysis
The GLM procedure of the SAS was used [7]. Mean separation was done by the Duncan multiple range method. Principal Component Analyses (PCA) were used to classify cultivars into similarity groups.

RESULTS

The proximate composition of grains of the 23 maize varieties used are presented in Table 2. Dry matter contents varied from 88.35 to 94.25 % for the hybrid 88094X87036 and Cam Inb STR-1 respectively. Nine cultivars had their dry matter contents higher than 90 %. Crude protein contents were 5.24 and 9.11% for Advanced NCRE and hybrid 87036XExp$_1$24 respectively. Ten cultivars exhibited crude protein contents of more than 8 %. However, observed protein content for Obapanpa was 7.96 % lower than 9.73% when grown in isolation.

PCA analyses (Figure 1) revealed that protein and fat contents as factors accounted for over 80% of intra cultivar variability related to chemical composition. Many major similarity groups emerged from left to right confirming major differences among cultivars. The group on the right comprises mostly cultivars tolerant to striga and rich in flour. The middle groups include most of the soft endosperm cultivars and the left groups are made up of protein rich cultivars. From top to bottom fat rich cultivars are on the upper lines while low fat cultivars are on the lower lines.

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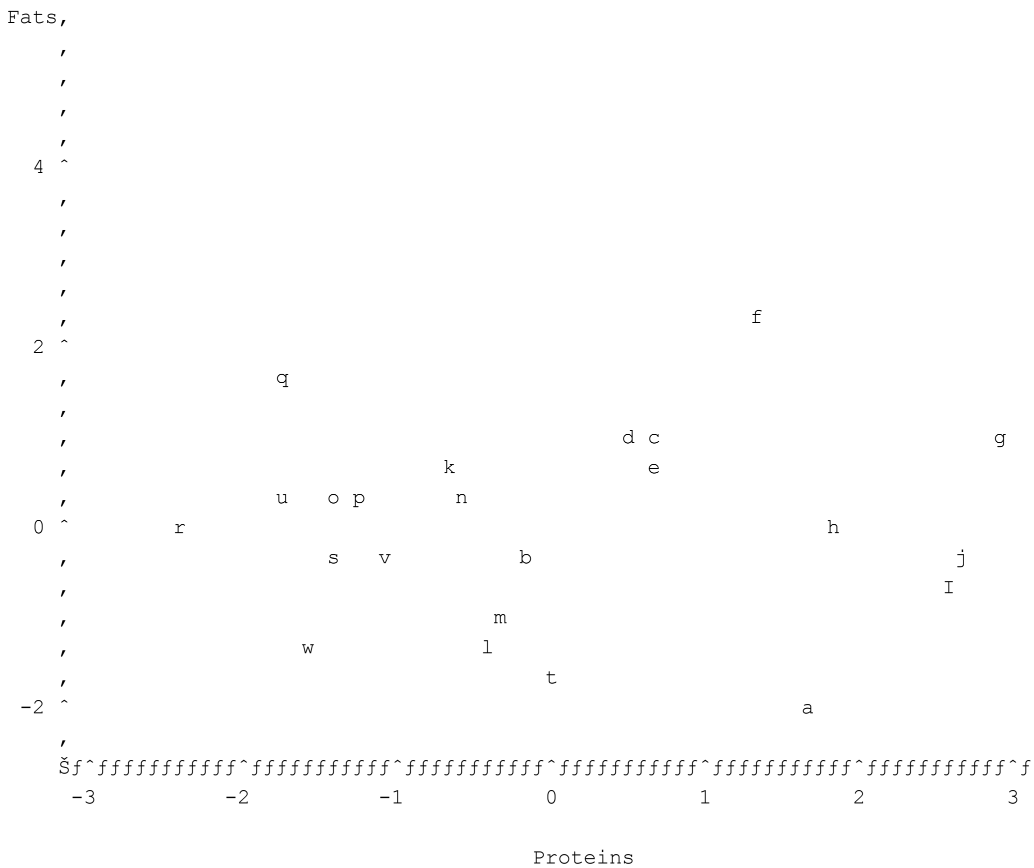

Figure 1: Distribution of maize cultivars according to their composition (Plot of Protein*Fat)

Codes:

a: TZEE SR-W	g: K9350	m: Kasai SR	s: 87036xM131xExp$_1$24
b: CMS 2019	h: Cam Inb STR1.	n: OBATAMPA	t: 870365xExp$_1$24x88069
c: CMS 8501	i: STR-Y	o: Tuxpeno Sequia	u: 88094x87036
d: CMS 9015	j: NCRE	p: Drought Pool Yellow	v: 87036xExp$_1$24
e: CMS 8704	k: ATP SR-Y	q: Drought Pool white	w: 88094xM131xExp$_1$24
f: CMS 8806	l: BSR 81	r: Acid Soil Pool Yellow	

Wet milling increased flour production of all cultivars (Figure 2) compared to dry milling which increased grit production (Figures 3). Cultivars TZEE SR-W, CMS 2019, CMS 9015, BSR 81, Kasai SR, Obatanpa, and all the hybrids (except 88094x87036 with less than 30 % grit yield) demonstrated poor ability for grit production in wet milling.

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Intermediate cultivars for grit production with yields between 30 and 35% were CMS 8501, CMS 8704, CMS 8806, Advanced NCRE, Acid soil pool yellow, and the hybrid 8809x87036. Only four cultivars exhibited grit yields of over 35 % (ATP SR-Y, Tuxpeno Sequia, Drought poll yellow and Drought pool white). For flour production, the leading cultivars were Obatanpa, TZEE SR-W, BSR 81 and all the hybrids. In dry milling peeled grain produced grit with yields ranging from 40 to 48 %.

Leading cultivars for grit production were ATP SR-Y, CMS 8704, Tuxpeno Sequia and Acid soil pooled yellow. ATP SR-Y and Advanced NCRE were less affected by the wet or dry milling treatments given and demonstrated good ability for flour and grit production.

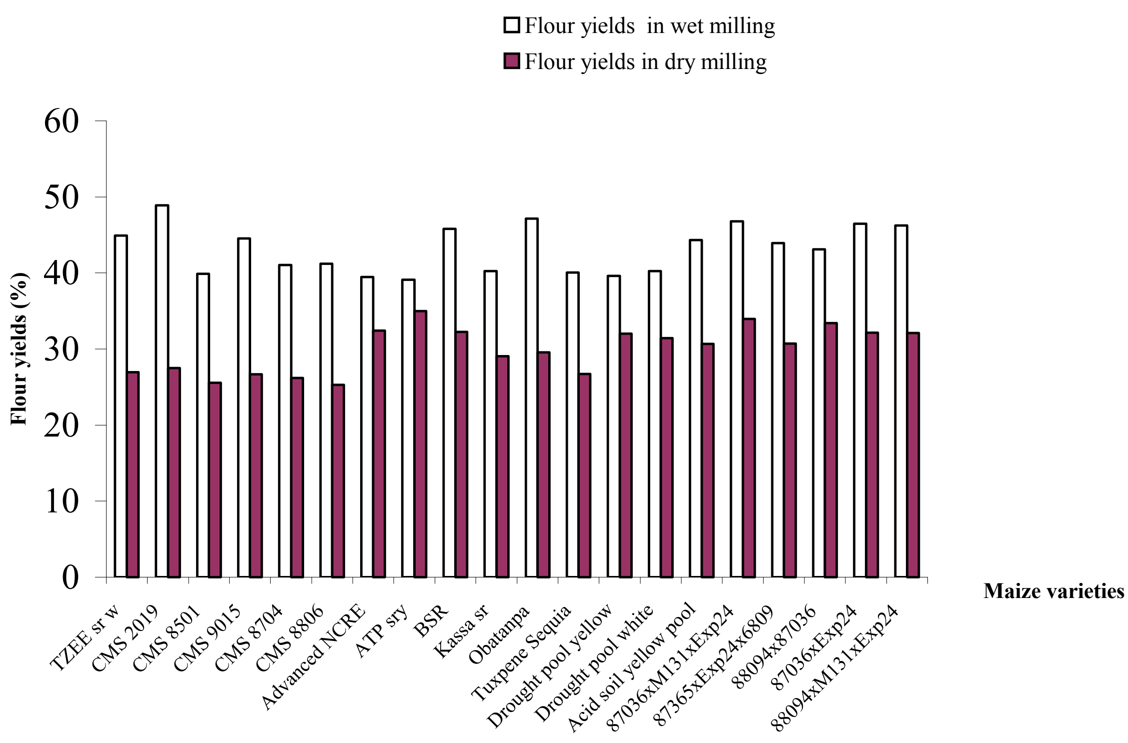

Fig. 2 Flour production of various maize cultivars in wet and dry milling

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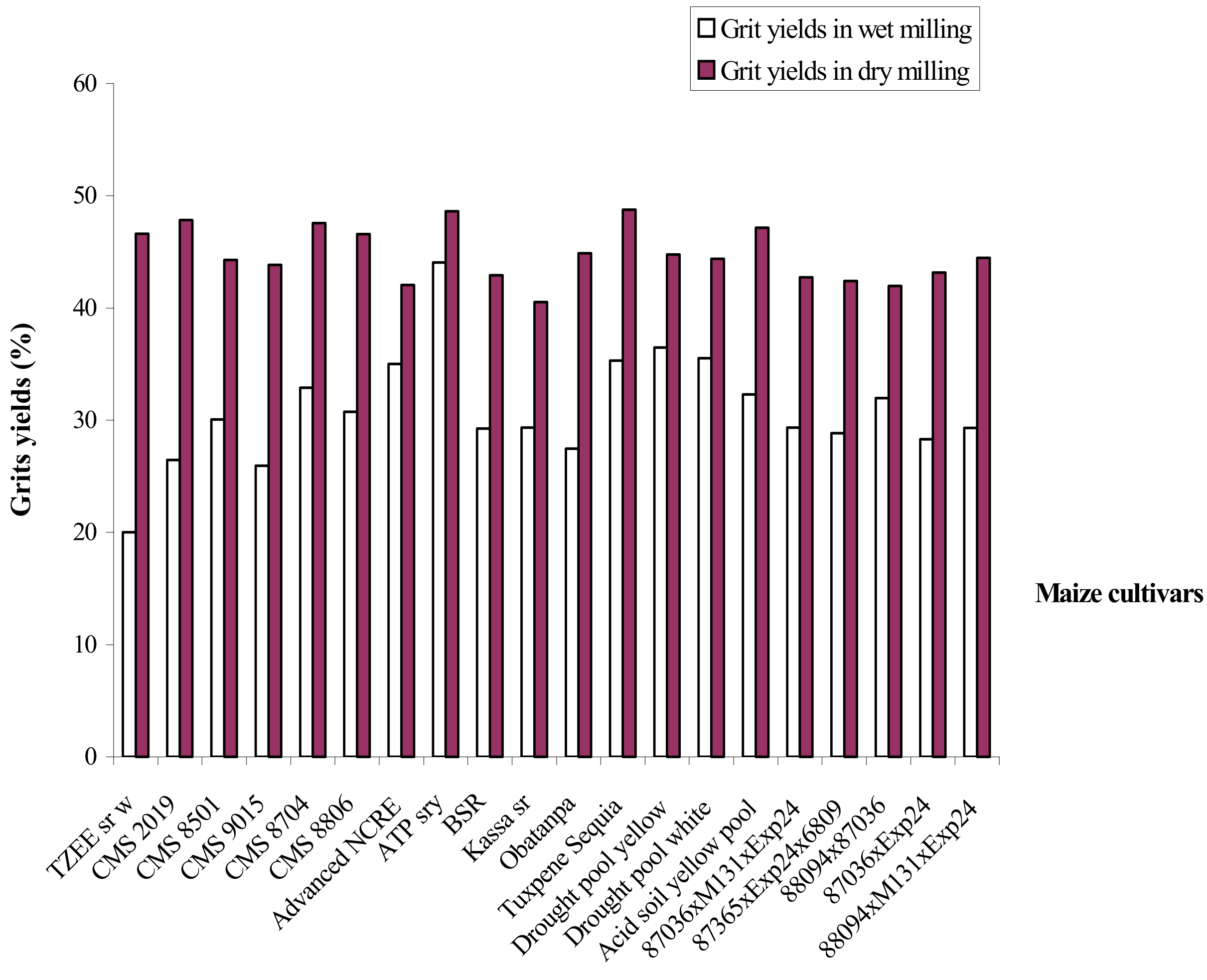

Fig. 3 Grit Production of various maize cultivators in wet dry milling

DISCUSSION

The contents of the main components (fat, protein and starch) of maize grain were cultivar dependant and this could explain the variability observed in the chemical composition of the various maize cultivars. The high dry mater contents observed in some cultivars (over 90%DM) is a good indicator for grain storability. The differences observed in their chemical composition confirmed the specificity of each cultivar. These variations which are normal and pertinent to maize cultivars have already been mentioned in Benin and with American Hybrids [8, 9].

Fat and protein contents showed variations due to cultivars while the similarity in starch contents indicates narrow genetic variability for starch content. The values for chemical composition obtained are within the range indicated by early results [10, 11]. However, observed protein content for Obapanpa was 7.96 % lower than 9.73% when grown in isolation [12]. Obatanpa is QPM very sensitive to contamination in open pollinating situation as is the case in farmers' fields. High protein contents makes this cultivar attractive for animal feed particularly mono-gastric and human consumption.

The technological attributes portrayed by maize cultivars is a possible response to simulation of the processing of maize from small farms which represent over 90 % of producers in the sudano sahelian Africa. Flour and grit yields are indicators of the possible output of such processing units working with the machinery currently available. Grit yields obtained in dry milling are quite favourable and can satisfy the need of agro industries (>40%). However, this process is economically costly. Hard grains cause a lot of damages on the hammers and the steel mesh against which they crash before breaking into small particles.

A consequence is a rapid wearing of machine which on the long run becomes coast inefficient due to frequent repairs. Wetting the grains renders them tender and increases their friability and ability to break into coarse particles when hit by the hammer. This explains the increases observed in flour yield under wet milling compared to dry milling. The low grit yields of the wet process confirmed the complains generally mentioned by agro industrial users. Among the cultivars developed, only one exceeded grit yield of 40% the acceptable limit for industrial commercial production. The soft endosperm cultivars exhibited the lowest yields for grit production. This could be explained by the soft nature of their grains They may be better recommended for flour production.

Although the Gondard pealing machine coupled to a hammer mill are the most available machinery currently used in towns and villages in Central Africa, they were not very suitable for quality grit production. The major handicap was its inability to remove the germs so as to reach the acceptable limit of fat contents in grit. The presence of fat in flour adversely affect its shelf live under prolong storage due to rancidity. To avoid prolong storage of flour, house wives preferred to only mill the daily quantity of maize needed. This is a major factor limiting maize flour sales in retail outlets. Germ removal should be improved upon through the use of more appropriate machinery for proper flour and grit production [13].

The adoption of various maize cultivars developed is a driving force of the current maize revolution in West and Central Africa. Initially, breeders laid emphasis on agronomic characteristics in terms of grain yields, soil and climatic tolerances. These factors along side processing properties need to be combined to provide cultivars that give satisfaction to both farmers and grain users. The low grit yields obtained in wet milling should equally be considered in the breeding programme so as to improve on these aspects. Most cultivars developed were suitable as food maize in terms of chemical composition.

From maize grain technological attributes and chemical composition, the user can be very specific and only request the cultivars suitable for his business. High protein cultivars are recommended for animal feed. For grit production leading cultivars were ATP SR-Y, Tuxpeno Sequia, Dought pool yellow and Drought Pool White. Based on grit fat content, only 2 hybrids out of all the cultivars introduced (87036xM131x$Exp_1$24 and 88094x87036) met the specifications of brewers with the machinery used. However if germ removal is improved, all the cultivars will be suitable for quality grit production in dry milling.

CONCLUSION

The evaluation of the suitability of maize cultivars for processing into flour and grit showed that flour and grits yields obtained were cultivar and treatment dependant. Flour yield was high in wet milling while grit yield was high in dry milling of pealed grains. The pealing machine was not very suitable for germ removal and grits had fat contents above 1 % for most cultivars. The cultivars exhibited their ability and suitability for different end uses.

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Table 1: Agronomic characteristics of some selected maize cultivars developed

Names	Pedigree	Origins	Grain texture	Grain colour	Maturity cycles
TZEE SR-W	Tuxpeno Sequia	Wecaman	Dent	White	Extra early
CMS 2019	Suwan 1 x pop 43 SR	IRAD	Flint/dent	White	Intermediate
CMS 8501	TZB x pop 49	IRAD	Dent/flint	White	Intermediate
CMS 9015	Pool 16 DT*	Wecaman	Dent	White	Early
CMS 8704	Suwan 1 SR	Wecaman	Flint	Yellow	Intermediate
CMS 8806	DMR-ESR-Y	Wecaman	Flint	Yellow	Early
K9350	Pop 43 SR x 9450	IRAD	Dent	white	Early
Cam inb-STR-1	Suwan 1x Pop 43 SR	IRAD	Flint	Yellow	Early
STR-Y	Suwan 1x Pop 43 SR	IRAD	Flint	Yellow	Early
Advanced NCRE	Inbred from various issues	IRAD	Dent/flint	white	Intermediate
ATP-SR-Y	TLPB x CMS 04	IRAD	Flint	Yellow	Intermediate
BSR-81	Local x TZLSR-w	IRAD	Dent/Floury	White	Early
Kassai SR	Pop 32 x pop 43 SR	Congo	Flint/dent	White	Intermediate
Obatanpa	EV8663QPM	Ghana	Flint/dent	White	Intermediate
Tuxpeno Sequia	Tuxpeno	CIMMYT*	Dent	White	Intermediate
Drought pool yellow	Pool 16 Dt x Maka x FBC6	IRAD	Flint	Yellow	Intermediate
Drought pool white	Pool16Dt x tuxpeno Sequia (2)	IRAD	Dent	White	Intermediate
Acid soil yellow	SA3xATPxCMS36 (2)	IRAD	Flint	Yellow	Intermediate
87036XM131XExp$_1$24	Pop32xTZMSRxPOP43	IRAD	Flint/dent	White	Intermediate
87365XP24X88069	Pop32xPop43xTZMSR	IRAD	Flint/dent	White	Intermediate
88094X87036	Pop43xPop32xTZMSR	IRAD	Flint	White	Intermediate
87036XExp$_1$24	Pop32xPop43TZMSR	IRAD	Flint	White	Intermediate
88094XM131XExp$_1$24	Pop43xTZMSRxPOP32	IRAD	Flint	White	Intermediate

** Obtained from CIMMYT*

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Table 2: Proximate composition (% DM) and Germ weight percentage of grains from some selected maize cultivars produced by local farmers.

Varieties	Dry Mater	Crude Protein	Fat	Ash	Crude Fiber	Starch	% Germ
TZEE SR-W	93.25^{g}	7.77^{h}	3.99^{cd}	0.70^{a}	2.09^{k}	85.45	9.44^{a}
CMS 2019	92.50^{g}	7.52^{g}	3.50^{ab}	1.40^{g}	2.63^{o}	84.95	11.73^{j}
CMS 8501	90.00^{efg}	6.03^{bc}	4.30^{f}	1.40^{g}	1.74^{f}	86.53	10.60^{e}
CMS 9015	88.53^{abc}	6.21^{cd}	4.20^{ef}	1.47^{h}	2.14^{l}	85.98	13.69^{m}
CMS 8704	89.07^{abcde}	5.77^{b}	4.21^{ef}	1.40^{g}	1.87^{h}	86.75	11.63^{j}
CMS 8806	90.22^{fg}	6.27^{d}	5.11^{i}	1.65^{i}	2.35^{m}	84.62	12.43^{l}
CMS K9350	92.97^{g}	5.95^{ab}	5.41^{j}	1.06^{d}	2.36^{m}	85.22	10.12^{c}
Cam Inb STR-1	94.25^{h}	6.65^{e}	4.62^{h}	1.07^{d}	2.02^{j}	85.64	10.96^{g}
STR-Y	93.25^{g}	5.86^{ab}	4.22^{ef}	0.93^{c}	2.45^{n}	86.54	11.38^{i}
Advanced NCRE	92.55^{g}	5.24^{e}	4.47^{g}	0.83^{b}	2.01^{j}	87.45	10.64^{e}
ATP SR-Y	88.88^{abcd}	6.92^{ab}	4.19^{ef}	1.37^{g}	1.27^{a}	86.25	10.79^{f}
BSR 81	88.62^{abc}	8.23^{a}	4.00^{cd}	0.73^{a}	1.86^{h}	85.18	11.48^{i}
Kasai SR	89.50^{cdef}	8.24^{f}	3.89^{c}	0.93^{c}	2.01^{j}	84.93	11.99^{k}
Obatanpa	88.50^{ab}	7.96^{i}	4.28^{f}	1.31^{f}	1.93^{i}	86.45	10.79^{f}
Tuxpeno Sequia	89.25^{abcdef}	8.24^{i}	4.10^{de}	1.35^{fg}	1.72^{f}	84.59	9.74^{b}
Drought pool yellow	88.81^{abcd}	8.58^{j}	4.58^{gh}	1.08^{d}	1.30^{b}	84.46	12.31^{l}
Drought pool white	90.51^{g}	8.24^{i}	4.02^{cd}	2.02^{j}	1.53^{d}	84.19	11.08^{gh}
Acid soil yellow pool	89.48^{bcdef}	9.03^{k}	3.50^{ab}	1.60^{i}	1.35^{c}	84.52	10.33^{d}
87036XM131XExp$_1$24	89.67^{defg}	8.62^{j}	3.89^{c}	1.31^{f}	1.55^{d}	84.63	11.16^{h}
87036x Exp$_1$24x88069	88.99^{abcd}	7.53^{g}	3.54^{b}	0.83^{b}	2.07^{k}	86.03	11.06^{gh}
88094X87036	88.35^{a}	9.12^{k}	4.09^{de}	1.46^{h}	1.77^{g}	83.56	10.19^{c}
87036XExp$_1$24	89.06^{abcde}	9.11^{k}	4.47^{g}	1.05^{d}	1.67^{e}	83.7	11.07^{gh}
88094XM131XExp$_1$24	88.73^{abcd}	8.75^{j}	3.38^{a}	1.17^{e}	1.77^{g}	84.93	11.90^{k}

*Means in column with the same letter are not significantly different ($P < 0.05$)

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