Variation of dietary fiber content in 282 common bean genotypes from the middle american gene pool

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Contents

Introduction

282 entries from the BeanCAP study were grown in Fort Collins, CO in 2015 to determine variation in fiber content. All entries originated from the Middle American gene pool and were further subdivided into the following races and market classes:

Table 1: Number of entries by race and market class included in the study.

Durango		Jalisco		Mesoamerican	
Market Class	No. Entries	Market Class	No. Entries	Market Class	No. Entries
GN	40	black mottle	1	black	41
pinto	91	flor de mayo	1	carioca	2
		pink	22	navy	45
		red mottle	1	small white	6
		small red	30	tan	2
Totals	**131**		**55**		**96**

Results: Entry Rankings

Tables below show the five entries with the greatest and five entries with the lowest values of each fiber component averaged across the two replications including standard deviation (sd), standard error (se) and confindence intervals (ci).

– Insoluble Dietary Fiber (IDF)

Table 2: Five entries with greatest IDF content.

Entry	mktclass	race	IDF	sd	se	ci
PR0443-151	black	mesoamerican	16.91	1.55	1.09	13.89
CDC Pinnacle	pinto	durango	16.73	2.76	1.95	24.80
CDC Jet	black	mesoamerican	16.71	1.32	0.94	11.90
TARS-VCI-4B	pinto	durango	16.46	3.43	2.42	30.79
TARS09-RR007	small red	jalisco	16.42	0.51	0.36	4.59

Table 3: Five entries with lowest IDF content.

Entry	mktclass	race	IDF	sd	se	ci
BelMiNeb-RMR-4	navy	mesoamerican	12.34	0.11	0.08	0.97
BelMiNeb-RMR-8	navy	mesoamerican	12.05	0.38	0.27	3.43
BelMiNeb-RMR-7	navy	mesoamerican	11.77	0.31	0.22	2.77
BelMiNeb-RMR-3	GN	durango	11.75	0.22	0.15	1.97
AC Pintoba	pinto	durango	11.44	0.19	0.13	1.70

– Soluble Dietary Fiber (SDF)

Table 4: Five entries with greatest SDF content.

Entry	mktclass	race	SDF	sd	se	ci
Voyager	navy	mesoamerican	10.29	0.12	0.08	1.03
SR7-3	small red	jalisco	9.83	0.83	0.59	7.48
NW-63	small red	jalisco	9.81	0.43	0.30	3.84
IP08-2	pinto	durango	9.48	0.76	0.53	6.79
BelMiNeb 2	GN	durango	9.45	0.05	0.03	0.42

Table 5: Five entries with lowest SDF content.

Entry	mktclass	race	SDF	sd	se	ci
ABCP-15	pinto	durango	5.76	0.56	0.39	5.00
Quincy	pinto	durango	5.53	0.22	0.16	2.00
Centa Pupil	small red	jalisco	5.34	0.52	0.37	4.69
TARS-VCI-4B	pinto	durango	5.16	1.32	0.93	11.84
I9365-5	pink	jalisco	5.09	1.57	1.11	14.13

– Raffinose (Raff)

Table 6: Five entries with greatest raffinose content.

Entry	mktclass	race	Raff	sd	se	ci
NE1-09-20	GN	durango	0.92	0.06	0.04	0.50
CDC Crocus	GN	durango	0.85	0.05	0.04	0.47
I9365-31	black	mesoamerican	0.85	0.25	0.18	2.24
A-55	black	mesoamerican	0.79	0.06	0.04	0.56
NE1-09-9	GN	durango	0.79	0.10	0.07	0.86

Table 7: Five entries with lowest raffinose content.

Entry	mktclass	race	Raff	sd	se	ci
Sawtooth	GN	durango	0.30	0.11	0.08	0.96
USRM-20	small red	jalisco	0.30	0.03	0.02	0.28
Bill Z	pinto	durango	0.28	0.01	0.01	0.13
Ind. Jamaica Red	red mottle	jalisco	0.28	0.07	0.05	0.60
Apache	pinto	durango	0.27	0.01	0.01	0.07

– Stachyose (Stach)

Table 8: Five entries with greatest stachyose content.

Entry	mktclass	race	Stach	sd	se	ci
ND021717	black	mesoamerican	5.16	1.86	1.31	16.69
Centa Pupil	small red	jalisco	4.90	0.26	0.18	2.29
Ind. Jamaica Red	red mottle	jalisco	4.89	0.43	0.31	3.90
GN Star	GN	durango	4.78	0.17	0.12	1.57
Inta Precoz	small red	jalisco	4.70	0.28	0.20	2.48

Table 9: Five entries with lowest stachyose content.

Entry	mktclass	race	Stach	sd	se	ci
ND040494-4	pinto	durango	3.10	0.24	0.17	2.11
NE1-09-9	GN	durango	3.07	0.32	0.23	2.86
NE1-09-20	GN	durango	3.03	0.08	0.05	0.69
T9905	navy	mesoamerican	3.00	0.10	0.07	0.93
F07-449-9-3	small red	jalisco	2.99	0.18	0.13	1.61

– Verbascose (Verb)

Table 10: Five entries with greatest verbascose content.

Entry	mktclass	race	Verb	sd	se	ci
Ind. Jamaica Red	red mottle	jalisco	0.233	0.031	0.022	0.281
Pink Floyd	pink	jalisco	0.233	0.002	0.001	0.017
ROG 312	pink	jalisco	0.229	0.024	0.017	0.216
ABC-Weihing	GN	durango	0.201	0.016	0.011	0.143
GN Star	GN	durango	0.201	0.002	0.002	0.020

Table 11: Five entries with lowest verbascose content.

Entry	mktclass	race	Verb	sd	se	ci
NE1-09-22	GN	durango	0.038	0.001	0.001	0.012
T9905	navy	mesoamerican	0.037	0.011	0.008	0.096
A-55	black	mesoamerican	0.036	0.035	0.025	0.317
GN9-4	GN	durango	0.033	0.032	0.022	0.284
McHale	navy	mesoamerican	0.021	0.006	0.004	0.050

– Total Oligosachharides (TOligos)

Table 12: Five entries with greatest total oligosaccharide (= Raff + Stach + Verb) content.

Entry	mktclass	race	TOligos	sd	se	ci
ND021717	black	mesoamerican	5.98	2.22	1.57	19.92
Centa Pupil	small red	jalisco	5.45	0.18	0.13	1.62
Ind. Jamaica Red	red mottle	jalisco	5.40	0.47	0.33	4.22
GN Star	GN	durango	5.39	0.23	0.16	2.04
Inta Precoz	small red	jalisco	5.32	0.25	0.18	2.24

Table 13: Five entries with lowest total oligosaccharide (= Raff + Stach + Verb) content.

Entry	mktclass	race	TOligos	sd	se	ci
Mariah	pinto	durango	3.60	0.30	0.21	2.67
NE1-09-19	GN	durango	3.57	0.08	0.06	0.71
ND040494-4	pinto	durango	3.55	0.14	0.10	1.24
T9905	navy	mesoamerican	3.53	0.12	0.09	1.08
F07-449-9-3	small red	jalisco	3.50	0.06	0.04	0.57

– Total Dietary Fiber (TDF)

Table 14: Five entries with greatest total DF (= IDF + SDF + Raff + Stach + Verb) content.

Entry	mktclass	race	TDF	sd	se	ci
PR0443-151	black	mesoamerican	30.23	1.22	0.87	11.00
IP08-2	pinto	durango	30.06	0.15	0.11	1.39
ND021717	black	mesoamerican	29.78	0.83	0.59	7.48
AC Resolute	GN	durango	29.45	1.57	1.11	14.08
Max	pinto	durango	28.59	0.81	0.57	7.26

Table 15: Five entries with lowest total DF (= IDF + SDF + Raff + Stach + Verb) content.

Entry	mktclass	race	TDF	sd	se	ci
T9905	navy	mesoamerican	23.59	0.93	0.66	8.39
Norstar	navy	mesoamerican	23.43	0.31	0.22	2.77

Entry	mktclass	race	TDF	sd	se	ci
BelMiNeb-RMR-7	navy	mesoamerican	23.36	0.12	0.08	1.05
Topaz	pinto	durango	23.18	0.00	0.00	0.02
AC Pintoba	pinto	durango	22.82	0.80	0.57	7.19

Results: Marketclass

– Boxplots

Figures below depict fiber content by market class.

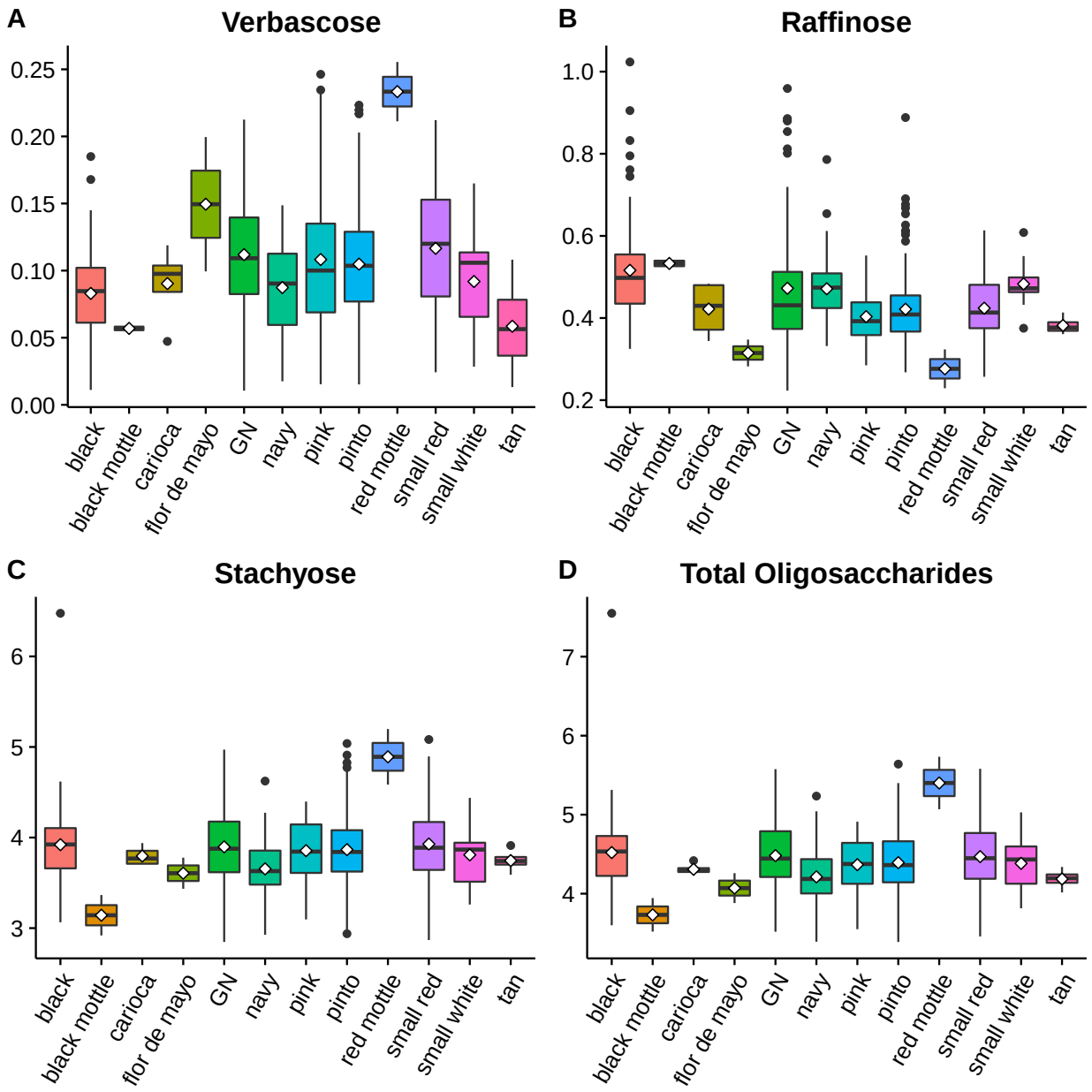


Figure 1: Oligosaccharide content in 282 common bean genotypes by marketclass (A) Raffinose, (B) Stachyose, (C) Verbascose, and (D) total oligosaccharides (= Raff + Stach + Verb).

Marketclass	Verbascose	Raffinose	Stachyose	Total Oligosaccharides
black	0.083 a	0.516 c	3.92 b	4.52 bc
black mottle	0.057 ab	0.533 bc	3.14 ab	3.73 ab
carioca	0.09 ab	0.422 bc	3.8 ab	4.31 abc
flor de mayo	0.149 abd	0.315 bc	3.61 ab	4.07 abc
GN	0.112 b	0.472 ac	3.9 b	4.48 bc

Marketclass	Verbascose	Raffinose	Stachyose	Total Oligosaccharides
navy	0.087 ac	0.471 ac	3.65 a	4.21 a
pink	0.108 bc	0.403 b	3.86 ab	4.37 ab
pinto	0.105 b	0.421 b	3.87 b	4.39 b
red mottle	0.233 d	0.276 ab	4.89 c	5.4 c
small red	0.117 b	0.424 ab	3.93 b	4.47 bc
small white	0.092 ab	0.483 bc	3.81 ab	4.38 abc
tan	0.059 ab	0.382 bc	3.75 ab	4.19 ab

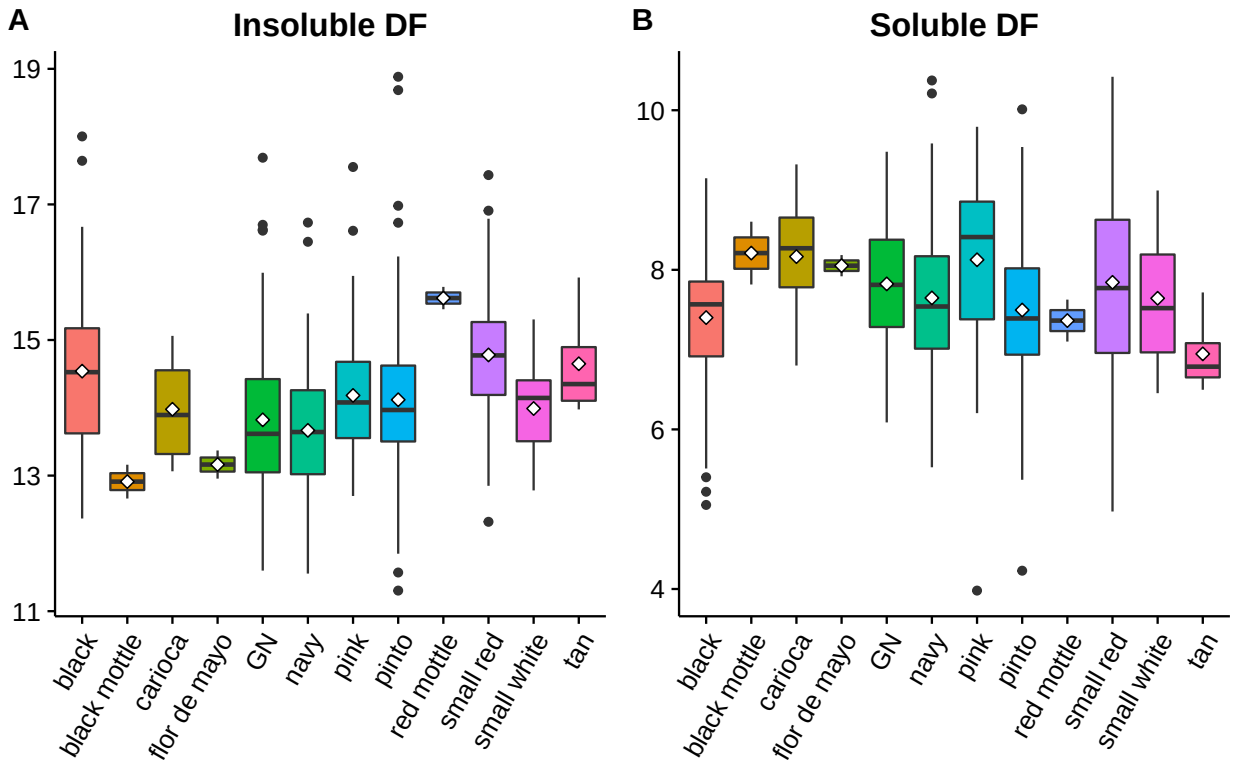


Figure 2: (A) Soluble and (B) insoluble dietary fiber in 282 common bean genotypes by marketclass,

Marketclass	Insoluble DF	Soluble DF
black	14.541 cd	7.401 b
black mottle	12.911 abc	8.21 ab
carioca	13.978 abc	8.166 ab
flor de mayo	13.163 abc	8.052 ab
GN	13.823 ab	7.824 ab
navy	13.667 a	7.648 ab
pink	14.182 abc	8.126 a
pinto	14.119 bd	7.496 b

Marketclass	Insoluble DF	Soluble DF
red mottle	15.619 abc	7.364 ab
small red	14.78 c	7.843 ab
small white	13.99 abc	7.643 ab
tan	14.649 abc	6.947 ab

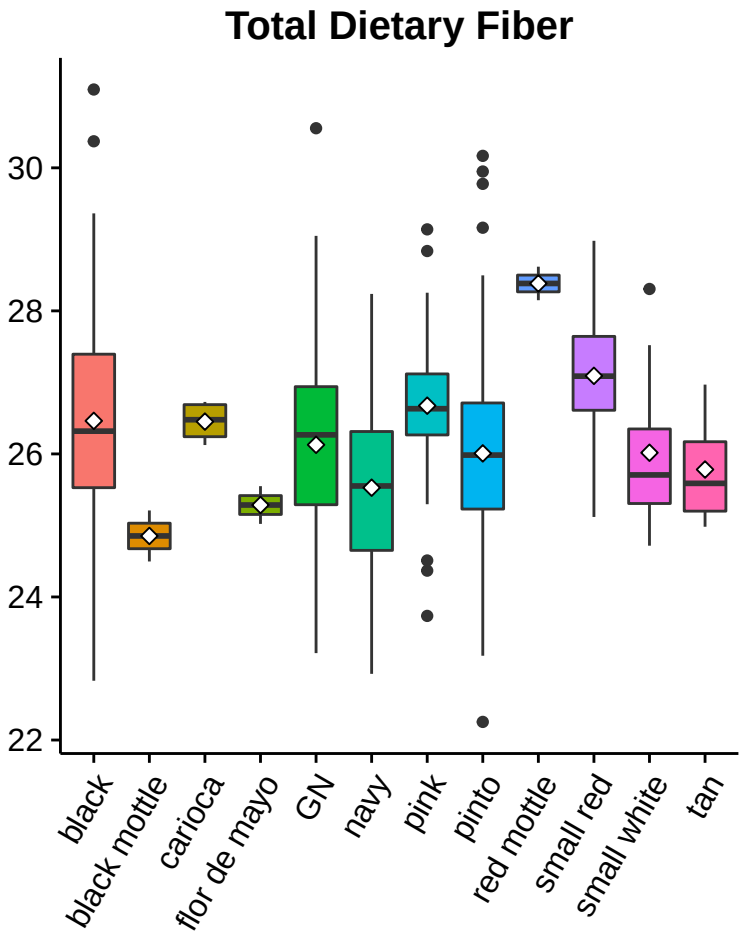


Figure 3: Total Dietary Fiber content in 282 common bean genotypes by marketclass

Marketclass	Total DF
black	26.462 bc
black mottle	24.853 abc
carioca	26.452 abc
flor de mayo	25.286 abc
GN	26.128 cd
navy	25.528 a
pink	26.675 bd

Marketclass	Total DF
pinto	26.007 ac
red mottle	28.383 bc
small red	27.092 b
small white	26.017 abc
tan	25.782 abc

Results: Race

– Boxplots

Figures below depict fiber content by race.

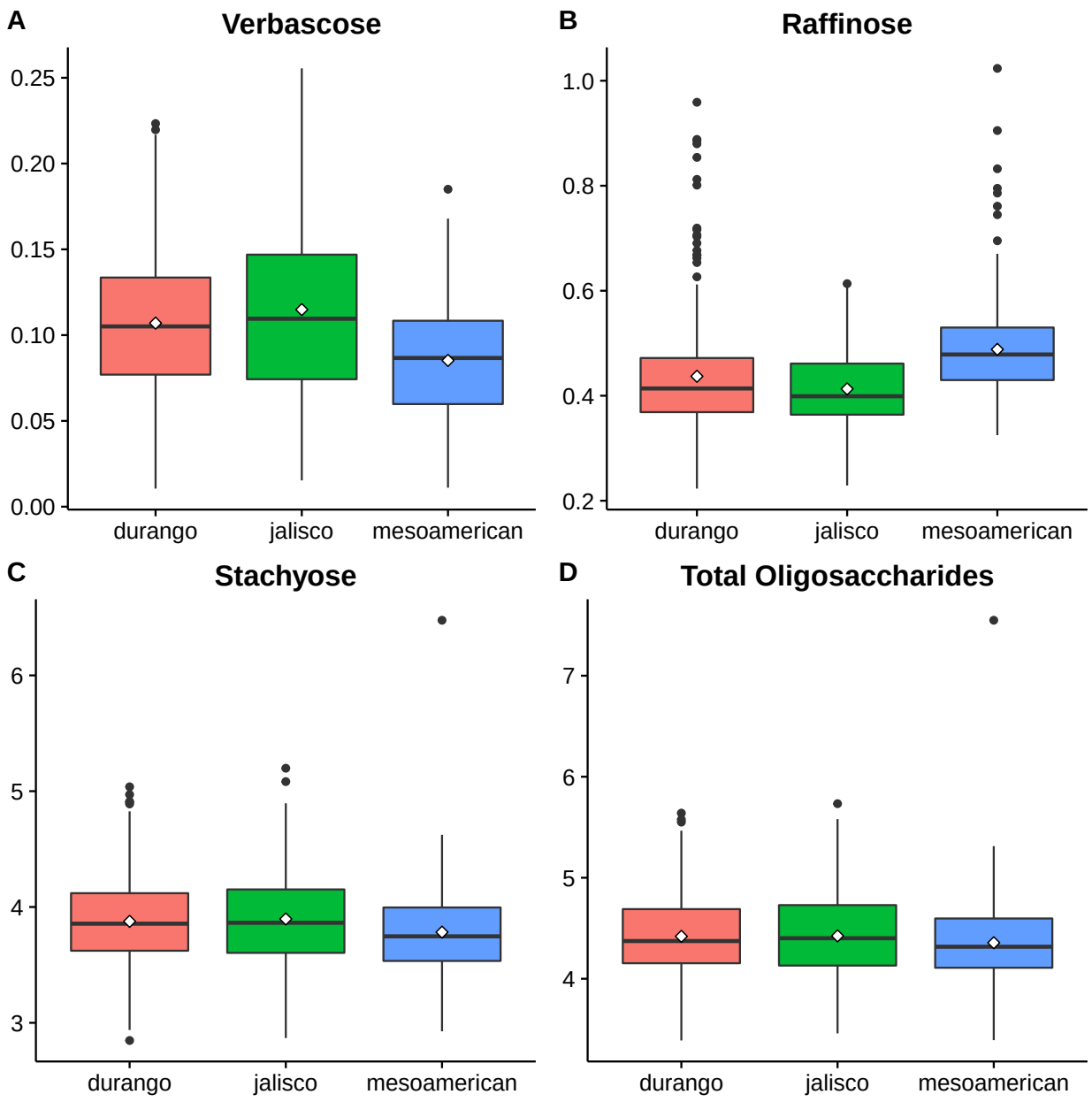


Figure 4: Oligosaccharide content in 282 common bean genotypes by race (A) Raffinose, (B) Stachyose, (C) Verbascose, and (D) total oligosaccharides (= Raff + Stach + Verb).

Race	Verbascose	Raffinose	Stachyose	Total Oligosaccharides
Durango	0.107 b	0.437 a	3.88 b	4.42 a
Jalisco	0.115 b	0.413 a	3.9 ab	4.42 a
Mesoamerican	0.085 a	0.488 b	3.78 a	4.36 a

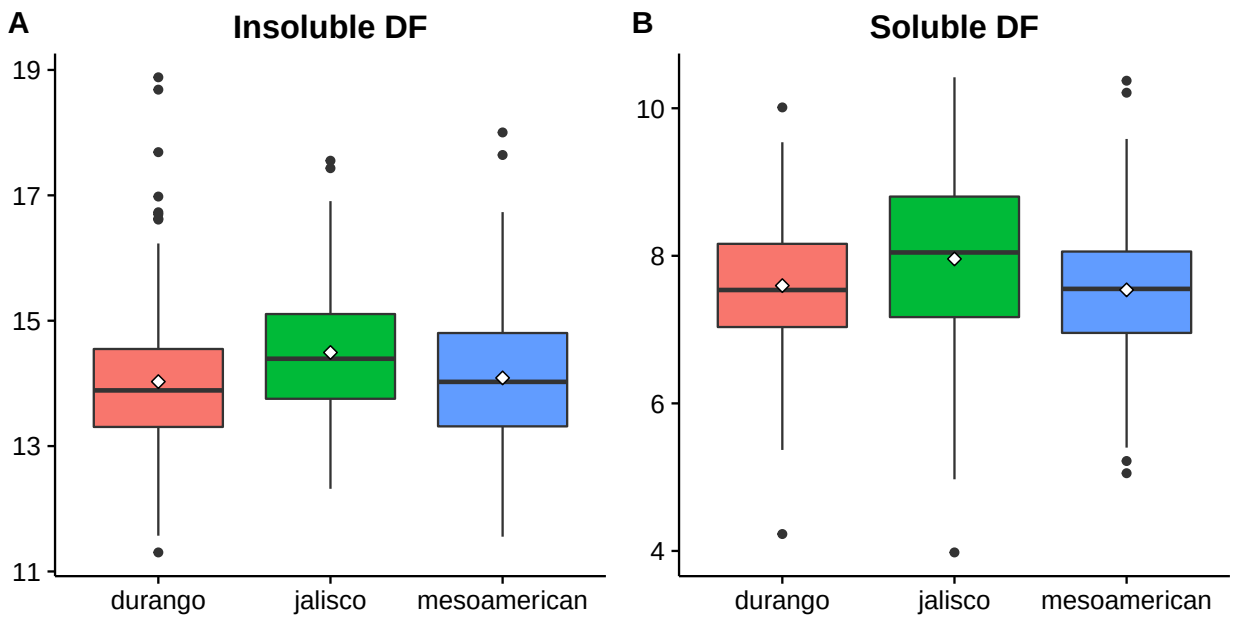


Figure 5: (A) Soluble and (B) insoluble dietary fiber in 282 common bean genotypes by race,

Race	Insoluble DF	Soluble DF
Durango	14.028 a	7.596 a
Jalisco	14.493 b	7.958 b
Mesoamerican	14.087 a	7.538 a

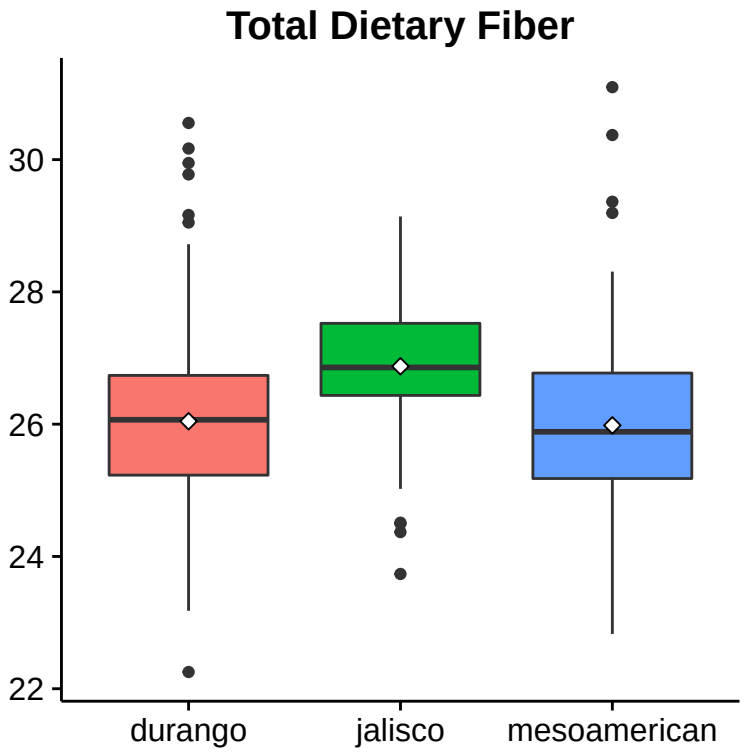


Figure 6: Total Dietary Fiber content in 282 common bean genotypes by race

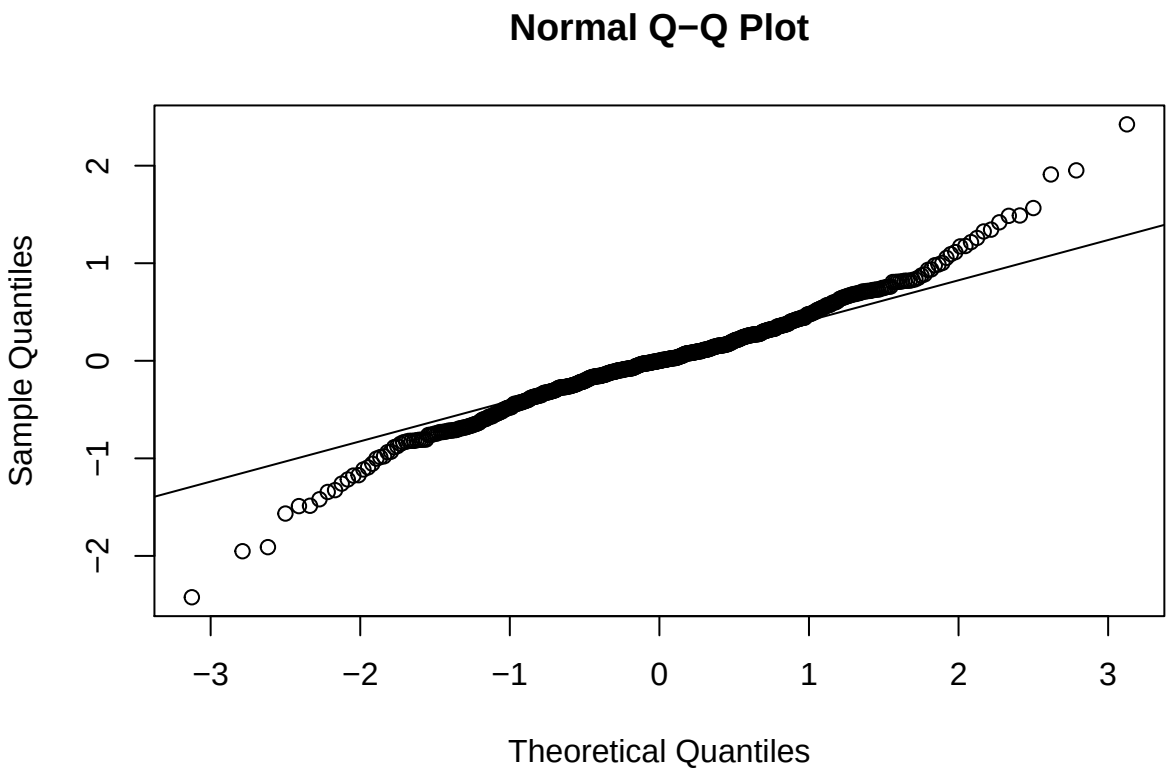
Race	Total DF
Durango	26.044 a
Jalisco	26.875 b
Mesoamerican	25.982 a

Statistical Methods

Statistical analyses, figures, tables, and reporting was completed using RStudio Version 0.98.1062.

– *Assumptions of Normality and Homogeneity of Variance*

Insoluble fiber, soluble fiber, raffanose, stachyose, and verbascose data were concluded to meet the assumptions of normality after plotting histograms, qqplots, and residuals versus predicted values as well as conducting Shapiro-Wilk and one-sample Kolmogorov-Smirnov normality tests.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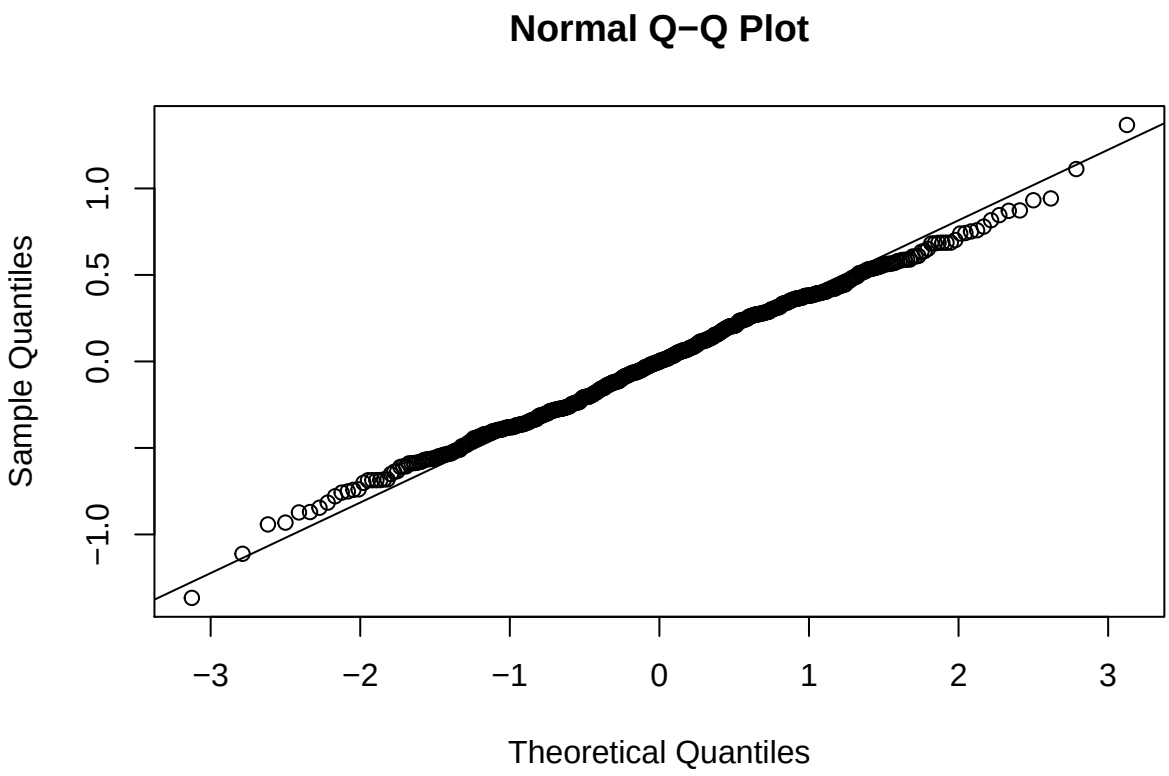
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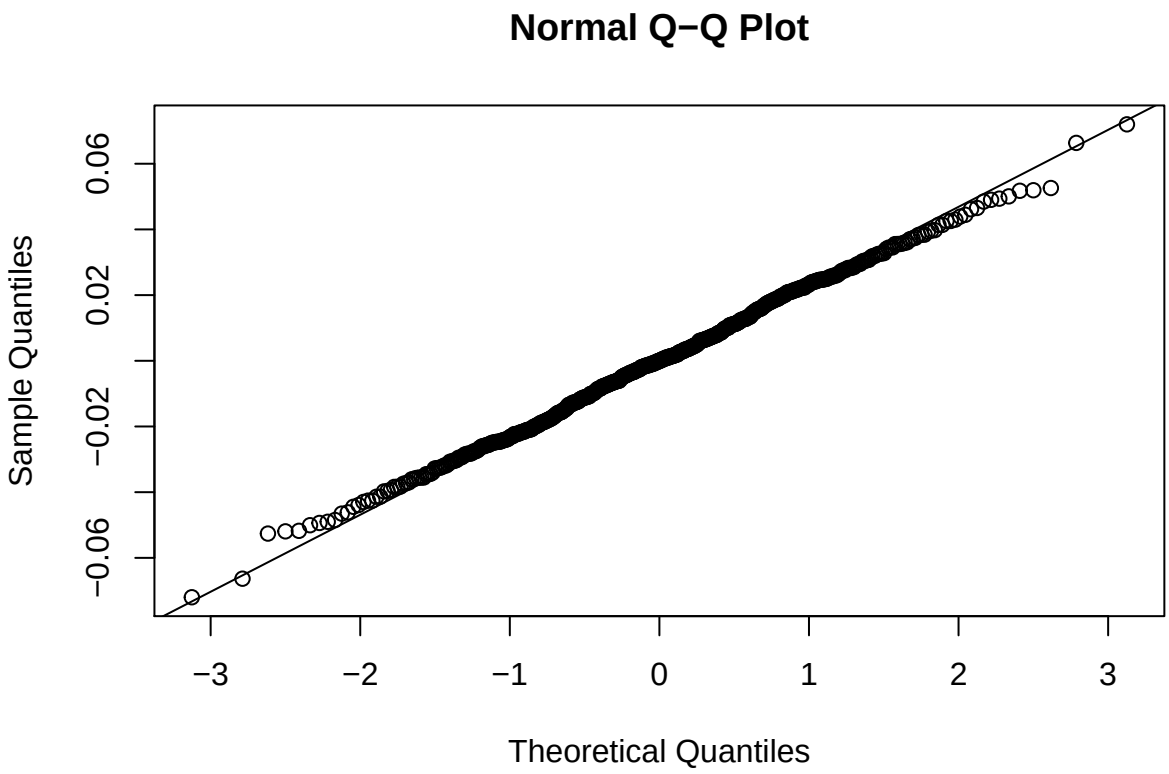
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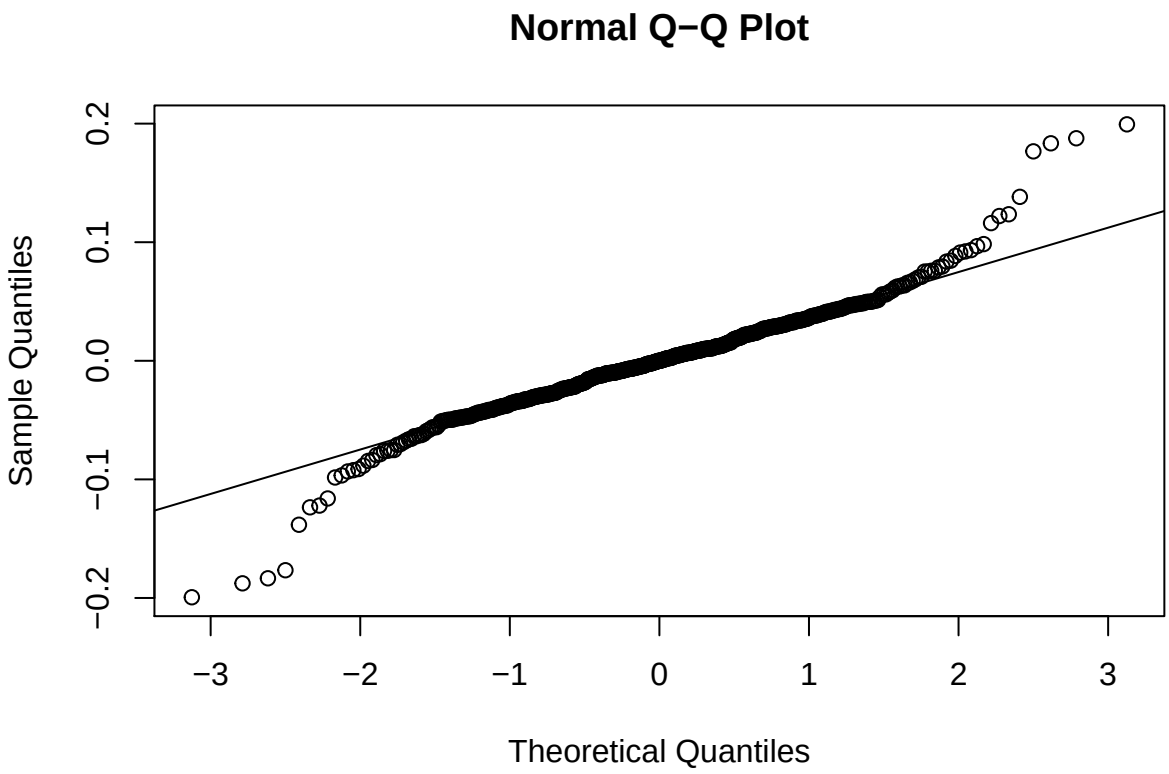
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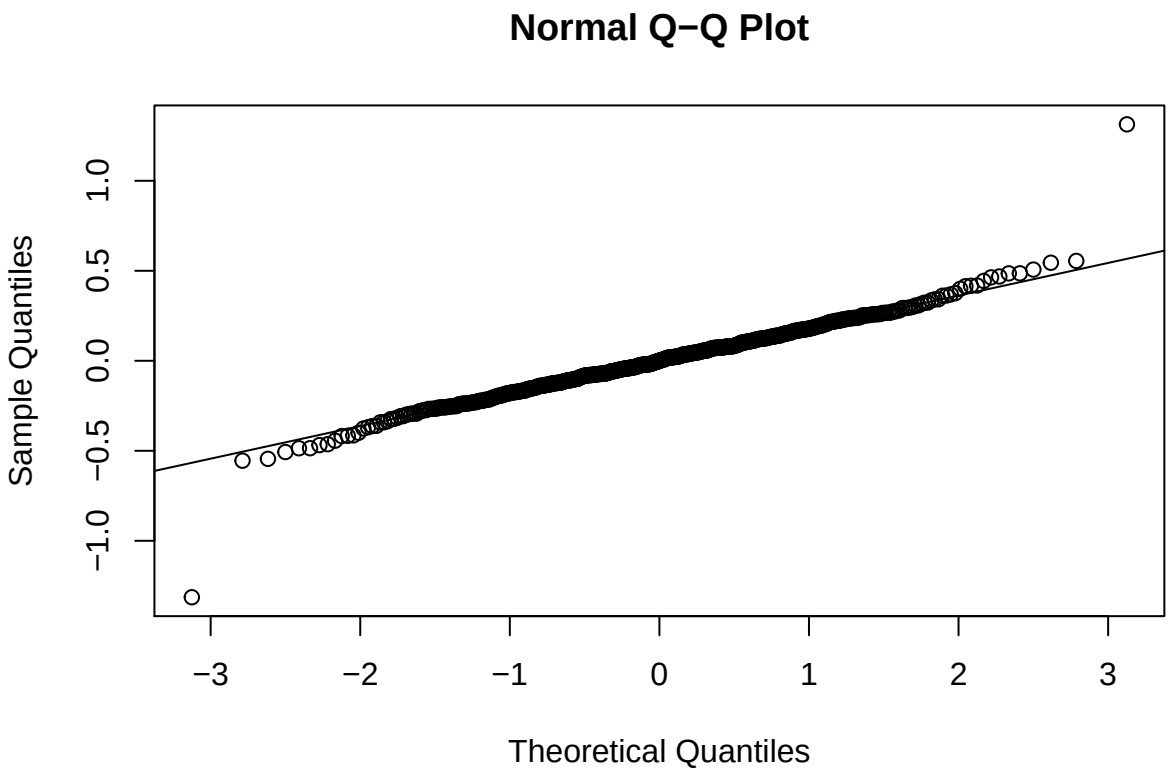

– *One-way ANOVA*

One-way analysis of variance was conducted to determine the effect of 1)market class and 2) race on fiber components of the 282 entries using the aov function.

1) Market class

Table 22: One-way ANOVA table testing differences in insoluble DF between market classes.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
mktclass	11	76.7617	6.9783	6.0667	0
Residuals	552	634.9496	1.1503	NA	NA

Table 23: One-way ANOVA table testing differences in soluble DF between market classes.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
mktclass	11	28.1329	2.5575	2.99	7e-04

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Residuals	552	472.1533	0.8554	NA	NA

Table 24: One-way ANOVA table testing differences in verbascose between market classes.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
mktclass	11	0.1246	0.0113	7.0095	0
Residuals	552	0.8920	0.0016	NA	NA

Table 25: One-way ANOVA table testing differences in raffanose DF between market classes.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
mktclass	11	0.8693	0.0790	8.0515	0
Residuals	552	5.4182	0.0098	NA	NA

Table 26: One-way ANOVA table testing differences in stachyose DF between market classes.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
mktclass	11	7.8272	0.7116	4.5727	0
Residuals	552	85.8973	0.1556	NA	NA

Table 27: One-way ANOVA table testing differences in total oligosaccharides DF between market classes.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
mktclass	11	8.5502	0.7773	4.3318	0
Residuals	552	99.0505	0.1794	NA	NA

Table 28: One-way ANOVA table testing differences in total DF between market classes.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
mktclass	11	127.1475	11.5589	8.0004	0
Residuals	552	797.5236	1.4448	NA	NA

2) Race

Table 29: One-way ANOVA table testing differences in insoluble DF between races.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
race	2	17.4862	8.7431	7.0653	9e-04
Residuals	561	694.2251	1.2375	NA	NA

Table 30: One-way ANOVA table testing differences in soluble DF between races.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
race	2	13.5696	6.7848	7.8203	4e-04
Residuals	561	486.7165	0.8676	NA	NA

Table 31: One-way ANOVA table testing differences in verbascose between races.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
race	2	0.0782	0.0391	23.3805	0
Residuals	561	0.9384	0.0017	NA	NA

Table 32: One-way ANOVA table testing differences in raffanose DF between races.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
race	2	0.4754	0.2377	22.9451	0
Residuals	561	5.8121	0.0104	NA	NA

Table 33: One-way ANOVA table testing differences in stachyose DF between races.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
race	2	1.2766	0.6383	3.8734	0.0213
Residuals	561	92.4478	0.1648	NA	NA

Table 34: One-way ANOVA table testing differences in total oligosaccharides DF between races.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
race	2	0.5340	0.2670	1.3989	0.2477
Residuals	561	107.0668	0.1908	NA	NA

Table 35: One-way ANOVA table testing differences in total DF between races.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
race	2	65.4603	32.7301	21.3703	0
Residuals	561	859.2108	1.5316	NA	NA

– *Pairwise Comparisons*

Tukey adjusted pairwise comparisons were made between each market class and each race for each fiber component using the TukeyHSD funcion.

```
OneWayFit <- aov(IDF~race, data=fiber)
TukeyHSD(OneWayFit)

library(multcomp)
PairComps <- glht(OneWayFit, linfct=mcp(race="Tukey"))
summary(PairComps)
cld(PairComps)
```