Research Article

Starch properties ratio among wheat species originated from different regions of the world

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Abstract: Amylose content may varies in different cereals even it varies specie to specie of a cereal especially in wheat, rice, barley and maize. A two-year study was organized to evaluate variability and availability of amylose and amylopectin among three wheat species (bread, emmer and durum), collected from various wheat cultivated countries, at the experimental site of Northwest Agriculture and Forestry University, Yangling, China during 2018 and 2019. According to the findings, bread, emmer and durum wheat carried out sufficient amount of amylose in both years with similar performance of amylopectin, which indicate the stability for both traits of starch in time period. According to our findings, out of 150 analyzed accessions of three different species of wheat during 2018 and 2019, 71 accessions (36 bread, 18 durum and 17 emmer) were with normal amylose content (20-30%), twenty accessions (9 bread, 4 durum and 7 emmer) were with ≥30% amylose content in 2018. During the year 2019, 80 accessions (36 bread, 24 durum and 20 emmer) had normal range of amylose (20-30%), twenty accessions (10 bread, 4 durum and 6 emmer) were with ≥30% amylose. Among all accession in both years no any waxy accession was observed which contain 1-2% of amylose.

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1. Introduction

Consumption of adequate food diet is enough to meet energy requirements of entire world. An adequate consumption of nutritious food is necessary for mankind for better healthy and productive life. A food can be say nutritious when it contains all essential nutrients, carbohydrate, fats, vitamins and protein in sufficient amount, such type of food can be able to create energy for human life. A wide range of food diet is available for consumption of human being that contains carbohydrates and other essential nutrients. Carbohydrates consist sugar, cellulose, hums and starches. Among all, starch is the main source of nutritive energy for the mankind, mostly it present in seeds. A wide variety of starch bearing crops are grown in the world; including wheat, maize, rice, sorghum, millet and barley which are used as staples food for the peoples of the different regions of the world [6]. Among all cereals, Hexaploid wheat is a major source of starch and β-glucans and being a major staple food that covers large area of cultivated land in the world [24]. A considerable carbohydrate of wheat is made up of amylose and amylopectin molecules. The high and low ratio of such types of molecules is responsible to establish starch structure and its properties. These starch molecules differ from each other through degree of polymerization and number of branches and that difference make variability in amylose and amylopectin content [26]. Variability of starch molecules not only depend on degree of polymerization and number of branches but also correlated with its physical and chemical properties [20, 36, 35, 38]. There is evidence that high amount of amylose in human diet will be responsible to resist against blood glucose and insulin level [15, 17] obesity or hyperinsulinemia [8, 19, 9, 16].

Amylose range varies in different cereals even it varies specie to specie of a cereal. The wheat seed carrying good source of starch; it varieties varies from 60 to 70 %. Soft wheat varieties have higher starch content than hard varieties, which ranges from 18 to 35% with an average 22-25% (Preston, 1998). It seems to have a relatively low range of variation. However, in waxy wheat varieties amylose content is very low 1.2-2.0%. Different wheat species demonstrates differently for amylose content, specie Emmer containing wide range (7.2 to 38.0 %) of amylose followed by specie Einkorn (1.3 to 28.5 %), while as specie Dicoccum containing less amount of amylose content as compared to Durum wheat and Polonicum wheat [1, 27]. This type of amylose variation in different species of wheat is controlled by waxy protein GBSSI (Granule-bound starch synthase *I*) and lack of this enzyme leads to decrease in amylose content. Along with, temperature also has influence to minimize amylose content [22, 18, 32]. So, genetic back ground and environmental factors are major factors that can help to improve wheat for maximum amylose content.

2. Materials and Methods

Emmer, *Triticum turgidum*.L (fifty two accessions) from ICARDA and Israel, Durum, *Triticum durum*.L (thirty accessions) and Bread, *Triticum aestivum*.L (sixty eight accessions) from different parts of the world including China were examined for amylose and amylopectin. All mentioned lines were grown at the experimental site of Northwest Agriculture and Forestry University, Yangling, China in 2018 and 2019. About 10mg grain flour was used for amylose and amylopectin content determination from wheat flour by using Chinese National standard method GB7648-87 and [33] through HPSEC LC-20AT (Shimadzu Corporation, Kyoto, Japan). All samples were repeated three times. Amylose and amylopectin content was measured according to the single wave length absorbance method at 620nm (OD620) and OD550-OD740, respectively. The data was expressed as the means of three replications.

3. Results

3.1. Variation for Amylose and Amylopectin

A two-year study was organized to analysis the variability and availability of amylose and amylopectin among wheat species. Mean values of three replications for 150 accessions (sixty eight bread, fifty two emmer and thirty durum wheat) are demonstrated in tabular and graphic form. According to the findings, bread, emmer and durum wheat carried out sufficient amount of amylose in both years with similar performance of amylopectin, which indicate the stability for both traits of starch in time period. Among sixty eight bread wheat, Pelsart (Australia) showed maximum 36% availability of amylose in both years with minimum availability 31% of amylopectin in 2018 while 33% amylopectin in 2019. Chinese bread wheat Zhongxin-378 produced 12% and 112% minimum amylose in 2018 and 2019 respectively. In case of amylopectin, Zhengmai-366 from China showed superiority in both years with 53% and Zhoumai-28 had minimum 30% amylopectin in 2019 (Table.1). The data of thirty durum wheat species showed similarity in ranges and averages for starch traits amylose and amylopectin during studied years. Amylose content was ranged 18-34% in 2018 and 19-35% in 2019 with average 23.8$\pm$4.8 and 24.8$\pm$4.3% in 2018 and 2019 respectively while amylopectin was ranged almost from 35 to 50% with average 42.5$\pm$3.60% in both years (Table 2). Hamira (Unknown) and Psevdo (Unknown) durum were with maximum amylose and minimum amylopectin in both years while Cyprus durum 'Akarhiotiko' showed maximum availability for amylopectin and minimum availability for amylose in 2018 and 2019 (Figure 1).

Table 1: Mean values of apparent amylose and amylopectin content % bread wheat specie.

			2018		2019	
S. No:	**Accessions**	**Origin**	**Amylose%**	**Amylopectin%**	**Amylose%**	**Amylopectin%**
1.	Luohan-1	China	26.71	43.25	25.28	45.00
2.	Luohan-3	China	21.96	41.50	20.03	44.50
3.	Luohan-6	China	15.94	50.20	15.75	53.00
4.	Luohan-7	China	27.03	42.50	29.98	40.75
5.	Luohan-8	China	27.75	43.00	27.22	43.50
6.	Luohan-9	China	24.24	35.25	25.37	35.50
7.	Luomai-21	China	15.73	51.50	13.31	50.25
8.	Luomai-23	China	27.97	41.78	27.90	40.50
9.	Aikang-50	China	24.32	44.75	24.06	42.00
10.	Beijing-12	China	22.15	48.50	24.22	46.50
11.	Fanmai-8	China	18.50	50.50	18.70	50.75
12.	Jinmai-40	China	20.01	50.95	18.02	52.25
13.	Yumai-48	China	21.75	45.75	23.94	47.50
14.	Longyu-4	China	17.83	50.00	16.40	49.50
15.	Zhengmai-366	China	16.01	53.75	17.72	53.25
16.	Zhou-18	China	22.61	47.50	21.74	47.50
17.	Zhongyu-12	China	27.23	41.75	27.15	41.75
18.	Zhou-19	China	22.48	47.50	23.65	46.25
19.	Zheng-9694	China	21.79	48.50	20.22	46.50
20.	Yangao-21	China	14.10	49.75	14.09	48.50
21.	Xuke-3210	China	23.69	40.00	24.10	40.00
22.	Zhoumai-28	China	35.24	33.75	34.61	30.00
23.	Xinmai-23	China	30.67	38.50	31.43	37.75
24.	Zhongxin-378	China	10.82	48.75	12.29	45.25
25.	Huaimai-05155	China	23.41	43.75	22.32	42.50
26.	Luomai-29	China	21.14	48.00	20.98	44.75
27.	Changhe-25	China	19.88	48.50	20.50	48.75
28.	08 Luo-33	China	24.22	41.75	23.95	44.00
29.	Tianmin-298	China	25.35	44.00	25.03	43.75
30.	Fengdecun-1	China	34.24	33.25	35.96	31.50
31.	Bainong-207	China	15.74	47.50	15.72	50.75
32.	Zhengmai-58-3	China	16.98	46.75	18.84	40.50
33.	Xuke-718	China	27.38	36.75	29.98	40.75
34.	Zhongluo-595	China	15.09	50.50	16.71	51.25
35.	Zhou-32	China	24.70	44.75	26.69	44.00
36.	Zheng-9697	China	23.15	43.02	25.24	44.75
37.	Zhoumai-18	China	25.21	43.25	25.67	43.50
38.	Jinmai-47	China	22.32	42.50	22.73	41.50
39.	Beijing-8	China	25.05	42.75	24.82	45.75
40.	Aikang-58	China	32.22	36.50	32.30	37.00

41.	Warigal	Australia	28.06	41.75	31.67	39.00
42.	Kennedy	Australia	21.98	41.75	20.93	40.50
43.	Rees	Australia	22.01	41.25	25.99	43.50
44.	Sunco	Australia	25.42	41.25	24.82	45.00
45.	Westoniq	Australia	21.95	45.50	23.07	46.00
46.	WEEbiII	Australia	18.22	40.00	16.89	42.00
47.	Sunstate	Australia	19.65	40.25	20.06	43.00
48.	Sunlin	Australia	17.50	47.75	18.51	48.00
49.	Suuvale	Australia	16.84	48.50	15.62	48.00
50.	Egahume	Australia	24.58	39.00	21.20	39.00
51.	Pelsart	Australia	36.85	31.50	36.17	33.00
52.	Pugsley	Australia	15.40	49.50	16.32	44.50
53.	Schomburgk	Australia	21.14	39.75	21.69	39.00
54.	Silverstar	America	16.01	49.00	17.29	49.00
55.	HLA-536	USA	31.59	38.60	33.94	36.00
56.	HLA-538	USA	32.22	36.50	33.85	35.50
57.	HLA-548	USA	16.98	45.25	17.97	50.50
58.	HLA-583	USA	17.03	50.75	16.79	48.00
59.	Antti	France	18.02	52.25	19.75	50.50
60.	Market	France	18.98	51.75	17.11	50.50
61.	Soissons	France	27.22	41.50	28.95	39.50
62.	Lampo	Italy	15.00	48.00	17.39	46.00
63.	Barra	Italy	16.83	48.75	15.98	45.50
64.	Trident	UK	18.12	50.00	20.00	51.00
65.	Shango	UK	22.43	46.75	20.78	43.00
66.	Gampari	Germany	33.28	37.00	31.79	37.50
67.	Boomer	Germany	33.37	40.00	32.79	38.50
68.	Koround	Germany	26.90	40.50	24.11	39.00

Figure 1. Amylose and Amylopectin% in thirty durum wheat accession during 2018 and 2019

Table 2, showing fifty two emmer wheat accessions are distributed normally for both traits amylose and amylopectin in both years ranging 7-36, 8-37, 31-58 and 32-60% amylose and amylopectin in 2018 and 2019 years respectively (Table 2). The average amylose content in emmer wheat was 21.9±7.6 and 22.9±7.6% in 2018 and 2019 years respectively; while as amylopectin content was 45.1±6.8 and 44.8±6.9% in both years respectively (Table 2).

3.2. Comparison for amylose and amylopectin%

A Comparison for better performance was carried out between bread, durum and emmer wheat species for amylose and amylopectin ratio. Analysis of Variance proved highly significant differences at P<0.001 level between these three species for both 2018 and 2019 years (Figure 3). According to Figure 3, emmer wheat from Israel and ICARDA was with wide range of amylose ratio, followed by bread wheat collected from China and other regions of the world and durum wheat collected from different countries of the world was with highest ratio for amylopectin followed by emmer wheat. According to Figure 3 year wise all three species had maximum range and average for amylose content in 2019 as compared year 2018.

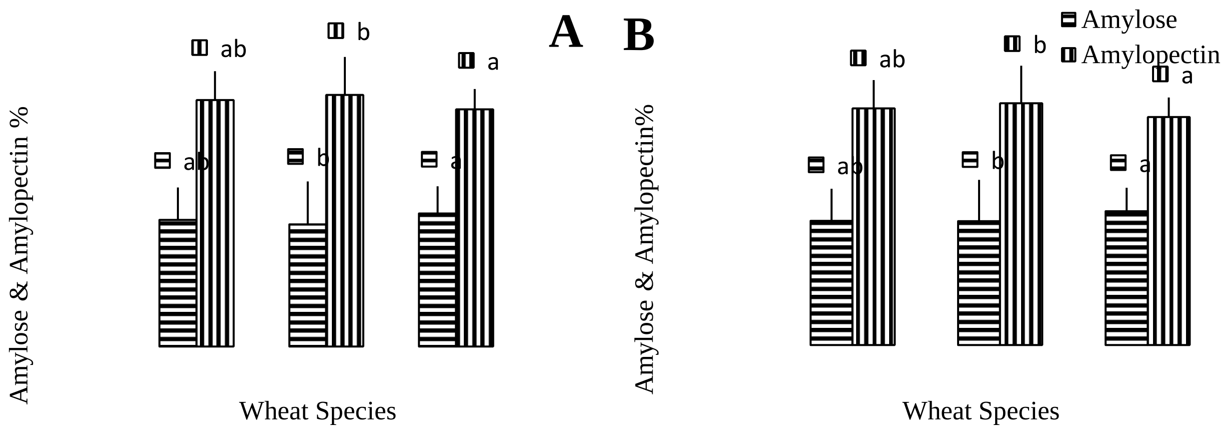

Figure 3. Comparison between wheat species (bread, emmer and durum) for amylose and amylopectin% in two years 2018(A) and 2019(B). Different letters above bars indicates significant differences at P<0.001 level by t-tests. Symbols and bars represent the mean±SD (n=3).

3.3. Associations for amylose and amylopectin

By analyzing data, range of distribution of thirty durum wheat, fifty two emmer and sixty eight bread wheat across two years showed significantly positive correlation (P<0.01) between years for both amylose and amylopectin content (Figure 4), with (r= 0.86, P<0.01 amylose and r = 0.78, P<0.01 amylopectin) for Durum wheat (Figure 4 above), (r = 0.97, P<0.01 amylose and r = 0.93, P<0.01 amylopectin) for emmer wheat (Figure 4 center) and (r = 0.93, P<0.01 amylose and r = 0.82, P<0.01 amylopectin) for bread wheat (Figure 4 bottom).

It is reported that, the normal cereal have 18-33% amylose and 72-82% amylopectin. Table 2 and Figure 2 and 3 express availability and variability of amylose and amylopectin content in three species of wheat like emmer (Israel and ICARDA), bread and durum wheat (different parts of the world including China). Among these three species emmer wheat showed superiority over durum and bread species, with wide range 7-37% of amylose content in studied years with ±22% averages which was followed by bread wheat with range of 10-36% (Table 2). Durum wheat contains narrow range for amylose. Slight differences between wheat species was observed with stability in two years for amylose and amylopectin (Table 2).

Hexaploid wheat ranges slightly low, generally ranges from 18 to 35% with 22-25% an average of amylose content (Preston. 1998), while waxy wheat contain about 1.2-2.0% amylose which is very low portion of total starch. Out of 150 analyzed accessions of three different species of wheat during 2018 and 2019, 36 accessions had normal (20-30%) and 10 had more than 30% of amylose ratio. Among all accession no any waxy accession was observed which contain 1-2% of amylose.

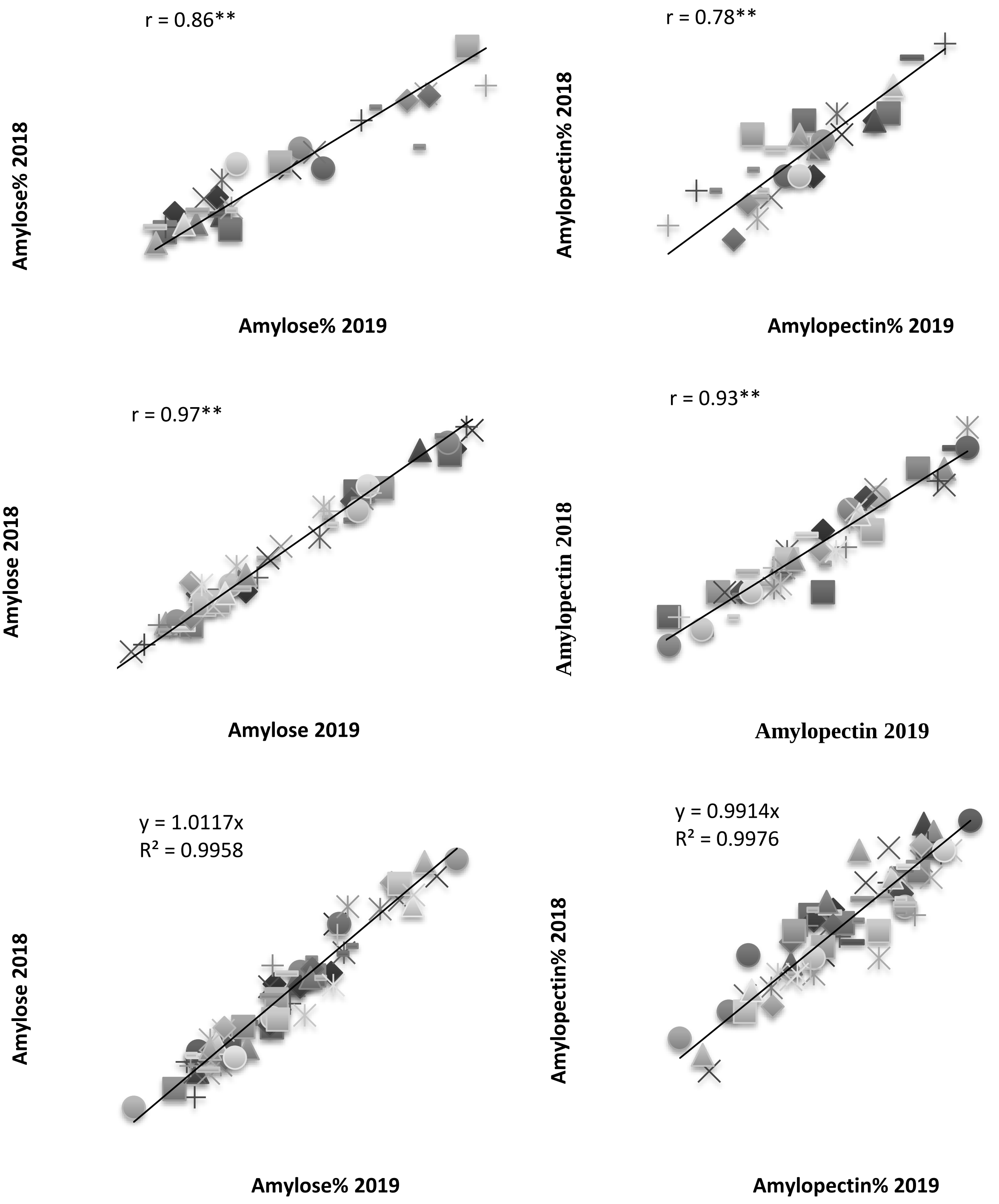

Figure 4. Correlations between Amylose and Amylopectin% in the 2018 vs. the 2019 for durum (above), emmer (center) and bread (bottom) wheat species.

Table 2. Summary statistics of apparent amylose and amylopectin content% of various wheat species.

Wheat Species		**Bread Wheat**	**Emmer Wheat**	**Durum Wheat**
No. of samples		68	52	30
Origin		China & Diff. Count.	Israel &ICARDA	Diff. Count.
		2018		
Amylose%	Mean+SD	22.74+5.79	21.92+7.69	23.88+4.86
	Range	10.82-36.85	7.39-36.85	18.06-34.01
	Amylose (20-30%)	36	17	18
	Amylose (>30%)	9	7	4
Amylopectin%	Mean+SD	44.22+5.71	45.11+6.83	42.54+3.65
	Range	31.50-53.75	31.75-58.00	35.17-50.50
		2019		
Amylose%	Mean+SD	23.03+5.96	22.98+7.66	24.80+4.37
	Range	12.29-36.17	8.17-37.54	19.14-35.17
	Amylose (20-30%)	36	20	24
	Amylose (>30%)	10	6	4
Amylopectin%	Mean+SD	43.88+5.27	44.82+6.99	42.27+3.65
	Range	30.25-53.25	32.50-60.50	34.50-50.50

4. Discussion

Amylose and amylopectin ratio is very important for starch synthesis and its functionality [37, 30, 28, 31, 11]. It is suggested that food containing high amylose can help to boost immune system against various diseases. The variation availability and ratio in grains depend on the genetic background and influences by the climate [14, 7]. These findings open up considerable amount of accessions which have good content of amylose and amylopectin ratio.

It was confirmed by the findings [1, 27] that different wheat species demonstrates differently for amylose content, specie Emmer containing wide range (7.2 to 38.0 %) of amylose followed by specie Einkorn (1.3 to 28.5 %), while as specie Dicoccum containing less amount of amylose content as compared to Durum wheat and Polonicum wheat. The amylose variation in different species of wheat is controlled by waxy protein GBSS-*I* and lack of this enzyme leads to decrease in amylose content. Along with, environmental factor temperature also has influence to minimize amylose content [22, 18, 32]. This is due to wide variations available in the genetics resource of wheat. Besides genetic background, climate has also influence on the synthesis of amylose [12]. According to the findings [2-4, 32, 23] that more temperature more amylose content. Seed size is also playing an important role besides all other factors [13, 10, 29, 21, 5]. Our results of wheat species for amylose and amylopectin content were supported by [34, 23].

5. Conclusions

It is concluded that wheat species were almost similar variation. The findings were more or less as per our expectation from the polyploidy of the species and their relationships to each other. The ranges are broad enough, so it should be possible to increase them through a targeted breeding program.

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