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Effect of Washing and Germination Process on Two Different Varieties of Quinoa Seeds

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ABSTRACT

Quinoa (Chenopodium *quinoa*Wild) is a pseudo-cereal that belongs to the *Amaranthaceae* family. The seed is considered the main source of protein for vegetarians and in developing countries. However, the seed coat is rich in bitter-tasting saponins, which should be removed before consumption. The washing and germination processes are the traditional methods performed to reduce or eliminate saponin. However, little is known about the effects of these methods on chemical composition. Therefore, this work was carried out to monitor the chemical composition and phytochemicals contents of two types of quinoa seeds namely white or sweet quinoa (SQS) and chipaya or bitter quinoa seeds (BQS), which are planted in Egypt. The results revealed that the washing process for 20 min by water in two phases, 10 min each, is an effective method to depress saponin concentration up to 45.36% in SQS and 61.75% in BQS, unlike the germination process. Both the two processes increase the protein, crude fiber, and ash content with decrements of ether extract and carbohydrates. Therefore, gained energy is reduced from 408.87 to 377.98 kcal/100g for SQS and from 402.26 to 391.31 kcal/100g for BQS because of the germination process. Consequently, the nutritional value of the seeds increased and became more healthy food and extra acceptable to the consumer.

1. INTRODUCTION

Quinoa (Chenopodium *quinoa* Wild) is a pseudo-cereal belonging to *Amaranthaceae* family **(Valencia-Chamorro, 2003)**. Although the origin of the plant is the Andean region, South America, its agriculture has been spread over the world due to its ability to withstand stress **(Bilalis *et al.*, 2019)**. Turkey, Pakistan, Egypt, China, and India are interesting countries to produce the seeds due to their high nutritional value. The seed has higher protein content and essential amino acids than those traditionally consumed as cereals **(Filho *et al.*, 2017; Dakhili *et al.*, 2020)**. Moreover, it is tasty, good, easy to digest, rich in dietary fiber, poly-carbohydrates, vitamins, minerals, high in unsaturated fatty acids and gluten-free **(Filho *et al.*, 2017)**. Secondary metabolites, such as polyphenols, flavonoids, stilbenes, tannins, and phenolic compounds which they are found in abundance in the seeds **(Fischer *et al.*, 2017)**. These compounds have great health benefits, as they protect against cardiovascular and digestive system diseases and they are considered as anticancer. **(Vilcacundo and Hernández-Ledesma, 2017)**. In addition, they have antioxidant activity **(Repo-Carrasco-Valencia, 2020)**. On the other hand, the seed coat is rich in bitter-tasting saponins, which should be removed **(Filho *et al.*, 2017)**. Consequently, researchers whose interested in nutrition have been paid for their effort to rid saponins. Saponins, from a chemical point of view, are a non-volatile secondary metabolite distributed mainly in plants **(Netala *et al.*, 2015)** which are found in external layers of the grains, fruits and flowers and are easy to remove by washing with water **(Prado *et al.*, 1996)**. Until recently, saponins have been highly toxic, nevertheless, those present in foodstuffs are non-toxic and it has been suggested that they may be even beneficial in the human diet **(Vilche *et al.*, 2003)**. They are antifungal **(Stuardo and San Martín, 2008)**, antimicrobial, raise immunity **(Netala *et al.*, 2015)** and anti-inflammatory **(Yao *et al.*, 2014)**.

There are different methods used to remove saponins from quinoa seeds. These methods are limited to two types of techniques.

1-The dry technique, which includes heat treatment, extrusion, roasting, mechanical corrosion and genetic methods.

2-The wet technique (washing with water) which widely used at the level of laboratories and industry. Both of these techniques are affecting the chemical composition and physical properties of quinoa seeds **(El Hazzam *et al.*, 2020)**.

Germination of grains and seeds is a new way to produce acceptable tasty vegetarian foods and people who suffer from a lack of animal protein **(Piñuel *et al.*, 2019)**. It raises the nutrition value by removing certain anti-nutritional substances and formation of antioxidants **(Televičiūtė *et al.*, 2020)**, making quinoa a more effective food **(Mariod and Salama, 2020)**. By analogous, type of processing can affect the bioactive compounds and antioxidant capacity of quinoa **(Chan *et al.*, 2009)**, either consumed as cooked rice, soups, yogurt and salads or flour **(Vega-Galvez *et al.*, 2010)**. However, little is known about the effects of different types of usual processing on the nutritional value of quinoa seeds.

Therefore, this work was designed to study the effect of the germination and washing process on the physical, chemical, and nutritional value of two different varieties of Egyptian quinoa seeds.

2. MATERIALS AND METHODS

2.1 Materials

White quinoa (Chenopodium quinoaWilld) seeds (SQS) were supplied from Agriculture Research Centre, Toukh, Qalyubia Governorate and Chipaya quinoa seeds (BQS) were purchased from Desert Research Center, Cairo Governorate, Egypt during the 2018 season. The seeds were cleaned and then stored at -18°C in a deep

freezer for further analysis. Foline-Ciocalteau reagent (2, 6 dichloro phenol indophenol) was purchased from Sigma-Aldrich Co. Petroleum ether (60-80°C), ethanol and methanol (99.9%), sulphoric Egypt. All other chemicals used in the analysis were analytical grades.

2.2 Methods

2.2.1 Chemical analysis

Gross chemical composition

Moisture (method no 934.01), ether extract (method no 935.38), crude protein N×6.25 (method no 950.36), ash using muffle at 450-550°C (method no 930.22) and crude fibers (method no 950.37) were determined as described in **AOAC (2000)**. While total carbohydrates (TC%) and nitrogen-free extract (NFE%) as dry weight bases were calculated according to **Aurand (2013)** following the equations:

TC% = 100 – [protein% + ether extract% + ash%]

NFE% = TC% - crude fiber%

2.2.2 Determination of phytochemicals

Quinoa seeds extract was prepared according to **Anagnostopoulou *et al.* (2006)** using 80% aqueous methanolic solution (v/v). Total saponin was estimated following the method of **Hiai *et al.* (1975)** using 8.0% vanillin in methanolic solution and 72% sulphoric. While total phenolic compounds were determined using Folin-Ciocalteu reagent (FCR) as described by **Kahkonen *et al.* (1999)**. Flavonoids were colorimetrically determined at 430 nm according to **Djeridane *et al.* (2006)**. Alkaloids were estimated according to **Clarke (1970)**.

2.2.3 Reduction of saponin content

Different treatments were carried out on the quinoa seeds in order to reduce saponin content.

2.2.4 Washing treatment

Quinoa seeds were soaked into tap water at ratio 1:3 (w/v) for different periods (10, 20 and 30 min) with occasionally steering using magnetic stirrer (JENWAY, model 1000, designed and manufactured in the EU by Barloworld Scientific Ltd, Dunmow, Essex CM6 3LB) at room temperature. The soaked seeds were then washed with distilled water and dried in an electric air oven at 50°C until completely dry.

2.2.5 Germination process

Cleaned seeds were sterilized by soaking into 0.1% (w/v) sodium hypochlorite solution for 30 min at room temperature, picked up and rinsed with distilled water to remove the trace of sodium hypochlorite **(Piñuel *et al.*, 2019)**. Then the seeds were germinated by soaking them in distilled water at room temperature for 3-6 hrs **(Paśko *et al.*, 2009)**, where imbibed seeds were set into cleaned sterilized glass jars and covered with cheesecloth. The jars were placed in darkness for five days at room temperature and subjected to sunlight for four hrs. The green sprouts were harvested and spread onto filter paper for drying at room temperature.

2.2.6 Preparation of quinoa flour

Quinoa flours were prepared from raw, washed seeds and their dried sprouts by grinding them into Moulienx grinder (model FP7131 4A, France). Flours were sieved to pass through a 0.45mm sieve (60mesh) and stored in polyethylene bags at -18°C in a deep freezer for further analysis.

3- RESULTS AND DISCUSSION

3.1 Chemical composition of raw quinoa seeds

The gross chemical composition of raw SQS is 19.89, 6.31, 2.92, 70.88, 68.13 and 2.75% for crude protein (CP), ether extract (EE), ash, total carbohydrates (TC), nitrogen-free extract (NFE) and crude fibers (CF), respectively. While the corresponding values for raw BQS are 14.99, 5.58, 3.34,

76.09, 73.02 and 3.07%, respectively (Table 1). Raw SQS contains significantly higher ($p<0.05$) CP and EE compared with those found in BQS. Contrary, ash, TC, NFE and CF are significantly lower ($p<0.05$). These differences could be due to the interactions of several factors, such as agriculture treatments, cultivars, and environmental conditions **(Abdel-Al *et al.*, 2020)**. These results agree with **Vidueiros *et al.* (2015)**, who found that the CP and EE of 21quinoa varieties ranged from 14.5 up to 18.2% and 4.7 up to 7.1%, respectively. In this respect, **Valencia-Chamorro (2003)** found CP content in quinoa seed varies from 8 to 22%, which is higher than that the average of CP in most common cereals such as rice, wheat, and barley.

3.2 Effect of different treatments on chemical composition (d.w.%)

3.2.1 Washing process

The CP content of raw quinoa seeds in both cultivars increased significantly ($p<0.05$) from 19.89% to 21.37% for SQS and from 14.99% to 17.75% in BQS as a result of washing them with tap water at room temperature for 20 min. In the opposite significant ($p<0.05$) decrease in ash, EE, CF, NFE and TC are noticed. These decrements may be related to the ability to dissolve part of the soluble compounds in the washing water **(Kajihausa *et al.*, 2014)**. These results are in complete agreement with those of **Gomaa *et al.* (2019)**, who found that CP increased, but ash, EE, CF, NFE and TC of quinoa seeds were decreased after they were washed with tap water.

3.2.2 Germination process

The germination process led to significant ($p<0.05$) increases in CP, CF and ash contents of quinoa seeds. However, EE, NFE and TC contents are significantly ($p<0.05$) decreased (Table 1). The increment of CP is mainly due to the synthesis of enzymes, nucleic acids, and other nitrogenous mg/100g (0.07%) while QS16 accession recorded the highest content of 220 mg/100g (0.22%). The saponin content of quinoa components in the germinated sprouts due to the germination process and degradation of protein to simple peptides by enzyme hydrolysis of the insoluble protein to soluble protein, which increased the protein availability during the germination process **(El-Adawy, 2002)**. While the decrements in EE, TC and NFE could be attributed to the use of these substances as a source of energy for the growth of the embryo **(Ferreira *et al.*, 2009)**. The increase in ash content may be related to endogenous enzyme hydrolysis of complex organic compounds to release more nutrients leaving the ant nutrients to leach into the germination medium **(Chikwendu, 2003)**. While the increments of fiber due to germination might be that the micro flora enzymes hydrolyzed complex carbohydrates to release fiber which subsequently decreased carbohydrates.

Reduction techniques to reduce saponin content

Saponins have a bitter taste and anti-nutritional factor which could be reduced the consumption of seeds. So, several treatments have been reported in order to wash off seeds' saponins, including wet and dry methods.

Reduction of saponin by wet technique (washing with tap water)

As shown in Table 2, the saponin content of BQS is 504.56 mg/100g (0.51%) higher than that of SQS (178.21 mg/100g (0.17%). These results are lower than those reported by **Mhada *et al.* (2020)** who found that the saponin content of two varieties of quinoa seeds was 1.41 and 2.03% which were comparable with 2.56% as reported by **Gomaa *et al.* (2019)**. However, the results are higher than 184 to 425 mg/100g of three varieties of quinoa seeds **(Farajzadeh *et al.*, 2020)**. In this respect, **Shams (2018)** pointed out that the lowest saponin content in nine Egyptian quinoa genotypes was 70

seeds is related to the genotype and the physiological status of the plant **(Yao *et al.*, 2014)**, where the bitter flavor is correlated

with the developmental phase of the crop. It is low throughout branching and boosts throughout flowering **(Bhargava *et al.*,** has the opposite effect **(Pulvento *et al.*, 2012)**. Though, the upsurge of saponins of the seed has been described in irrigated part as opposite to a cold climate **(Miranda *et al.*, 2013)**. Quinoa can be classified according to its saponin concentrations as either "sweet" (saponin free or having less than 0.11% saponins on a fresh weight basis) or "bitter" (containing more than 0.11% saponins) **(Koziol, 1991)**.

Referring to Table 2, the saponin content in SQS significant decreases ($p<0.05$) from 178.21 mg/100g to 156.10 mg/100g with a decrease of 11.75% as a result of 10 min washing (T1), which continuous decreases reach to 112.97 mg/100g with 36.13% reduction by extending wash time 30 min. Washing the seeds in more than one phase, each 10 min, with renewed soaking water was more efficient, as the reduction ratio of saponins increased to 45.36% and 49.40% in T3 and T5, respectively. The percentage of saponins reduction in seeds washed for 30 min over three phases (T5) was the most significantly superior ($p< 0.05$) for saponins reduction of SQS. The same trend was observed in BQS, with a higher reduction than SQS, as saponin decreased from 504.56 mg/100g in raw seeds to 420.79 mg/100g in washed ones for 10 min with a reduction ratio of up to 16.57%. It is interesting to note that washing the seed for 20 min in two phases (T3) was not significantly ($p< 0.05$) different from washing the seeds for 30 min at one phase (T4). The reduction in saponin by the washing process is probably due to the water solubility of some saponin compounds **(González *et al.*, 2020)**. These results are in accordance with those reported in the literature, as the saponins content of quinoa seeds was decreased due to the washing process **(Nickel *et al.*, 2016; Gomaa *et al.*, 2019; Abdel-Al *et al.*, 2020)**. **El-Sebeay and Hafez (2018)** reported saponin in quinoa seeds was depressed at 46.36% due to the washing process for **2006)**. Drought led to a decrease in saponin by 45% **(Gómez-Caravaca *et al.*, 2011)**, whereas salinity

45min. Although the best technique to reduce saponin is wet and conventional methods as in T5, T3 was preferred as it is economical in terms of short time and consumption in water that is difficult to reuse. However, the wet method is criticized as consuming more time than the dry method, as the seeds need drying and some seeds begin to germinate. Also, the dry method, such as mechanical dehulling by abrasion, is effective, cheaper, and faster than the wet method **(Mujica and Jacobsen, 1999)**. Nevertheless, it has been criticized for not extracting a significant ($p< 0.05$) portion of the saponins compared to the wet method and the seeds may also lose some nutrients **(Wright *et al.*, 2002)**.

Effect of germination on saponins content

The germination process leads to a significant increase ($p<0.05$) in the saponins content compared to the raw one, as its concentration jumped to 359.36mg/100g (0.36%) in SQS and 552.47mg/100g (0.55%) in BQS. **Huang *et al.* (2017)** monitored that, the amounts of saponins during the first six hours in germination decreased rapidly and then stabilized within 6-42 hrs, it started again and gradually increased after 42 hrs of germination until it reached its peak concentration on the fourth day 7.80mg/g (780mg/100g). After that, it decreased slowly with the increase in the duration of germination.

Effect of different treatments on total phenolics (TP %) and flavonoids (TF%)

1- Washing process:

The total phenolics (TP) in the aqueous extract of raw SQS and BQS are 146.80 and 160.78 mg GAE/100g, respectively (Table 3). Where they are significantly higher ($p<0.05$) than that of alcoholic extract (89.54 and 99.53 mg GAE/100g). This result agrees with **Ozer *et al.* (2016)**. The contrary of TF content where alcoholic extracts for SQS

and BQS are 17.53 and 19.18 mg RE/100g which are significantly ($p<0.05$) higher than those of aqueous extracts, whether these seeds were raw, washed or sprouted. These results are in agreement with **(Gorinstein *et al.*, 2007; Alvarez-Jubete *et al.*, 2010; Carciochi *et al.*, 2014; Nickel *et al.*, 2016; and Farajzadeh *et al.*, 2020)**, whose results ranged from 17.58 to 97.60mg GAE/100g. However, the results are lower than those reported by **Choque-Quispe *et al.*, (2021)** who stated that the TP content in quinoa seed was between 159.69 and 198.23 mg GAE/100g. Also, **Saad-Allah and Youssef (2018)** pointed out total phenolics content of five genotypes of quinoa seeds introduced to Egypt was ranged from 0.66 to 2.02 mg/g (66 to 202 mg/100g). The difference between these values can be partially explained by different solvents and extraction methods. In addition, it is important to note that the amounts of TP in the seeds is strongly influenced by genotype (variety/cultivar), soil, environmental conditions, maturity level at harvest and post-harvest storage conditions **(Nsimba *et al.*, 2008; Huang *et al.*, 2017)**, since the colored varieties have a higher TP **(Tang *et al.*, 2015; Han *et al.*, 2019)**. The TP in the aqueous and alcoholic extracts of raw quinoa seeds, whether SQS or BQS, decreased significantly ($p<0.05$) as a result of the washing process. In contrast, the total amount of phenolics in the case of germinated SQS or BQS increased significantly ($p<0.05$) in both the aqueous and alcoholic extract compared to the raw seeds (Table 3).

The TF in the methanolic extract of the raw SQS and BQS are 17.53 and 19.18mg/100g, respectively. While the TF in the aqueous extract is 8.55 for SQS and 8.79 mg/100g for BQS. These results are in accordance with the results of **Carciochi *et al.* (2014)**, who respectively. The TF in the aqueous extract of SQS is increased significantly ($p<0.05$) because of the washing and germination germination. As for BQS, TF is gradually increased in both aqueous and alcoholic extracts because of the washing and germination process.

found that TF was 11.06 mg/100g and comparable with **Farajzadeh *et al.* (2020)**. However, it is lower than 38.6 mg catechin/100g **(Gorinstein *et al.*, 2007)**. The low TF in the aqueous extract may be related to the faint solubility of flavonoids in water **(Antolovich *et al.*, 2000)**.

The TF of both SQS and BQS is significantly ($p<0.05$) increased due to the washing or germination process. Whereas TF in methanolic extracts of washed SQS and BQS are 15.95 and 19.78 mg/100g, respectively. The corresponding values for water extracts are 13.81 and 11.59mg/100g. These values augment to reach 35.61 mg/100g in SQS, 42.78 mg/100g in BQS for methanolic extracts, and 19.85 mg/100g in SQS, 12.82 mg/100g BQS for water extracts after germination. **Carciochi *et al.* (2014)** pointed out that the TF of raw quinoa seeds was increased reaching 17.65mg/100g, 72 hrs after germination.

2- Germination process:

The significant ($p<0.05$) highest concentration of TP in both methanolic extract of SQS and BQS's sprouts is 829.95 and 708.68 mg GAE/100g, followed by its concentrations in the water extracts (244.67 and 303.64 mg GAE/100g). These results are in full agreement with **Alvarez-Jubete *et al.* (2010)** who stated that TP in germinated seeds for 82 hrs is 147 mg GAE/100g and **Choque-Quispe *et al.* (2021)**, who reported that the germination process of three varieties of quinoa seeds for 48 hrs raised the TP content in the range between 308.82 and 417.75 mg GAE/100g. However, the differences in the TP concentrations could be related to the variation in the germination period. In this respect, **Carciochi *et al.* (2014)** found the TP and TF of quinoa seeds germinated for 72 hrs were 79.04 and 17.65 mg/100g,

process. While TF is reduced in the alcoholic extract due to the washing process and may be increased in

The increment of TP during the germination process could be explained by the fact that seeds suffer biotic and a biotic stress during germination, which induces oxygen reactive species (ROS). These compounds are vital to protecting the seeds during germination and for the biochemical and physiological functions of the sprouts, releasing aglycones due to enzymatic activity, which translates into an increase in phenols **(Sani *et al.*, 2012)**.

Effect of washing and germination process on alkaloids contents

Alkaloids are an effective plant substance used as an anti-cancer, anti-malarial and analgesic. Also, it is used in the treatment of Parkinson's disease, hypertension, and disorders of the central nervous system as well as it shows remarkable physiological effects when administered to animals **(Rathbone and Bruce 2002)**. Alkaloids content in raw BQS is 5.81 mg/g, which is significantly ($p<0.05$) higher than that of SQS 5.41 mg/g. A significant ($p<0.05$) decrement in its concentration is observed because of the germination process (4.83mg/g) and washing with water at two phases (4.89 mg/g). The corresponding values for SQS are 4.10 mg/g for the germination process and 4.22 mg/g for washing (Table 4). These results are close to the data of **Saad-Allah and Youssef (2018)**, who reported that alkaloids content in quinoa seeds' kvl-sra2 genotype was 4.18 mg/g and 4.85 mg/g in Q37 genotype (wet weight basis). It is worthy to note that the author has not found current data exist in the literature regarding the concentration of alkaloids in quinoa seeds.

Table 1: Effect of washing* and germination** process on the chemical composition of quinoa seeds (%)

Type of Quinoa Components	Sweet quinoa seed(SQS)			Bitter quinoa seed (BQS)		
	Raw	Washing*	Germination**	Raw	Washing*	Germination**
Crude protein	19.89±0.18^{c}	21.37±0.08^{d}	24.14±0.07^{e}	14.99±0.18^{a}	17.75±0.19^{b}	20.30±0.09^{c}
Ether extract	6.31±0.10^{d}	5.75±0.04^{c}	2.99±0.04^{a}	5.58±0.05^{c}	4.47±0.08^{b}	4.51±0.01^{b}
Ash	2.92±0.01^{b}	2.40±0.02^{a}	3.43±0.03^{cd}	3.34±0.06^{c}	3.02±0.05^{b}	3.47±0.02^{d}
Total carbohydrates	70.88±0.08^{c}	70.48±0.02^{b}	69.44±0.00^{a}	76.09±0.11^{f}	74.76±0.07^{e}	71.72±0.09^{d}
NFE	68.13±0.10^{c}	67.99±0.03^{c}	63.62±0.09^{a}	73.02±0.11^{e}	72.24±0.08^{d}	67.37±0.10^{b}
Crude fiber	2.75±0.04^{b}	2.49±0.03^{a}	5.82±0.08^{e}	3.07±0.01^{c}	2.52±0.00^{a}	4.35±0.05^{d}
Total Energy (Kcal)	408.87±0.62^{d}	409.21±0.13^{d}	377.98±0.48^{a}	402.26±0.25^{d}	400.23±0.21^{c}	391.31±0.06^{b}

Washing* = seeds were soaked for 20 min in water at two phases of 10 min each, with continuous stirring and renewed the water in each phase.

Germination** = Sterilized seeds were germinated in the dark for 5 days at room temperature then subjected to sunlight for 4 hrs.

Values are means ± standard error (M±SE) of three successfully trails.

Means having the same superscript letters are not significantly different at ($p>0.05$)

Table 2: Effect of washing and germination process on saponin content (mg/100g) of the two types of quinoa seeds

Treatments	SQS	Reduction (%)	BQS	Reduction (%)

Raw seeds	178.21±1.54$^{f\,A}$	-	504.56±0.60$^{d\,B}$	-
T 1	156.10±0.63^{eA}	11.75±0.35^{a}	420.79±0.5^{cB}	16.57±0.10^{a}
T 2	134.91±2.66^{dA}	23.73±1.50^{b}	215.92±5.32$^{b\,B}$	57.19±1.05^{b}
T 3	96.63±2.08$^{b\,A}$	45.36±1.17^{d}	189.24±2.0$^{a\,B}$	61.75±0.51^{c}
T 4	112.97±0.41$^{c\,A}$	36.13±0.23^{c}	191.97±3.70$^{a\,B}$	61.94±0.73^{c}
T 5	89.49±0.28$^{a\,A}$	49.40±0.15^{e}	181.91±0.45$^{a\,B}$	63.93±0.08^{d}
Germination*	359.36±1.09$^{g\,A}$	-	552.47±5.61$^{e\,B}$	-

T 1 = Seeds were soaked for 10 min in water with continuous stirring,
T 2 = Seeds were soaked for 20 min in water with continuous stirring,
T 3 = Seeds were soaked for 20 min in water at two phases of 10 min each, with continuous stirring and renewed the water in each phase,
T 4 = Seeds were soaked for 30 min in water with continuous stirring,
T 5 = Seeds were soaked for 30 min in water at three phases of 10 min each, with continuous stirring, and renewed the water in each phase.
Germination* = Sterilized seeds were germinated in the dark for 5 days at room temperature and then subjected to sunlight for 4 hrs.
Values are means ± standard error (M±SE) of three successfully trails
In a column, means having the same small superscript letters are not significantly different at ($p>0.05$)

Table 3: Effect of washing* and germination** process on total phenolic compounds (TP) and total flavonoids (TF)(mg/100 g)of the two types of quinoa seeds

Components	Type of seeds	Raw		Washing*		Germination**	
		Methanol	Water	Methanol	Water	Methanol	Water
Phenolics	SQS	89.54±0.52^{b}	146.80±1.64^{c}	80.32±0.13^{a}	152.47±0.51^{d}	708.68±0.17^{f}	244.67±2.09^{e}
	BQS	99.53±0.88^{b}	160.78±0.58^{d}	93.67±0.32^{a}	111.42±0.46^{c}	829.95±0.53^{f}	303.64±2.20^{e}
Flavoniods	SQS	17.53±0.01^{d}	8.55±0.05^{a}	15.95±010^{c}	13.81±0.17^{b}	35.61±0.35^{f}	19.85±0.13^{e}
	BQS	19.18±0.18^{d}	8.79±0.04^{a}	19.78±0.12^{e}	11.59±0.12^{b}	42.78±0.19^{f}	12.82±0.15^{c}

Washing* = seeds were soaked for 20 min in water at two phases of 10 min each, with continuous stirring and renewed the water in each phase. Germination** = Sterilized seeds were germinated in the dark for 5 days at room temperature then subjected to sunlight for 4 hrs. Values are means ± standard error (M±SE) of three successfully trails. In a row, means having the same superscript letters are not significant different at ($p>0.05$)

Table 4: Effect of washing and germination process on alkaloid content (mg/g) of the two types of quinoa seeds

Treatment	SQS	Reduction (%)	BQS	Reduction (%)
Raw	5.41±0.02^{c}	---	5.81±0.08^{b}	---
Washing*	4.22±0.03^{b}	22.0	4.89±0.01^{a}	15.84
Germination**	4.10±0.04^{a}	24.22	4.83±0.05^{a}	16.87

Washing* = seeds were soaked for 20 min in water at two phases of 10 min each, with continuous stirring and renewed the water in each phase, Germination** = Sterilized seeds were germinated in the dark for 5 days at room temperature then subjected to sunlight for 4 hrs. Values are means ± standard error (M±SE) of three successfully trails. In a column, means having the same superscript letters are not significantly different at

($p>0.05$)

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