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Research Article
Chemical Composition and Genetics of Indonesian Maize Hybrids

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Abstract
Background: Maize is an important commodity in Indonesia for food and feed in food industry. The chemical composition and the genetics of Indonesian maize need to be identified for utilization as raw material in food industry. **Materials and Methods:** We evaluated nutritional composition of 45 single cross hybrids, 14 Indonesian maize inbred lines and 3 inbred testers following AOAC procedure. Combining ability estimate for chemical composition applied line×tester method. The F-test was used to test the significance of hybrids and combining ability mean squares. **Results:** The chemical compositions of Indonesian maize were varied. The protein ranged from 7.13-11.84% db, fat ranged from 2.58-7.17% db, carbohydrate ranged from 69.67-79.83% db, ash ranged from 0.95- 1.56% db, crude fiber ranged from 1.43-3.69% db. The good combiners for chemical composition of Indonesia maize were: DR 6 and DR 8 for carbohydrates, MDR 14.2.2 for protein, MDR 7.4.1 and DR 4 for fat, MDR 7.1.9 for crude fiber, MDR 9.1.3 and DR 8 for number of seeds per plant and MDR 9.1.3 for seed weight per plant. The superior hybrids were selected for chemical components. The superior hybrids are as follows: MDR 7.4.2×DR 6 for protein and crude fiber, MDR 14.2.2×DR 8 for protein and ash, MBR 153.7.1×DR 6, MDR 7.4.2×DR 4 for fat and carbohydrate, MDR 3.1.2×DR 4 for carbohydrate and ash. **Conclusion:** The chemical compositions of Indonesian maize were varied based on their genetic background. There are some good Indonesian maize parental combiners for each chemical composition traits and cross combination hybrids as well. These selected hybrids can be utilized in food industry.

Key words: Genetic factors, Indonesian maize, nutrition composition, proximate analysis

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal grain in the world. The majority of the product in developing countries is for human consumption, in the developed world it is mainly used for industrial purposes and animal feed. Maize is a substantial source of carbohydrates and protein in the daily menu of Indonesian. Wilson[1] and Iken *et al.*[2] reported that the amount of carbohydrates in maize ranges from 72-73% of kernel, whereas, protein ranges from 6-12% depending upon the varieties. Maize is also rich in functional food components, such as dietary fiber, essential fatty acid, isoflavones, Fe mineral, β-carotene as pro-vitamin A and the essential amino acids of lysine and tryptophan[3,4]. BeMiller and Whistler[5] described that maize contains moisture (16.7% wb), starch (71.3% db), protein (9.91% db), fat (4.45% db), ash (1.42% db), crude fiber (2.66% db). Maize also contains pentoglycans (6.2% db), cellulose and lignin (3.3% db), total sugar (2.58% db) and total carotenoids (30 mg kg^{-1}).

Improved nutritive and technological maize grain value is very important for its use in food industry as healthy diets. There are two kind of maize for food industry, viz., field corn and sweet corn. Field corn can be processed into a various food products such as cooked corn milk. This product is futher processed into pudding, ice cream and fresh milk. The dry seed can be turned into semi-finished materials, viz., corn rice, flour and starch. Furthermore, it can be processed into food products such as rice substitute and wheat substitutefor noodles, bread, cake and cookies. Sweet corn is grown primarily for fresh consumption and for high-fibre and no-calorie flour from sweet corn pericarps[3].

Domestic consumption of maize is expected to increase gradually every year along with an increase in the number of population. However, maize production is declining thus in order to comply with the demands, maize importation is done. The effort to increase national maize production is through the intensification and extension of agricultures product. The most important component of the effort is the availability of a superior maize hybrid, which is suited either for optimum or marginal land conditions.

Zilic *et al.*[6] mentioned that genetic improvement of maize has played a key role in the development of specialty maize hybrids for high nutritional values, such as high lysine, high oil, waxy, white and sugary. These specialty maize have been the subject of a renewed interest because of their improvements in agronomic performances, commitments by marketers to preserve the identity of specialty grain and the advance in our understanding of digestion and nutrient requirements.

Maize breeding programs for development of a superior hybrid for healthy diet require potential parental line for chemical composition. The basis of parental line selection for hybrid is their genetic parameter such as combining ability. The importance of genetic parameters include: (1) Indicator for selecting superior parental lines of hybrid varieties, (2) The criteria for identifying high yielding hybrids and (3) Identification of gene action involved in various quantitative characters[7-10]. The present investigation was carried out to identify the chemical composition and genetics of 14 promising Indonesian maize inbreds and their hybrids for utilization as raw material in food industry.

MATERIALS AND METHODS

Genetic material evaluated in the study included 14 genotype of mutant lines, 42 line×tester hybrids and 3 tester lines. Hybrids were made during 2013 according to Singh and Chaudhary[11]. The evaluation of hybrids and their parental lines in experimental trials were performed in 2014 at the experimental field station of the Faculty of Agriculture, Padjadjaran University in Arjasari, Bandung. The proximate analysis of maize were conducted in 2015 at the Laboratory of Agriculture Industrial Technology, University of Padjadjaran, Bandung, Indonesia. The mutant lines had several features, such as: Early maturity[12], field resistance to downy mildew, leaf sheath blight and leaf rust[13], drought tolerance[14] and high yield potential[9]. Parental line MDR is a line derived from mutation of DR line by gamma rays at a 200 gray dose. The mutants were selfed and selected based on pedigree method until the 5th generation. The tester line DR is a genotype obtained from crossing between Downy Mildew Resistant (DMR) maize and Quality Protein Maize (QPM)[15].

The evaluation of genetic materials were based on a completely random block design, with 2 replicates and 59 genotypes as treatment. The genotypes included 14 mutant lines, 3 tester lines and 42 F_1 hybrids. The experimental plot consisted of single rows, 5 m long with 0.75 m between rows and between plots and 0.20 m within rows. The plots were harvested by hand for proximate analysis.

The seed weight per plant was measured on average of fifteen representative plants in each replicate. Proximate analysis consisted of carbohydrate, protein, fat, ash and fiber following AOAC[16] procedure with slight modifications. Protein content was determined using the Kjeldahl[16] method, AOAC 981.10. One gram of sample, one Kjeltec catalyst tablet and 10 mL H_2SO_4 was put into Kjeldahl tube and digested for 2 h at 420°C. The product was then made basic with 30% (w/v)

NaOH before distillation into 0.1 M HCl and titration against 0.25 M NaOH. The factor used to convert nitrogen into crude protein was 6.25. Moisture content was determined with a modified version of the AOAC[16] 925.04. Ten grams of sample was dried at 105°C for 24 h and the water content of the samples was gravimetrically determined. Fat content was determined by using a Soxhlet extractor (Behrotest, Behr Labor Technik Gro bH, Dusseldorf, Germany). The water free sample was put into a pre-weight Soxhlet tube and petroleum ether was recycled through the sample for 2 h. Remaining ether was evaporated and the sample was dried at 105°C overnight. Fat content was then determined gravimetrically. Ash content was analyzed using modified version of AOAC[16] 938.08. The water and fat free sample was combusted at 500°C for 12 h and ash content was determined gravimetrically.

Analysis of variance for line×tester was estimated according to Singh and Chaudhary[11], where mutant lines, tester lines and hybrids were treated as fixed factor. Estimation of GCA and SCA applied line×tester method according to Kempthorne[17]. The F-test was used to test the significance of hybrids, GCA and SCA mean squares.

RESULTS AND DISCUSSION

Chemical composition of selected Indonesian maize: The chemical composition of Indonesian maize both mutant parental lines and their hybrids are presented in Table 1 and 2 and is summarized in Table 3. The chemical composition of the Indonesian maize varied as shown by their proximate analyses. The proximate analyses showed that protein ranged from 8.83-11.84% db for parental lines and from 7.13-10.78% db for hybrids. Fat ranged from 2.62-7.17% db for parental lines and 2.58-5.49% db for hybrids. Carbohydrate ranged from 69.97-79.83% db for parental lines and 69.6-75.68% db for hybrids. Ash ranged from 0.95-1.56% db for parental lines and 1.01-1.54% db for hybrids. Crude fiber ranged from 1.43-2.71% db for parental lines and 1.75-3.69% db for hybrids.

The selected parental lines based on two chemical composition are MBR 153.7.1 and MDR 7.1.9 for protein and fat; MDR 1.2.12 and MDR 7.4.2 for protein and ash; MDR 14.3.1 for fat and ash; MDR 3.1.2, MDR 3.1.4 and MBR 153.3.2 for carbohydrate and crude fiber. Thus MDR 14.2.2 is selected for three chemical compositions i.e., for carbohydrate, ash and crude fiber.

The selected hybrids based on two chemical composition are MDR 7.4.2×DR 6 for protein and crude fiber, MDR 14.2.2×DR 8 for protein and ash; MBR 153.7.1×DR 6, MDR 7.4.2×DR 4 for fat and carbohydrate, MDR 3.1.2×DR 4 for carbohydrate and ash. The rest selected hybrids are MDR 9.1.3×DR 4, MDR 1.1.3×DR 4, MDR 14.2.2×DR 4, DR 1.2.12×DR 8 for fat, MDR 1.1.3×DR 8, MBR 153.3.2×DR 6, MDR 14.2.2×DR 6 and MDR 3.1.4×DR 8 for carbohydrate, DR 7.4.1×DR 4 and DR 7.4.1×DR 8 for ash, MDR 3.6.2×DR 8, MDR 1.1.3×DR 6 and MDR 7.4.1×DR 6 for crude fiber.

Table 1: Chemical composition of maize parental lines

Genotypes code	Water content (% wb)	Fat content (% db)	Protein content (% db)	Ash content (% db)	Carbohydrate content (% db)	Crude fiber content (% db)
Mutant parental lines						
MDR 3.6.2	9.44	6.37	10.97	1.25	71.98	1.47
MBR 153.6.1	10.45	4.86	9.40	1.12	74.17	1.69
MBR 153.7.1	10.52	5.53	11.29	1.12	71.54	1.70
MDR 7.4.2	8.08	4.29	11.14	1.45	75.04	2.49
MDR 3.1.2	5.79	4.17	9.03	1.19	79.82	2.71
MDR 9.1.3	5.74	2.62	10.52	1.30	79.83	1.64
MDR 14.3.1	8.40	5.17	11.00	1.45	73.97	1.90
MDR 1.1.3	12.33	4.82	10.21	0.95	71.68	1.69
MBR 153.3.2	7.12	4.95	10.85	1.32	75.76	2.24
MDR 14.2.2	7.30	4.68	11.12	1.51	75.40	2.29
MDR 1.2.12	5.73	4.13	11.16	1.56	77.43	2.08
MDR 7.1.9	11.41	6.12	11.11	1.34	70.02	2.05
MDR 3.1.4	7.06	4.59	10.22	1.50	76.63	2.52
MDR 7.4.1	11.31	4.61	11.84	1.25	70.99	2.09
Tester parental lines						
DR 4	12.82	5.23	8.83	1.15	71.97	1.43
DR 6	12.15	7.17	9.31	1.40	69.97	1.79
DR 8	12.65	4.48	10.33	1.36	71.19	1.73

Table 2: Chemical composition of hybrid maize

Crossing code	Water content (% wb)	Fat content (% db)	Protein content (% db)	Ash content (% db)	Carbohydrate content (% db)	Crude fiber content (% db)
MDR 3.6.2×DR 4	13.40	4.62	9.06	1.37	71.55	2.19
MDR 3.6.2×DR 6	13.14	4.14	8.57	1.20	72.97	2.15
MDR 3.6.2×DR 8	12.62	3.80	9.82	1.32	71.95	3.35
MBR 153.6.1×DR 4	13.34	4.25	9.93	1.41	71.07	2.32
MBR 153.6.1×DR 6	13.41	4.48	8.72	1.17	72.21	2.23
MBR 153.6.1×DR 8	13.76	4.08	9.30	1.54	71.33	2.47
MBR 153.7.1×DR 4	13.43	4.48	10.14	1.43	70.53	1.91
MBR 153.7.1×DR 6	12.23	4.62	8.15	1.20	73.81	2.11
MBR 153.7.1×DR 8	13.10	3.08	9.35	1.25	73.23	2.83
MDR 7.4.2×DR 4	13.50	5.49	7.13	1.34	72.55	1.84
MDR 7.4.2×DR 6	13.57	4.05	9.92	1.36	71.10	2.65
MDR 7.4.2×DR 8	13.34	3.79	9.09	1.36	72.42	2.37
MDR 3.1.2×DR 4	13.14	4.68	7.37	1.40	73.47	1.99
MDR 3.1.2×DR 6	13.56	4.36	8.96	1.13	71.99	2.42
MDR 3.1.2×DR 8	13.37	3.78	7.93	1.23	73.69	1.75
MDR 9.1.3×DR 4	12.82	5.33	8.57	1.31	71.98	2.10
MDR 9.1.3×DR 6	13.07	3.83	9.58	1.32	72.20	2.21
MDR 9.1.3×DR 8	13.89	3.91	9.21	1.34	71.65	2.59
MDR 14.3.1×DR 4	13.16	3.78	9.45	1.31	72.30	1.73
MDR 14.3.1×DR 6	12.81	4.05	9.79	1.34	72.01	2.52
MDR 14.3.1×DR 8	13.20	4.39	9.04	1.24	72.12	2.38
MDR 1.1.3×DR 4	14.31	4.60	10.11	1.38	69.60	1.86
MDR 1.1.3×DR 6	13.32	3.88	8.56	1.31	72.93	2.93
MDR 1.1.3×DR 8	10.54	2.58	8.84	1.25	76.80	2.72
MBR 153.3.2×DR 4	14.91	4.38	8.90	1.50	70.31	2.77
MBR 153.3.2×DR 6	11.48	4.43	7.98	1.01	75.08	2.11
MBR 153.3.2×DR 8	13.07	3.55	8.74	1.32	73.32	2.63
MDR 14.2.2×DR 4	12.63	4.95	9.62	1.27	71.55	1.99
MDR 14.2.2×DR 6	11.78	3.38	9.45	1.21	74.17	2.12
MDR 14.2.2×DR 8	13.82	3.62	10.78	1.44	70.34	2.19
MDR 1.2.12×DR 4	14.96	3.82	10.23	1.36	69.63	1.50
MDR 1.2.12×DR 6	12.66	4.21	9.10	1.29	72.74	2.34
MDR 1.2.12×DR 8	13.71	4.48	8.76	1.15	71.92	1.30
MDR 7.1.9×DR 4	14.33	3.94	9.92	1.38	70.44	2.32
MDR 7.1.9×DR 6	12.80	4.43	9.22	1.26	72.31	2.66
MDR 7.1.9×DR 8	13.37	3.58	9.18	1.26	72.61	3.69
MDR 3.1.4×DR 4	14.57	3.90	10.49	1.39	69.65	2.16
MDR 3.1.4×DR 6	12.59	4.42	9.65	1.23	72.10	3.14
MDR 3.1.4×DR 8	11.86	4.11	8.18	1.16	74.68	2.77
MDR 7.4.1×DR 4	12.53	4.53	10.08	1.50	71.37	2.43
MDR 7.4.1×DR 6	14.17	4.25	8.70	1.22	71.67	2.77
MDR 7.4.1×DR 8	13.36	4.32	10.18	1.44	70.69	2.19

Table 3: Chemical composition of maize grain

Components	Standard maize grain	Hybrids maize grain	Lines maize grain
Maize grain			
Water content (% wb)	16.70	11.48-14.96	5.73-12.33
Protein content (% db)	9.91	9.93-10.78	8.83-11.84
Fat content (% db)	4.45	4.48-5.49	4.48-7.17
Ash content (oxide) (% db)	1.42	1.43-1.54	1.45-1.56
Carbohydrate content (% db)		69.60-75.68	69.97-79.83
Crude fiber content (% db)	2.66	2.66-3.69	1.43-2.71

Source: BeMiller and Whistler[5]

Genetics of selected Indonesian maize based on their chemical composition: The general combining ability for chemical composition of Indonesia maize parental lines is presented in Table 4 and the specific combining ability and heterosis for chemical composition of Indonesian maize hybrid are presented in Table 5 and 6, respectively. Based on Table 4, the following parental lines were good combiners, viz., DR 6 and DR 8 for carbohydrates, MDR 14.2.2 for protein, MDR 7.4.1 and DR 4 for fat, MDR 7.1.9 for crude fiber, MDR 9.1.3 and DR 8 for number of seeds per plant and MDR 9.1.3 for seed weight per plant.

Based on their Specific Combining Ability (SCA) and High Parent Heterosis (HPH) in Table 5 and 6, the superior hybrids were selected for chemical components. The superior hybrids are as follows: MDR 7.4.2×DR 6 for protein and crude fiber, MDR 14.2.2×DR 8 for protein and ash; MBR 153.7.1×DR 6, MDR 7.4.2×DR 4 for fat and carbohydrate, MDR 3.1.2×DR 4 for carbohydrate and ash.

Table 4: Percentage of general combining ability value

Strain	Carbohydrate	Protein	Fat	Fiber	Total seeds per plant	Seed weigh per plant
M5DR 3.6.2	0.01	-0.03	0.03	0.21	36.40	-9.68
M5DR 153.6.1	-0.61	0.13	0.12	-0.01	-5.93	-13.23
M5DR 153.7.1	0.38	0.03	-0.09	-0.07	-41.26	-2.79
M5DR 7.4.2	-0.12	-0.47*	0.30	-0.06	-11.76	1.77
M5DR 3.1.2	0.91	-1.10**	0.12	-0.30	9.07	35.32
M5DR 9.1.3	-0.20	-0.06	0.21	-0.05	49.40**	38.66**
M5DR 14.3.1	0.00	0.24	-0.07	-0.14	21.74	-3.12
M5DR 1.1.3	0.97	-0.02	-0.46	0.15	-52.60	-8.90
M5DR 153.3.2	0.76	-0.64**	-0.03	0.15	-30.93	-21.89
M5DR 14.2.2	-0.12	0.77**	-0.17	-0.25	-10.43	-33.89
M5DR 1.2.12	-0.71	0.18	0.02	-0.64**	-50.60	-9.56
M5DR 7.1.9	-0.36	0.25	-0.17	0.54*	20.24	11.33
M5DR 3.1.4	0.00	0.26	-0.01	0.34	31.74	15.88
M5DR 7.4.1	-0.90	0.47	0.22*	0.11	34.90	0.11
Tester						
DR 4	-1.00**	0.17	0.33**	-0.27*	-45.46**	-22.61*
DR 6	0.52*	-0.16	0.03	0.11	16.00	7.89
DR 8	0.48*	-0.01	-0.36**	0.17	29.46*	14.72

**Significant to F<0.01, *Significant to F<0.05

This study is a first report on proximate analysis and genetic factor of Indonesian maize hybrids and their parental line. Parental line and hybrids maize possessed higher protein than the standard grain maize as previously studied by BeMiller and Whistler[5]. Based on study of Wei *et al.*[18], protein content of the parental lines (12.81% db) and single crosess (10.48% db) of maize grown in Beijing and protein content of the parental lines (11.09% db) and single crosess (9.92% db) of maize grown in Changzi. Development of maize varieties with high quality protein (QPM) in Indonesia has been started in 2002 and for the first time two QPM's "White Srikandi-I" and "Yellow Srikandi-I" were released[19] in 2004. According to Swastika *et al.*[20], the "Yellow Srikandi" QPM has higher protein (10.38%), lysine 0,48% and tryptophan (0.09%) content than "Lamuru"common hybrid maize.

When we compare to the protein content of Indonesia QPM maize hybrid, Srikandi Yellow-1 (10.38%), the protein content of maize hybrids in this study had almost similar amount at 9.93-10.78% db; whereas, the protein content of its parental lines was even higher at about 10.21-11.84% db. The selected genotypes could potentially be used in the food sector, for instance, in the manufacture of various high-protein food products, such as bread, biscuits and cookies. To determine the protein quality of maize, however, analysis of amino acid composition and digestibility of the protein should be conducted.

Similar to the protein content, the fat content of selected Indonesianmaize hybrids (5.49% db) and their parental lines (7.17% db) in this study are higher than standard maize of BeMiller and Whistler[5] (4.45% db). Based on study of Wei *et al.*[18], oil content of the parental lines (3.67% db) and single crosess (4.55% db) of maize grown in Beijing and oil content of the parental lines (4.78% db) and single crosess (4.77% db) of maize grown in Changzi. This selected fat rich content maize could potentially be used in the manufacture of maize oil production development. To determine the oil quality of maize, however, analysis of fatty acid composition of the oil should be conducted.

Maize oil known by the public is used as food oil that has many benefits. Maize oil is composed mainly of acylglyserol and has 59% poly unsaturated (PUFA) and 24% mono-unsaturated (MUFA) and 13% Saturated Fatty Acid (SFA). Maize oil has one of the highest PUFA level after sun flower, saf flower, walnut and wheat germ oil[21]. The primary PUFA is linoleic acid (C18:2n-6) with a small amount of oleic acid (C18:3n-3). Maize oil contains amount of ubiquinone and high amount of γ-tocopherols (vitamin E)[22]. These high contents of PUFA and vitamin E may contribute to health benefits of maize oil consumption.

The ash content of maize hybrids and their parental lines in this study was higher than the standard one. Ash contains a mixture of inorganic or mineral components, which compound in a food material. Food material consists of 96% inorganic material and water, while the rest are mineral elements. The element is also known as organic matter or ash. The ash component is an indicator of total minerals in a food material. Hence, it is most likely that the mineral content of maize in this study is greater than the mineral content of maize in general. Based on study of Enyisi *et al.*[23], the mineral composition of the maize and maize based product are

Table 5: Percentage of specific combining ability

Crossing pair	Carbohydrate	Protein	Fat	Fiber	Total seeds per plant	Seed weigh per plant
M5DR 3.6.2×DR 4	0.40	-0.26	0.10	-0.10	71.63	2.39
M5DR 3.6.2×DR 6	0.29	-0.43	-0.08	-0.52	-32.33	-11.11
M5DR 3.6.2×DR 8	-0.69	0.68	-0.02	0.62	-39.30	8.72
M5BR 153.6.1×DR 4	0.54	0.45	-0.35	0.25	-38.54	-28.72
M5BR 153.6.1×DR 6	0.15	-0.44	0.19	-0.22	50.50	44.78
M5BR 153.6.1×DR 8	-0.69	-0.01	0.17	-0.04	-11.96	-16.05
M5BR 153.7.1×DR 4	-0.99	0.75	0.09	-0.10	33.80	13.50
M5BR 153.7.1×DR 6	0.76	-0.90*	0.53	-0.28	0.33	21.33
M5BR 153.7.1×DR 8	0.23	0.15	-0.62	0.38	-34.13	-34.83
M5DR 7.4.2×DR 4	1.53	-1.75**	0.71	-0.18	-5.20	40.28
M5DR 7.4.2×DR 6	-1.44	1.36**	-0.42	0.26	-6.67	-12.88
M5DR 7.4.2×DR 8	-0.08	0.39	-0.29	-0.08	11.87	-27.39
M5DR 3.1.2×DR 4	1.42	-0.89*	0.08	0.20	-16.04	-7.61
M5DR 3.1.2×DR 6	-1.58	1.03*	0.06	0.26	18.00	1.89
M5DR 3.1.2×DR 8	0.16	-0.14	-0.13	-0.47	-1.96	5.72
M5DR 9.1.3×DR 4	1.03	-0.72	0.64	0.07	3.13	10.72
M5DR 9.1.3×DR 6	-0.26	0.62	-0.56	-0.20	5.17	-30.44
M5DR 9.1.3×DR 8	-0.78	0.10	-0.09	0.12	-8.30	19.73
M5DR 14.3.1×DR 4	1.16	-0.15	-0.62	-0.21	32.30	25.50
M5DR 14.3.1×DR 6	-0.65	0.52	-0.05	0.21	17.83	-5.34
M5DR 14.3.1×DR 8	-0.50	-0.37	0.67	0.00	-50.13	-20.17
M5DR 1.1.3×DR 4	-2.51**	0.77	0.58	-0.37	-17.87	-25.73
M5DR 1.1.3×DR 6	-0.70	-0.45	0.16	0.32	-6.83	14.11
M5DR 1.1.3×DR 8	3.21**	-0.32	-0.75	0.05	24.70	11.61
M5BR 153.3.2×DR 4	-1.59	0.19	-0.08	0.54	-37.54	-24.72
M5BR 153.3.2×DR 6	1.66	-0.40	0.28	-0.50	47.50	30.44
M5BR 153.3.2×DR 8	-0.07	0.21	-0.21	-0.04	-9.96	-5.72
M5DR 14.2.2×DR 4	0.53	-0.51	0.64	0.16	40.46	27.28
M5DR 14.2.2×DR 6	1.63	-0.34	-0.63	-0.08	-55.50	-28.89
M5DR 14.2.2×DR 8	-2.16*	0.84*	-0.01	-0.08	15.04	1.61
M5DR 1.2.12×DR 4	-0.79	0.69	-0.67	0.06	-67.87	-53.05
M5DR 1.2.12×DR 6	0.79	-0.10	0.01	0.52	67.17	30.11
M5DR 1.2.12×DR 8	0.00	-0.59	0.67	-0.58	0.70	22.95
M5DR 7.1.9×DR 4	-0.34	0.31	-0.37	-0.30	9.80	-2.95
M5DR 7.1.9×DR 6	0.00	-0.06	0.42	-0.34	-11.17	-10.44
M5DR 7.1.9×DR 8	0.34	-0.25	-0.04	0.64	1.37	13.39
M5DR 3.1.4×DR 4	-1.50	0.88*	-0.57	-0.26	-71.70	-36.17
M5DR 3.1.4×DR 6	-0.56	0.37	0.25	0.34	19.33	20.33
M5DR 3.1.4×DR 8	2.06*	-1.24**	0.32	-0.09	52.37	15.83
M5DR 7.4.1×DR 4	1.12	0.25	-0.17	0.24	63.63	59.28
M5DR 7.4.1×DR 6	-0.09	-0.80	-0.15	0.20	-113.33*	-63.89
M5DR 7.4.1×DR 8	-1.03	0.54	0.32	-0.44	49.70	4.61

**Significant to F<0.01, *Significant to F<0.05

phosphorus (23-85%), magnesium (29.33-47%), potassium (10.67-15.60%), sodium (1.5-4.43%) were all in high percentage, while other mineral content such as calcium, manganese, zinc, iron, copper were all in low percentage.

The crude fiber of maize hybrids and their parental lines in this study is also high based on study of BeMiller and Whistler[5]. Fibre components are one of the most important nutritionaland technological factors of the maize grain. The dietary fibre consists of non-digestible carbohydrates and lignin that are intrinsic and intact in plants. The content of dietary fiber specialty maize hybrid consists of cellulose (3.11-4.15% db), hemicellulose (7.07-10.29% db), Neutral Detergent Fiber (NDF) (11.02-14.72% db), Acid Detergent Fiber (ADF) (3.63-4.76% db) and lignin (0.29-0.80% db)[5].

Differences in GCA effects reffer to additive genetic variance in the base population, while differences in SCA effects due to dominance and epistatic genetic effects. Sprague and Tatum[24] proposed that the importance of general combining ability was relatively more than specific combining ability for unselected inbred lines, while specific combining ability was more important than general combining ability for previously selected lines. They also stated that the general combining ability is largely due to the additive effect of genes while in specific combining ability dominance or epistatic effects of genes are commonly involved.

Table 6: Percentage of heterosis

Crossing pair	Carbohydrate	Protein	Fat	Fiber	Total seeds per plant	Seed weigh per plant
M5DR 3.6.2×DR 4	-0.59	-8.43*	-20.34*	51.38	-4.73	-39.93*
M5DR 3.6.2×DR 6	2.80*	-15.53**	-38.92**	31.90	-2.75	-7.14
M5DR 3.6.2×DR 8	0.51	-7.79	-29.95**	109.37**	6.49	0.47
M5DR 153.6.1×DR 4	-2.74*	9.00	-15.86	48.72	-30.93*	-54.02**
M5DR 153.6.1×DR 6	0.19	-6.79	-25.44**	27.87	17.20	30.21
M5DR 153.6.1×DR 8	-1.86	-5.78	-12.74	44.15	13.67	-12.20
M5DR 153.7.1×DR 4	-1.70	0.80	-16.82	22.04	-27.37	-27.99
M5DR 153.7.1×DR 6	4.31**	-20.87**	-27.32**	20.92	-11.40	26.35
M5DR 153.7.1×DR 8	2.61*	-13.51**	-38.46**	65.01**	-9.74	-14.31
M5DR 7.4.2×DR 4	-1.30	-28.59**	15.34	-6.12	-27.10	-20.00
M5DR 7.4.2×DR 6	-1.94	-3.03	-29.23**	24.07	-2.6	-4.63
M5DR 7.4.2×DR 8	-0.95	-15.37**	-13.45	12.32	14.08	-16.18
M5DR 3.1.2×DR 4	-3.20*	-17.53**	-0.43	-4.11	-22.24	-21.57
M5DR 3.1.2×DR 6	-3.88**	-2.29	-23.1**	7.56	13.07	34.84*
M5DR 3.1.2×DR 8	-2.40	-18.08**	-12.60	-21.17	21.06	29.86
M5DR 9.1.3×DR 4	-5.17**	-11.42*	35.8**	36.81	-16.69	-18.00
M5DR 9.1.3×DR 6	-3.60**	-3.38	-21.76*	28.86	8.43	4.74
M5DR 9.1.3×DR 8	-5.12**	-11.65**	10.14	53.71*	16.84	27.32
M5DR 14.3.1×DR 4	-0.92	-4.74	-27.21**	3.60	-11.63	-27.65
M5DR 14.3.1×DR 6	0.06	-3.59	-34.28**	36.86	11.69	-1.4
M5DR 14.3.1×DR 8	-0.63	-15.19**	-9.02	30.85	6.36	-13.57
M5DR 1.1.3×DR 4	-3.09*	6.20	-8.46	19.23	-40.46**	-52.99**
M5DR 1.1.3×DR 6	2.97*	-12.35**	-35.28**	68.68*	-15.42	6.07
M5DR 1.1.3×DR 8	7.51**	-13.92**	-44.52**	59.06*	3.05	0.18
M5DR 153.3.2×DR 4	-4.81**	-9.5*	-14.05	50.95*	-39.84**	-59.08**
M5DR 153.3.2×DR 6	3.05*	-20.78**	-26.82**	4.71	3.19	5.13
M5DR 153.3.2×DR 8	-0.22	-17.47**	-24.71*	32.49	0.07	-18.60
M5DR 14.2.2×DR 4	-2.90*	-3.61	-0.10	6.99	-14.54	-37.39
M5DR 14.2.2×DR 6	2.05	-7.44	-42.95**	3.92	-11.68	-29.40
M5DR 14.2.2×DR 8	-4.03**	0.51	-21.07*	8.71	19.20	-13.27
M5DR 1.2.12×DR 4	-6.78**	2.30	-18.27	-14.53	-48.81**	-62.37**
M5DR 1.2.12×DR 6	-1.30	-11.09**	-25.58**	21.19	7.19	28.67
M5DR 1.2.12×DR 8	-3.22*	-18.47**	3.95	-31.76	1.83	17.36
M5DR 7.1.9×DR 4	-0.78	-0.50	-30.66**	33.33	-19.30	-31.15
M5DR 7.1.9×DR 6	3.30*	-9.75*	-33.41**	38.54	0.72	10.06
M5DR 7.1.9×DR 8	2.84*	-14.41**	-32.55**	95.5**	15.50	18.84
M5DR 3.1.4×DR 4	-6.27**	10.13*	-20.57*	9.37	-38.21**	-49.83**
M5DR 3.1.4×DR 6	-1.63	-1.18	-24.74**	45.71*	3.12	14.87
M5DR 3.1.4×DR 8	1.05	-20.34**	-9.48	30.35	21.89	7.75
M5DR 7.4.1×DR 4	-0.16	-2.47	-8.03	38.35	-4.06	-11.17
M5DR 7.4.1×DR 6	1.69	-17.73**	-27.84**	42.78	-19.54	-34.47
M5DR 7.4.1×DR 8	-0.56	-8.12*	-4.84	14.66	32.99*	2.22

**Significant to F<0.01, *Significant to F<0.05

CONCLUSION

The chemical composition of selected Indonesian maize varied as shown by their proximate analysis. The proximate analysis showed that protein ranged from 8.83-11.84% db for parental lines and from 7.13-10.78% db for hybrids. Fat ranged from 2.62-7.17% db for parental lines and 2.58-5.49% db for hybrids. Carbohydrate ranged from 69.97-79.83% db for parental lines and 69.6-75.68% db for hybrids. Ash ranged from 0.95-1.56% db for parental lines and 1.01-1.54% db for hybrids. Crude fiber ranged from 1.43-2.71% db for parental lines and 1.75-3.69% db for hybrids.

Based on their general combining ability for chemical composition of Indonesia maize, the following parental lines are good combiners, viz., DR 6 and DR 8 for carbohydrates, MDR 14.2.2 for protein, MDR 7.4.1 and DR 4 for fat, MDR 7.1.9 for crude fiber, MDR 9.1.3 and DR 8 for number of seeds per plant and MDR 9.1.3 for seed weight per plant.

Based on their Specific Combining Ability (SCA) and High Parent Heterosis (HPH), the superior hybrids were selected for chemical components. The superior hybrids are as follows: DR 1.1.3×DR 6, DR 1.1.3×DR 8, DR 3.1.4×DR 8, DR 3.6.2×DR 6, MBR 153.7.1×DR 6, MBR 153.7.1×DR 8, MBR 153.3.2×DR 6, DR 7.1.9×DR 8 and DR 3.1.4×DR for carbohydrates. These selected hybrids can be utilized in food industry.

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