Enhancing the Markets for U.S. Grown Quinoa

Final Report

14-FSMIP-WA-0016

Federal Agency Funding Amount: $80,444
Non-Federal Matching Amount: $80,456

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Summary:

In this project, we had proposed to: 1) assess infrastructure requirements to move Quinoa from farm to market, and the potential to appropriate existing grain (e.g. wheat, corn) infrastructure for Quinoa; 2) assess marketing trends for whole and processed Quinoa in the US and globally; 3) assess processing challenges which impede the utilization of quinoa in food products; 4) assess key Quinoa processing characteristics, and develop model extruded food products based on these characteristics to guide market expansion; and 5) inform industry leaders of key findings relating to Quinoa supply-chain, processing, and marketing topics through targeted tracks at two Cascadia Grains Conferences, and printed materials.

The project goals were all completed as planned. As an outcome of this work, three peer reviewed manuscripts were published (see attachments) and the data was presented at the Cascadian Grain Conference. One MS student (Ms. Nicole Aluwi) who was hired on to this project has successfully completed her research and graduated in May 2016. The attachment, A4, is her thesis presentation, which walks through the project work in a very informative manner. All the different available varieties and breeding lines of quinoa were characterized and grouped into clusters based of their potential applications. The student graduated and now works in the Quinoa industry at Lundberg Family Farms in the state of CA.

Information generated and published from this work is being utilized by the breeder of the program (Dr. Kevin Murphy) in furthering the quinoa breeding trials and potential release of the varieties to the markets. We have had enquiries from quinoa processors and as assisting them in their value-added product development and thus helping to increase the markets for the quinoa.

All the information generated from this project was published in peer reviewed journals and presented at conferences. An attempt was made to effectively disseminate the information to the stakeholders.

1. Briefly summarize activities performed and milestones achieved for each objective and sub-element of the project work plan.

i) Conduct market research on the current situation of the quinoa production, supply and end uses;

- This work was completed by our collaborator at Northwest Agriculture Business Center (NABC).

- A detailed report was submitted during one of the quarterly reports.
- The report is also attached to this email.
- In summary there is lack of infrastructure to have a systematic supply chain of quinoa from the growers to the processors/millers to the end users.
- There needs to be more collaboration between the different stakeholders to develop and sustain the infrastructure. Please see attached market report for details.

ii) Study the processing characteristics of the different varieties of quinoa;

- An MS student (Nicole Aluwi) worked on this research objective and has successfully completed significant amount of this work. This student was advised by Drs. Ganjyal, Murphy and Lewis.
- From the 2014 Quinoa harvest season and through the project co-operators, we collected samples of 28 different varieties of quinoa.
- We completed the testing of all the 28 varieties, for their composition (starch, protein, lipids, fiber, moisture and ash) as shown in Table 1, pasting properties (using visco-amylograph) as shown in Figure 1, thermal properties (using DSC, at 60% moisture contents) as shown in Table 2, and functional properties (WAI/WSI and FSP) as shown in Table 3.
- Based on this data, we have categorized the 28 quinoa varieties into four clusters (C1-C4) using Hierarchical Cluster Analysis as shown in Figure 2.
- Using Principal Component Analysis, varieties were related to their physicochemical properties (Figure 3) and were suggested for suitable food products.
    - Cluster 1-Characteristic of high viscosity and gelatinization properties.
        - High rising baked goods (cakes, breads, etc.).
    - Cluster 2-Characteristic of low viscosity and gelatinization properties.
        - Dense baked goods.
    - Cluster 3-Characteristic of low flour swelling power and water solubility.
        - Pasta noodles, instant ramen noodles, cereal.
    - Cluster 4-Characteristic of high flour swelling power.
        - Japanese udon noodles (elastic properties).
- The manuscript from this work was published in the Cereal Chemistry journal (a peer reviewed journal). See attachment.
- Further we did extensive work analysis of the saponins in the quinoa. A protocol to quantify the total saponin content by spectrophotometric method has been developed (Page 7) and another method to assess the components of the saponins via GC-MS was also developed. This is a significant contribution to the quinoa industry.
    - Total saponin content of 28 quinoa varieties have been quantified, as shown in Figure 5.
    - This data was published in the Food Chemistry journal (peer reviewed journal).

See attachment.

iii) Develop extruded products with select quinoa varieties;

- Extrusion of 3 commercial varieties (Cherry Vanilla, Black, and Bolivian Royal) has been completed, as shown in Figure 4.
    - Cherry Vanilla and Black varieties were extruded in their scarified and unscarified flour forms.
    - Bolivian Royal variety was extruded in scarified and degermed flour forms.
- Proximate composition, physicochemical properties, and saponin content were also evaluated, as shown in Tables 4, 5, and 6, respectively.
- Significant differences in the extrusion expansion properties were seen with different varieties. The impacts of the scarification and degermination were also found to be significant on the extrudate properties.
- This data was published in the Journal of Food Science (peer reviewed journal). See attachment.

iv) Conduct extensive outreach activities to disseminate the results obtained from the above objectives.

- The data has been presented at the 2016 Cascadian Grain Conference (CGC) on 9th January of 2016 (http://cascadiagrains.com/2015/09/08/2016-conference-date-announced/). Nicole (graduate student) presented this data.
- The summary reports from the CGC conference in 2015 and 2016 are enclosed as attachments to this report. This provides a good idea of the audience to whom the information on the quinoa was exposed to, by integrating into the workshop.
- Field days (for both agronomy and value-added processing) were conducted in Jefferson County. Please see pictures in Figures 6 and 7.
- The data from all three published papers from the work done under this project has been shared with various quinoa processors in North America.
- The information from this work has been utilized by our co-PI (Dr. Kevin Murphy) to assist in the selection of varieties for breeding program and variety release.
- We have also been in constant communication with the quinoa growers in the PNW and assessing their interests in postharvest processing and value-addition.

Note: These quinoa varieties included in the study are : Titicaca, Kaslaea, QQ74, Black, Blanca, KU2, Isluga, Linares, Puno, Cahuil, QuF9P1-20, Red Head, NL-6, Cherry Vanilla, Oro de Valle, CO 407 WMF, CO 407 Dave, French Vanilla, Temuko, Black WWA, BBR, UDEC1, QuF9P40-

29, QuF9P39-51, QuF9P39-72, Japanese Strain, QuF9P39-73, and QuF9P39-64.

2. Describe any unexpected delays or impediments as well as favorable or unusual developments.
   - We had two changes in project personnel.
   - Extension – Dr. Lucas Patzek departed from WSU. In his place now we have Dr. Laura Lewis on board as the Co-PI and has assumed all the responsibilities of Dr. Patzek. All the paperwork was completed related to this change. Dr. Laura is the county director at Jefferson County in the state of WA and is also managing the Cascadia Grain Conference which is one of major avenues that we utilized for disseminating the information generated from this project.
   - Marketing – Ms. Lucy Norris departed from NABC. David Bauermeister assumed all the responsibilities related to this objective. Both Dr. Ganjyal and Dr. Lewis assisted in these efforts as they have major extension appointment at WSU.

3. Comment on the level of grant funds and matching contributions expended to date on the project.
   - Majority of the funding requested was used for supporting the MS student.
   - Since the funding available is only for 1 year of student support, other funds from the PI were used for the first year of support.
   - Part of the funds were used for purchasing supplies related to the research work.
   - Some funds were spent on the crop seed planting for increases.

Attachments:

A1. Physicochemical Characterization of Different Varieties of Quinoa. (published peer reviewed paper).
A2. Impacts of Scarification and Degermination on the Expansion Characteristics of Select Quinoa Varieties during Extrusion Processing. (published peer reviewed paper).
A3. GC−MS Profiling of Triterpenoid Saponins from 28 Quinoa Varieties. (published peer reviewed paper).
A4. Nicole Aluwi Thesis Presentation Final Copy 042216
A5. Marketing Report - Enhancing the markets for US grown quinoa
A6. 2015 Cascadia Grains Conference - Summary Report
A7. 2016 Cascadia Grains Conference - Summary Report

Table 1. Proximate composition of whole quinoa flours (% dry weight basis).

Quinoa	Moisture	Ash	Protein	Starch	Fat	Fiber
Red Head	9.68 ± 0.06	3.65 ± 0.06	14.24 ± 0.28	62.54 ± 0.84	7.50 ± 0.00	12.09 ± 0.62
QuF9P40-29	9.71 ± 0.09	3.47 ± 0.09	15.13 ± 0.35	61.11 ± 1.05	5.56 ± 0.07	14.72 ± 0.86
Titicaca	10.03 ± 0.03	3.76 ± 0.02	14.37 ± 0.34	56.35 ± 0.34	6.58 ± 0.04	18.93 ± 0.39
CO 407 WMF	10.14 ± 0.03	3.88 ± 0.01	13.10 ± 0.11	59.06 ± 0.26	6.23 ± 0.02	17.73 ± 0.24
Cahuil	10.40 ± 0.05	3.83 ± 0.06	14.42 ± 0.14	58.24 ± 1.23	5.42 ± 0.03	18.09 ± 1.36
Kaslaea	9.97 ± 0.03	3.65 ± 0.03	13.59 ± 0.14	60.03 ± 0.83	6.82 ± 0.03	15.92 ± 0.78
Blanca	10.54 ± 0.02	3.75 ± 0.01	14.32 ± 0.17	58.04 ± 0.05	5.08 ± 0.01	18.81 ± 0.15
QQ74	10.13 ± 0.06	3.44 ± 0.06	12.99 ± 0.16	57.60 ± 0.99	6.18 ± 0.01	19.80 ± 0.86
Linares	9.89 ± 0.05	3.71 ± 0.02	14.31 ± 0.10	58.32 ± 0.53	6.40 ± 0.03	17.27 ± 0.61
CO 407 Dave	9.95 ± 0.06	3.69 ± 0.04	13.56 ± 0.17	64.31 ± 0.99	6.74 ± 0.08	11.70 ± 0.84
Temuko	10.20 ± 0.07	3.61 ± 0.04	15.15 ± 0.21	57.84 ± 0.18	6.17 ± 0.01	17.23 ± 0.05
UDEC1	9.96 ± 0.09	3.62 ± 0.02	15.05 ± 0.18	54.39 ± 0.77	6.17 ± 0.09	20.78 ± 0.53
Isluga	9.88 ± 0.03	3.59 ± 0.04	14.03 ± 0.14	57.71 ± 1.20	6.17 ± 0.05	18.50 ± 1.14
French Vanilla	10.17 ± 0.03	3.46 ± 0.01	14.21 ± 0.11	62.88 ± 0.17	6.51 ± 0.09	12.95 ± 0.13
Cherry Vanilla	9.55 ± 0.04	3.68 ± 0.02	14.15 ± 0.22	58.66 ± 0.67	6.83 ± 0.03	16.69 ± 0.84
Oro de Valle	10.30 ± 0.06	3.40 ± 0.03	13.53 ± 0.11	58.92 ± 0.72	6.76 ± 0.06	17.38 ± 0.58
Black	10.43 ± 0.04	3.78 ± 0.04	13.80 ± 0.12	55.55 ± 0.15	6.33 ± 0.02	20.54 ± 0.09
Black WWA	10.16 ± 0.06	3.68 ± 0.05	14.48 ± 0.17	59.16 ± 0.29	6.28 ± 0.01	16.40 ± 0.22
QuF9P39-64	10.08 ± 0.06	3.95 ± 0.03	15.78 ± 0.14	55.64 ± 1.32	6.92 ± 0.06	17.71 ± 1.52
QuF9P1-20	9.96 ± 0.03	3.73 ± 0.03	15.42 ± 0.14	57.84 ± 0.82	6.51 ± 0.09	16.49 ± 0.79
Puno	10.27 ± 0.04	3.57 ± 0.05	14.70 ± 0.21	62.55 ± 0.53	5.49 ± 0.03	13.69 ± 0.50
QuF9P39-51	9.79 ± 0.06	3.58 ± 0.01	13.91 ± 0.08	60.47 ± 0.64	5.41 ± 0.05	16.63 ± 0.76
BBR	9.82 ± 0.08	3.45 ± 0.07	13.06 ± 0.21	63.94 ± 0.18	6.97 ± 0.06	12.58 ± 0.51
Japanese Strain	9.33 ± 0.04	3.73 ± 0.06	14.85 ± 0.28	55.71 ± 1.09	6.08 ± 0.03	19.63 ± 0.95
QuF9P39-73	9.82 ± 0.05	3.38 ± 0.02	14.60 ± 0.08	56.82 ± 0.29	6.29 ± 0.03	18.91 ± 0.38
QuF9P39-72	9.92 ± 0.02	3.75 ± 0.03	14.54 ± 0.20	59.14 ± 0.79	6.76 ± 0.05	15.80 ± 1.02
KU2	9.95 ± 0.12	3.91 ± 0.07	15.58 ± 0.17	56.68 ± 1.21	6.54 ± 0.02	17.30 ± 1.28
NL-6	9.74 ± 0.02	3.67 ± 0.03	15.07 ± 0.21	58.18 ± 0.44	6.59 ± 0.05	16.49 ± 0.54

Figure 1. Micro Visco-Amylograph (MVAG) data of quinoa flours.

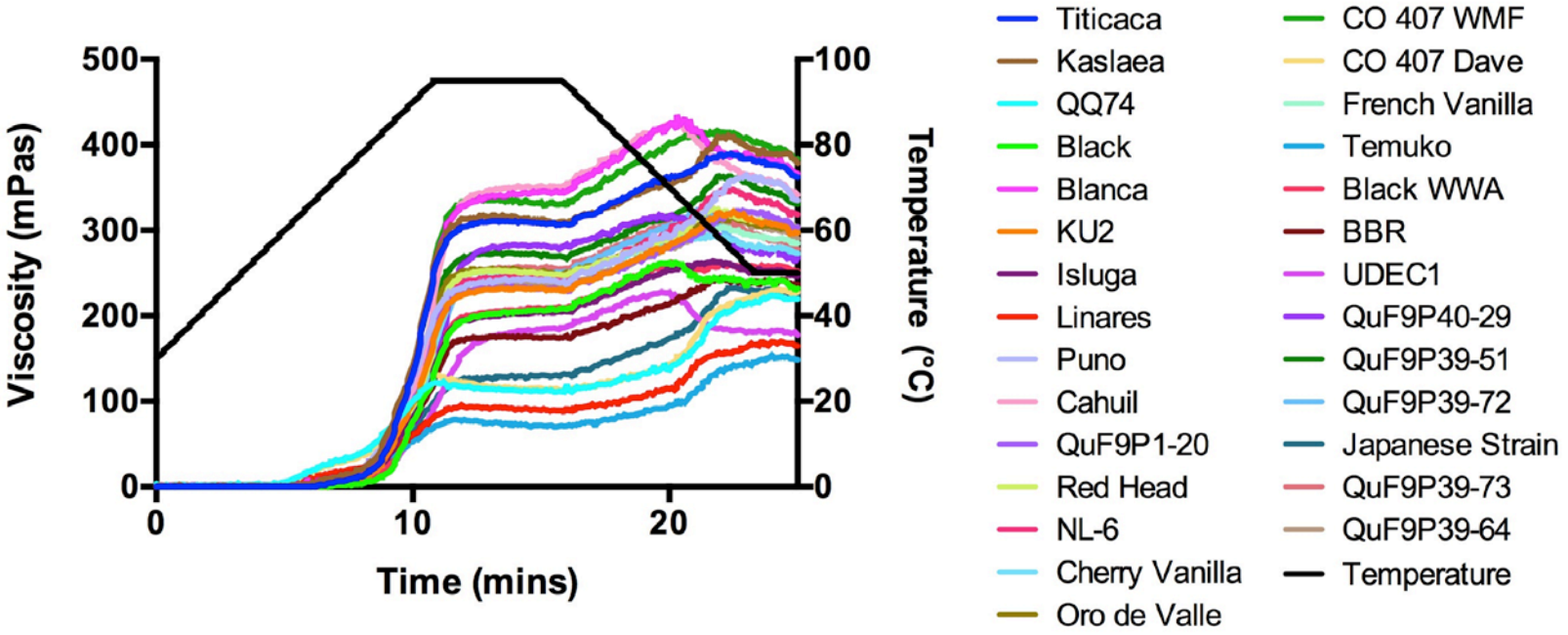


Figure 2. Quinoa groups derived from Hierarchical Cluster Analysis and based off physicochemical properties.

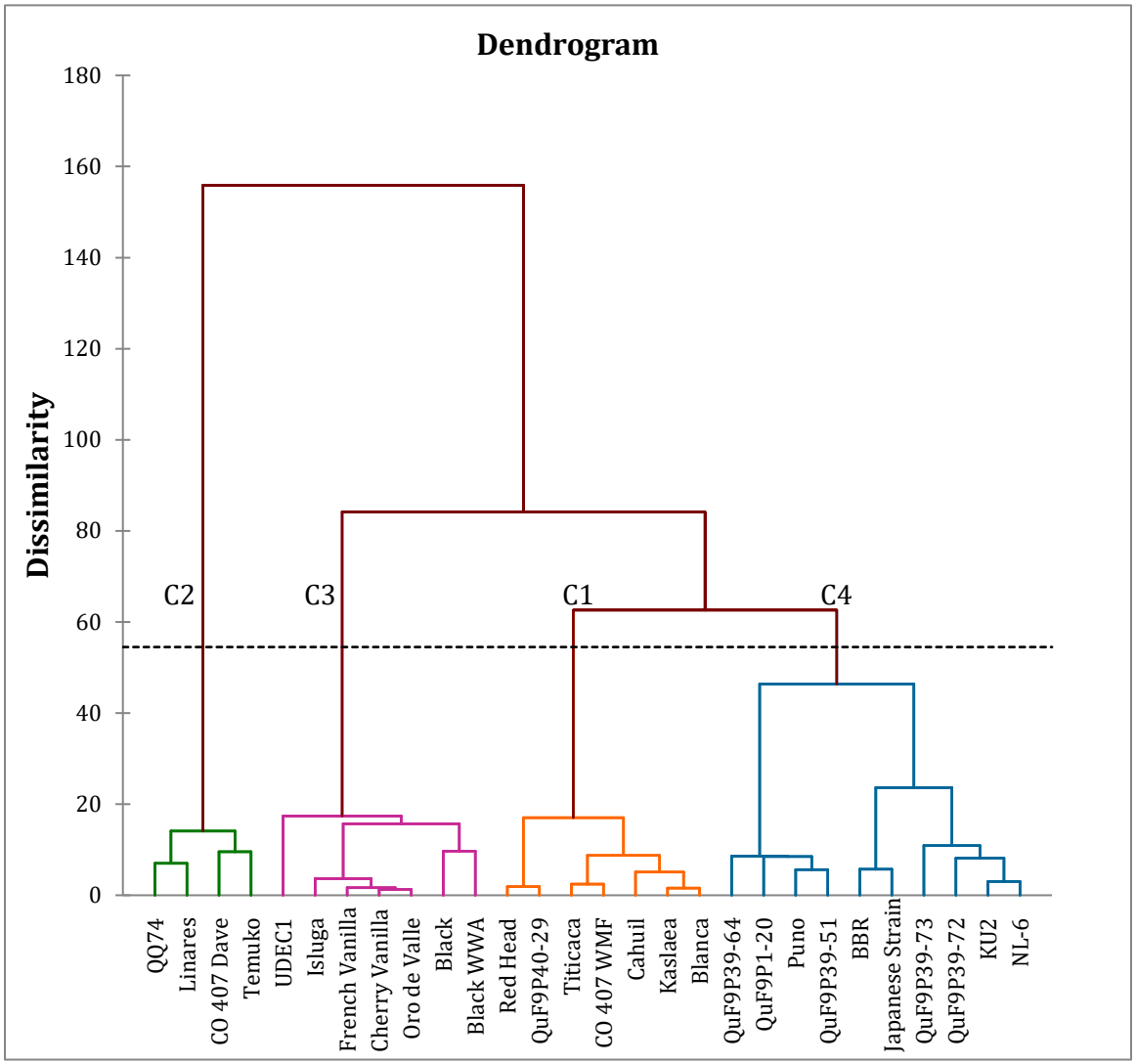


Figure 3. Principle component analysis (PCA) biplot of quinoa varieties and their relationship to the factor loadings.

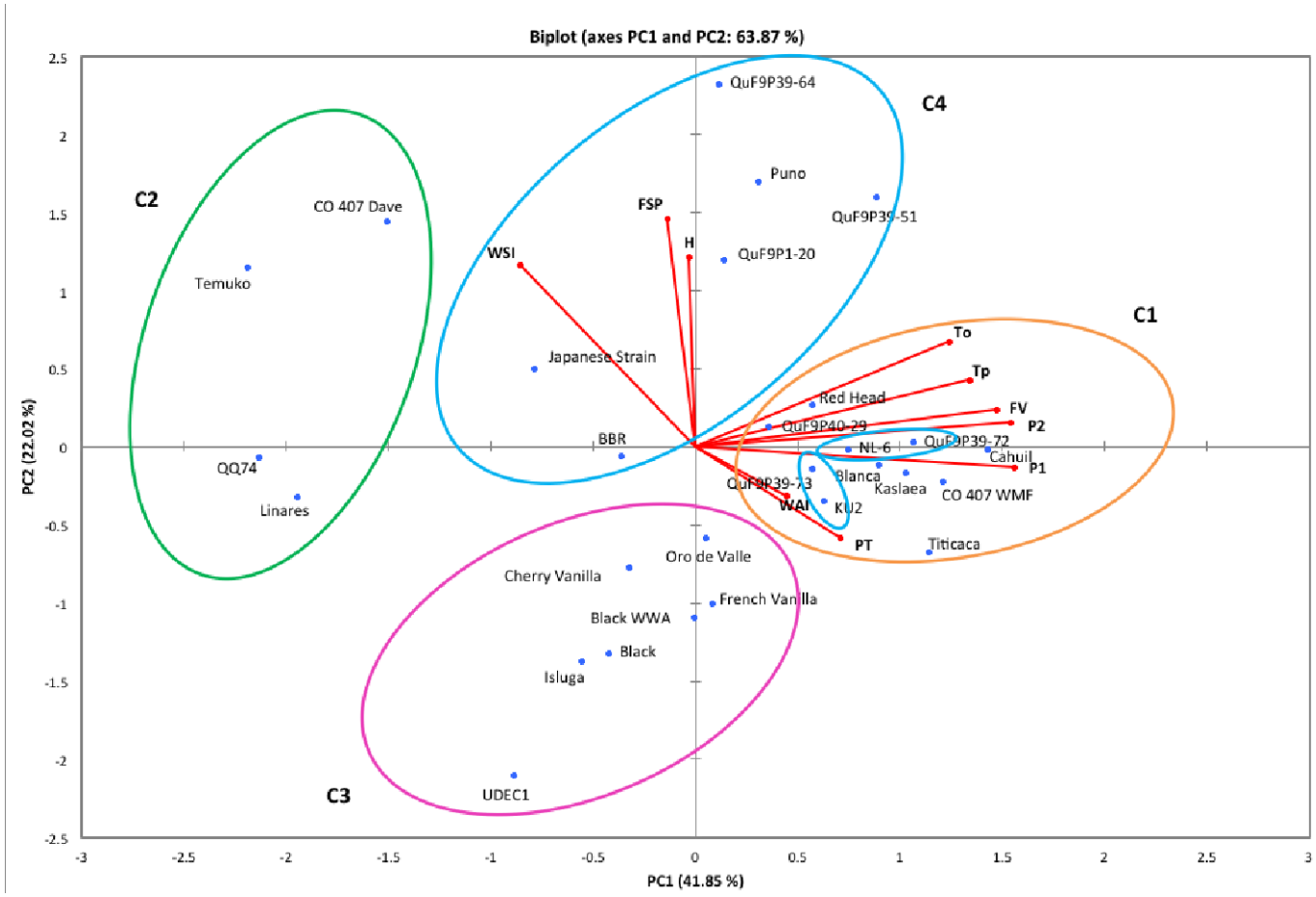


Table 2. Differential scanning calorimetry (DSC) of quinoa flours at 60% moisture content.

Cluster	Quinoa	To (°C)	Tp (°C)	ΔH (J/g)
	Red Head	67.46 ± 0.46	73.43 ± 0.02	4.55 ± 0.05
	QuF9P40-29	66.67 ± 0.08	72.96 ± 0.14	4.52 ± 0.05
	Titicaca	66.37 ± 0.13	72.75 ± 0.47	3.70 ± 0.07
1	CO 407 WMF	66.13 ± 0.29	72.82 ± 0.54	4.04 ± 0.08
	Cahuil	66.40 ± 0.72	73.60 ± 0.02	4.52 ± 0.32
	Kaslaea	66.34 ± 0.13	72.10 ± 0.47	4.32 ± 0.06
	Blanca	65.04 ± 0.84	72.14 ± 0.39	4.38 ± 0.29
	QQ74	61.78 ± 0.20	68.84 ± 0.74	4.25 ± 0.04
2	Linares	63.75 ± 0.38	70.77 ± 0.21	3.85 ± 0.19
	CO 407 Dave	65.14 ± 0.09	70.38 ± 0.27	4.38 ± 0.26
	Temuko	64.21 ± 0.23	70.47 ± 0.12	4.94 ± 0.06
	UDEC1	63.30 ± 0.94	71.00 ± 0.27	3.43 ± 0.24
	Isluga	64.16 ± 1.04	70.87 ± 1.24	3.91 ± 0.29
	French Vanilla	64.92 ± 1.04	72.07 ± 0.10	3.94 ± 0.12
3	Cherry Vanilla	64.24 ± 0.13	71.22 ± 0.03	3.98 ± 0.10
	Oro de Valle	64.39 ± 0.61	72.38 ± 0.32	4.14 ± 0.04
	Black	63.95 ± 0.34	71.41 ± 0.53	4.47 ± 0.00
	Black WWA	66.31 ± 0.38	73.25 ± 0.33	3.69 ± 0.24
	QuF9P39-64	66.82 ± 0.70	74.00 ± 0.43	5.16 ± 0.07
	QuF9P1-20	67.36 ± 0.25	73.26 ± 0.87	4.12 ± 0.04
	Puno	66.45 ± 0.38	72.52 ± 0.16	4.47 ± 0.19
	QuF9P39-51	67.63 ± 0.16	73.81 ± 0.17	4.79 ± 0.07
4	BBR	65.54 ± 0.03	73.24 ± 0.79	4.53 ± 0.00
	Japanese Strain	65.81 ± 0.74	72.45 ± 0.15	4.32 ± 0.21
	QuF9P39-73	66.89 ± 0.03	73.08 ± 0.09	4.16 ± 0.07
	QuF9P39-72	68.52 ± 0.10	74.72 ± 0.14	4.36 ± 0.07
	KU2	67.92 ± 0.58	73.11 ± 0.61	3.87 ± 0.12
	NL-6	67.76 ± 0.74	73.01 ± 0.34	3.64 ± 0.37

Table 3. Water absorption index (WAI), water solubility index (WSI), and flour swelling power (FSP) of whole quinoa flour.

Cluster	Quinoa	WAI (g/g)	WSI (%)	FSP (g/g)
	Red Head	0.97 ± 0.02	24.58 ± 0.34	6.86 ± 0.05
	QuF9P40-29	0.92 ± 0.01	24.34 ± 0.12	7.07 ± 0.23
	Titicaca	1.02 ± 0.03	24.07 ± 0.13	7.20 ± 0.27
1	CO 407 WMF	0.95 ± 0.04	24.40 ± 0.55	7.10 ± 0.13
	Cahuil	1.00 ± 0.02	22.99 ± 0.30	7.20 ± 0.05
	Kaslaea	0.97 ± 0.01	23.79 ± 0.10	6.94 ± 0.20
	Blanca	0.95 ± 0.03	23.97 ± 0.17	6.93 ± 0.26
	QQ74	0.92 ± 0.01	26.17 ± 0.21	7.33 ± 0.20
2	Linares	0.94 ± 0.01	26.16 ± 0.23	7.23 ± 0.08
	CO 407 Dave	0.90 ± 0.00	26.85 ± 0.21	8.36 ± 0.12
	Temuko	0.93 ± 0.01	27.84 ± 0.06	7.63 ± 0.03
	UDEC1	1.08 ± 0.01	24.82 ± 0.21	6.63 ± 0.04
	Isluga	0.98 ± 0.00	24.07 ± 0.03	6.66 ± 0.05
	French Vanilla	1.00 ± 0.01	24.48 ± 0.15	6.71 ± 0.11
3	Cherry Vanilla	0.99 ± 0.03	24.65 ± 0.51	6.95 ± 0.10
	Oro de Valle	0.99 ± 0.02	24.53 ± 0.13	6.83 ± 0.04
	Black	0.91 ± 0.00	24.37 ± 0.14	6.27 ± 0.05
	Black WWA	0.89 ± 0.01	24.77 ± 0.16	6.42 ± 0.06
	QuF9P39-64	0.95 ± 0.01	28.70 ± 0.29	7.85 ± 0.02
	QuF9P1-20	0.90 ± 0.02	27.78 ± 0.28	7.57 ± 0.08
	Puno	1.02 ± 0.01	27.16 ± 0.09	8.37 ± 0.05
	QuF9P39-51	0.95 ± 0.01	25.75 ± 0.24	8.12 ± 0.03
4	BBR	1.02 ± 0.01	25.07 ± 0.14	6.86 ± 0.02
	Japanese Strain	1.10 ± 0.03	27.27 ± 0.66	7.40 ± 0.02
	QuF9P39-73	1.22 ± 0.02	25.46 ± 0.25	7.21 ± 0.08
	QuF9P39-72	1.07 ± 0.01	23.61 ± 0.12	7.25 ± 0.04
	KU2	1.03 ± 0.04	25.60 ± 0.16	6.95 ± 0.18
	NL-6	1.05 ± 0.01	25.17 ± 0.39	7.62 ± 0.26

Table 4. Proximate composition of quinoa flours used for extrusion (% dry weight basis).

Quinoa	Moisture	Ash	Protein	Starch	Fat	Fiber
US-B	10.79 ± 0.02	2.90 ± 0.01	12.59 ± 0.50	58.98 ± 0.43	7.11 ± 0.02	18.41 ± 0.87
S-B	10.21 ± 0.02	2.02 ± 0.03	12.38 ± 0.24	62.97 ± 0.41	6.74 ± 0.03	15.88 ± 0.60
US-CV	10.87 ± 0.02	3.24 ± 0.01	12.84 ± 0.29	61.32 ± 1.75	8.11 ± 0.18	14.49 ± 1.34
S-CV	6.37 ± 0.03	2.06 ± 0.03	15.14 ± 1.00	62.91 ± 1.23	7.93 ± 0.02	11.97 ± 1.89
S-BR	8.49 ± 0.02	2.33 ± 0.03	12.42 ± 0.07	64.40 ± 0.14	6.58 ± 0.40	14.26 ± 0.48
DG-BR	14.24 ± 0.03	0.40 ± 0.02	3.88 ± 0.06	87.61 ± 0.59	1.27 ± 0.13	6.84 ± 0.66

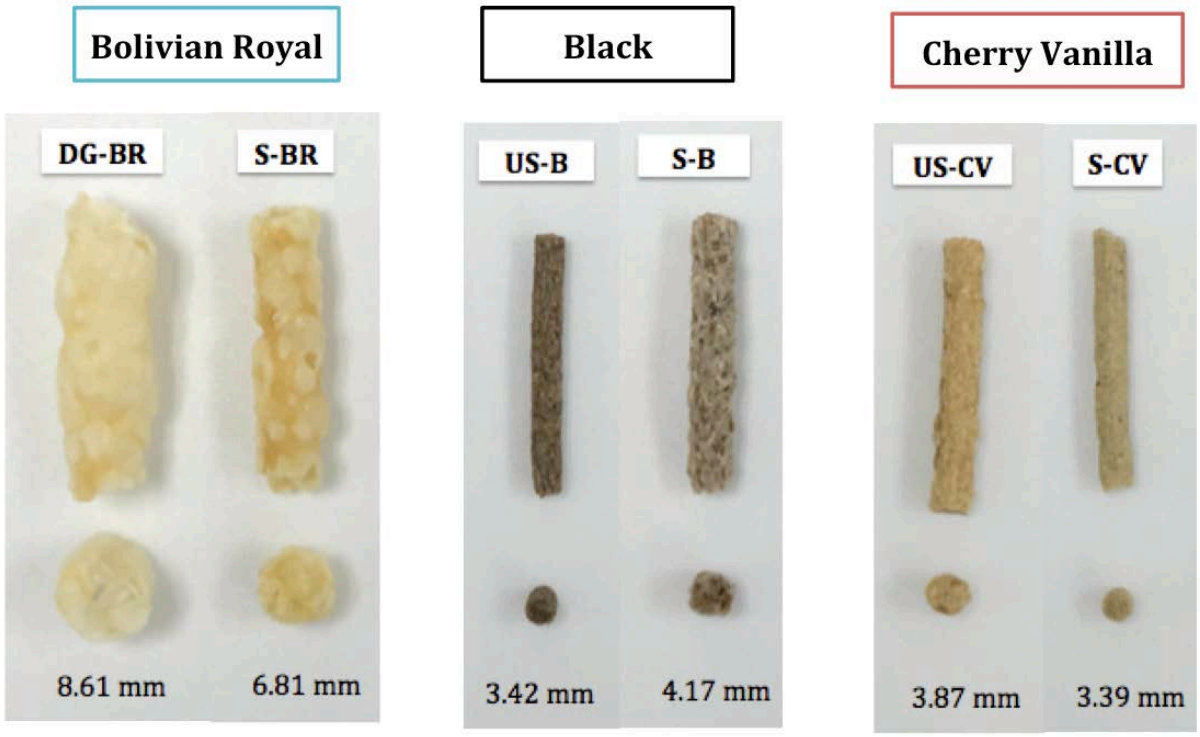
US = unscarified, S = scarified, DG = degermed, B = Black, CV = Cherry Vanilla, BR = Bolivian Royal.

Table 5. Physicochemical properties of quinoa flours used for extrusion.

	Quinoa[1]	US-B	S-B	US-CV	S-CV	S-BR	DG-BR
MVAG[2]	PT (°C)	65.83 ± 0.46	67.60 ± 0.98	64.87 ± 0.71	65.07 ± 2.57	62.17 ± 0.45	61.47 ± 0.06
	P1 (mPa·s)	270.33 ± 7.02	243.33 ± 2.08	441.00 ± 6.56	321.67 ± 11.59	333.00 ± 4.58	1214.67 ± 4.04
	P2 (mPa·s)	399.33 ± 8.96	285.67 ± 8.02	558.33 ± 9.07	448.00 ± 12.17	439.00 ± 6.00	1241.67 ± 13.32
	FV (mPa·s)	370.00 ± 10.44	249.33 ± 7.64	509.33 ± 7.37	418.00 ± 11.27	403.00 ± 10.39	1182.00 ± 7.21
DSC[3]	T_o (°C)	61.85 ± 0.06	60.45 ± 0.19	62.74 ± 0.39	64.28 ± 0.39	58.11 ± 0.14	55.66 ± 0.15
	T_p (°C)	67.73 ± 0.37	67.53 ± 0.31	68.23 ± 0.49	69.51 ± 0.27	65.86 ± 0.07	62.51 ± 0.07
	ΔH (J/g)	3.71 ± 0.10	4.37 ± 0.03	4.25 ± 0.17	5.20 ± 0.02	5.59 ± 0.05	5.89 ± 0.04

[1] US = unscarified, S = scarified, DG = degermed, B = Black, CV = Cherry Vanilla, BR = Bolivian Royal.
[2] PT = pasting temperature, P1 = first peak viscosity, P2 = second peak viscosity, FV = final viscosity.
[3] T_o = onset gelatinization temperature, T_p = peak gelatinization temperature, ΔH = change in enthalpy.

Figure 4. Extrudates and their diameters at processing conditions: 140°C barrel temperature, 20% moisture content, and screw speed of 200 rpm.



US = unscarified, S = scarified, DG = degermed, B = Black, CV = Cherry Vanilla, BR = Bolivian Royal.

Determination of Saponins in Cereals by spectrophotometric method by Medina-Meza (2015)

1. Fat extraction

- AACC International method 30-20.01

2. Saponins extraction

- From air dried deffated sample, extract by Soxhlet using a methanol-water solution (4:1v/v) for 4 h. Then evaporate under reduced pressure, until obtain around 20 ml of concentrate.

3. Hydrolysis

- Add 2 ml of a solution 6N of HCl to an aliquot of saponin extract. Heat up to 110°C for 2 h. Cool at room temperature. Then centrifuge at 3000 rpm for 5 min and recover supernatant.

4. Neutralization

- Neutralize the hydrolysate by adding 2 ml of NH4OH solution

5. Sapogenins extraction

- Extract the sapogenins in a separatory funnel with 10 ml of ethyl acetate, stirring vigorously, let stand for 10 min. Recover the upper phase. Filter in a Na2SO4 anhydrous bed with Whatman paper No. 1. Evaporate until dryness under N2 stream. Add 1 ml of ethyl acetate to dissolve the saponenins.

6. Quantification

- Place 240 uL of extract in a glass tube and add 960 uL of color reagent. Vortex well and heat at 60°C for 30 min. After reaction, cool at room temperature.
- Using a 1.5 mL cuvette, read samples at 527 nm in UV-Vis spectrophotometer. Use glacial acetic acid as blank. Use always a control sample with acetic acid glacial instead of sample.
- Results should be reported as mg/mL of Oleanolic acid equivalent.

Color reagent: Add 20 mL of glacial acetic acid (96 % purity) into 20 mL of sulfuric acid (96% purity), stirring gently in a water bath. Let stand for 2 h before use.
Standard solution of oleanolic acid: Dissolve 2 mg of oleanolic acid in 1 mL of glacial acetic acid.

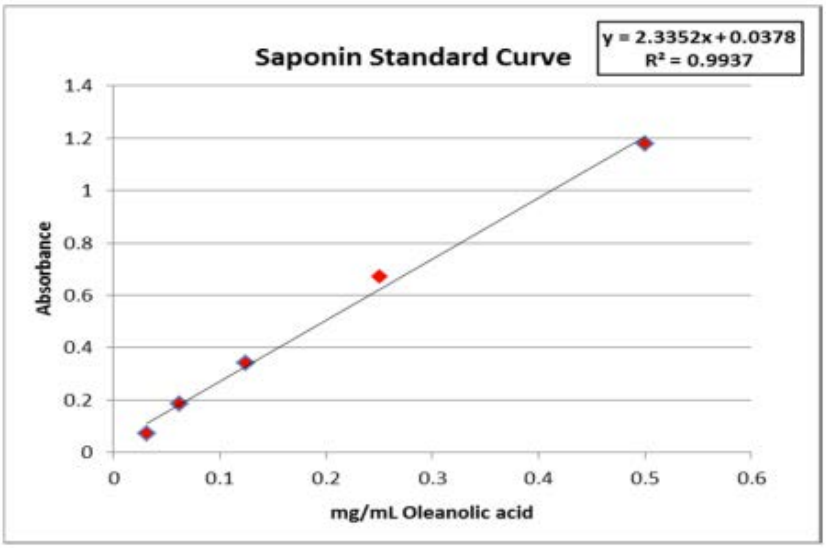


Figure 5. Saponin content of 28 quinoa varieties by UV-Visible spectrophotometry.

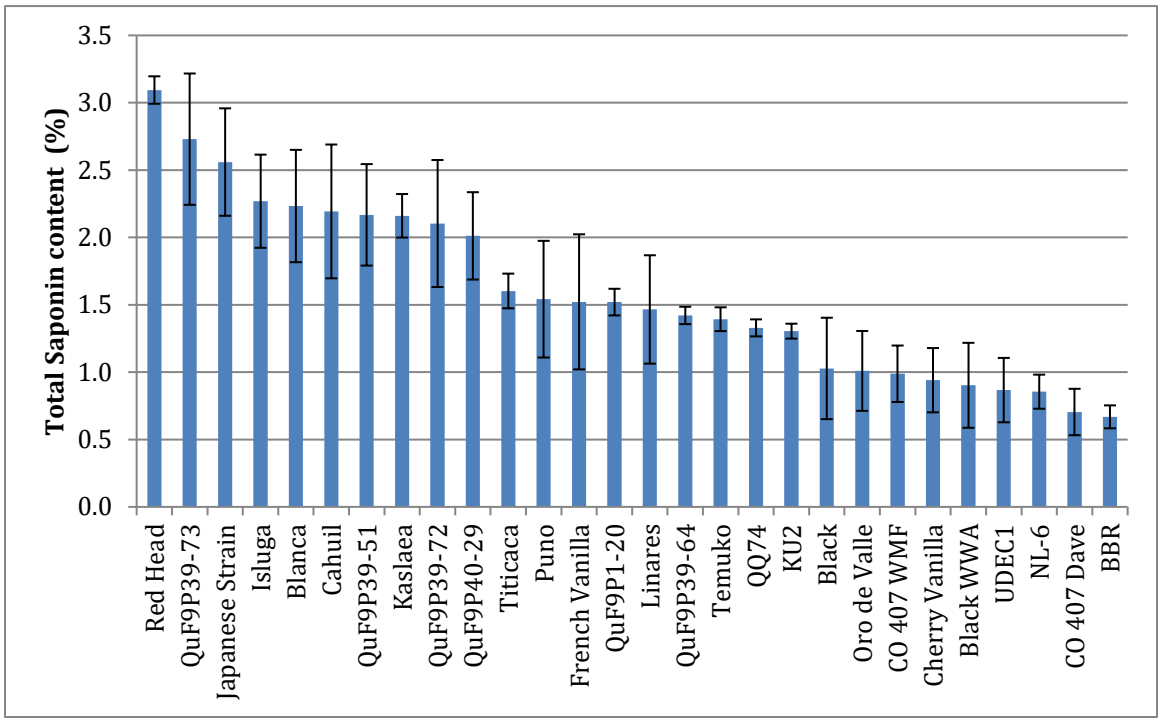


Table 6. Saponin content of quinoa flours used for extrusion by UV-Visible spectrophotometry (% dry weight basis).

Quinoa	Saponin (%)
Unscarified Black	2.29 ± 0.73^{a}
Scarified Black	0.45 ± 0.13^{cd}
Unscarified Cherry Vanilla	1.19 ± 0.10^{b}
Scarified Cherry Vanilla	0.98 ± 0.21^{bc}
Scarified Bolivian Royal	0.92 ± 0.22^{bcd}
Degermed Bolivian Royal	0.22 ± 0.04^{d}

Figure 6. Field Day – Dr. Kevin Murphy's student presenting the information about quinoa corp production

Figure 7. Field Day – Dr. Ganjyal presenting the information about quinoa processing and value-addition