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Effect of tomato dregs supplementation on the quality of bovine milk production in the Holstein breed

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Abstract

This work focused on the one hand on the characterization of tomato by-products (*Solanum lycopersicum* L. 1753) and on the other; on the supplementation of tomato spent grain in the diet of Holstein breed cows and its effect on the volume and quality of milk. A comparative study between two lots; one contains dairy cows fed through a diet without tomato spent grain, the second batch fed with tomato spent grain. The physicochemical analyzes of tomato spent grain focused on the water content, dry matter, mineral matter, total proteins, fat, defatted matter, Phosphorus, Calcium and vitamins A and Vitamin E. We note that tomato spent grain is very rich in vitamin A and E as well as in calcium and phosphorus and that it also has a low fat and protein content. According to the results obtained, we notice an improvement in the following physicochemical parameters of milk: a significant increase ($p < 0.001$) in density which goes from 1026 ± 1.97 to 1028 ± 2.14, a significant increase ($p < 0.01$) in fat which goes from 40.74 ± 7.07 to 43.94 ± 8.45, and a significant increase ($p < 0.001$) of the dry extract which goes from 124.56 ± 11.31 to 148.7 ± 29.88. A significant increase ($p < 0.001$) in the average daily volume of milk is observed in the batch supplemented with tomato spent grain (13.73 ± 3.47 l/d) compared to the batch not supplemented with tomato grain (11.12 ± 3.00 l/d). The statistical study reveals that there is a relationship between the duration of supplementation and the continuous improvement of parameters: density ($p < 0.001$); dry extract ($p < 0.001$); degreased material ($p < 0.001$).

Keywords: tomato dregs; *Solanum lycopersicum*; quality; milk; Holstein cow.

Practical Application: Processing tomato industry is generating a huge amount of polluting matters and wastes that can be used and recycled as by-products and valuated in breeding of the Holstein breed.

1 Introduction

Waste management is an important issue for the food industry which is a major sector of the global economy. Since the 1970s-1980s, environmental regulations have become more and more demanding in order to reduce the pollutant load of agro-industries, leading to increasing taxation of the landfill of organic materials resulting from technological and non-valued processes (Chapoutot et al., 2018). The best utilization of these "residues" by alternative means to landfill has been explored, including that of animal feed, which improves the net efficiency of production systems, in terms of protein and energy (Laisse et al., 2018). Tons of industrial tomatoes are processed each year in the food industry worldwide, thus generating high food value by-products for cattle breeding (Tommonaro et al., 2008). The purpose of recovering these solid residues is to extract bio-polymers, lycopene, oil, feed production and compost. This approach is an excellent alternative for a suitable operation to the new philosophy of sustainable development (Ahishakiye & Aitamour, 2010). The work s conducted in countries where the production and industrial use of this fruit release very large volumes of residues (China, South America, Italy, Spain, Iran, etc.). These studies focused primarily on the use of these residues in livestock feed, more particularly ruminants, due to the high content of skin fibers, even if some experiments have been carried out on pigs and poultry (Cotte, 2000). The reintegration of these agricultural by-products in food can help to provide an added value to this "false waste". The biologically active compounds of these natural by-products help to provide better food quality technologically and particularly nutritionally (Food and Agriculture Organization of the United Nations, 2010a). The tomato is a market garden plant, which has become an essential element in the gastronomy of many countries, and especially in the Mediterranean basin. It is the second cultivated species in the world in terms of production volumes, after the potato (Food and Agriculture Organization of the United Nations, 2020). Tomato peels exhibit structural and biochemical particles that can influence its nutritional value. Several studies associate the consumption of tomatoes with a beneficial effect on human health such as reduced risk of contracting cancers; cardiovascular diseases and other chronic diseases (Basu & Imrhan, 2007; Bazzano et al., 2003; Chanforan, 2010). Tomato is rich in potentially active

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substances, such as vitamins, minerals, micronutrients or fibers (Berrino & Villarini, 2008). These substances are also suitable for rheumatics and the hemisynthesis of steroid hormones, which are interest the phytopharmacy and veterinary medicine (Étienne, 2005; Harborne, 1998; Bruneton, 1999; Kansole, 2009) the prevention of oxidative damage to membrane cells, lipids, proteins caused by free radicals and the decrease in the permeability of blood capillaries are enhanced by the action of carotenoids presented in tomato pulp (Middleton et al., 2000; Zhang et al., 2001; Narayana et al., 2001; Seyoum et al., 2006). In Algeria, tomato production increases each year to reach 12 million quintals in 2017 and around 14 million quintals in 2018, 80% the production of which is supplied by the North-East departments, such as El-Tarf, Annaba, Guelma and Skikda. This production is intended much more for industrial processing for the production of Double Tomato Concentrate (Boumendjel & Boutebba, 2003). Recycling the by-products accumulated during the manufacturing process in large quantities, would help limit the impact of this industry on the environment. The goal of this first study in Algeria is to characterize tomato waste and then reincorporate it into beef feed. This work has two parts: the first concerns the characterization of tomato spent grain used in supplementation in a breeding of the Holstein breed; the second part deals with the effect of this supplementation on the production volume and the quality of the obtained milk.

2 Materials and methods

2.1 Biological material dregs

Tomato dregs

Tomato dregs are obtained from the by-products of industrial processing of tomatoes for the production of double tomato concentrates using the Hot break method (Boumendjel et al., 2013). The sample comes from a processing unit located in the department of El-Tarf. The resulting tomato dregs are transported to the laboratory where it is dried in the open air and protected from the sun for 4 days. It is then crushed and stored at 4-8 °C before analysis.

Holstein race cows breeding

The cows in our experimentation originate from the intensive breeding of the Holstein race, just at the beginning of the 2nd scale lactation. The cows received the same food, with the same breeding system, in the same building, in the same climate and during the same period. We first divided our herd into two lots; each lot contains 20 dairy cows. In the first set, the cows are fed with a fodder-based regime (hay, straw, clover-oats, and industrial food of the dairy cow type). In the second lot, the cows have the same previous food as lot #1, together with the tomato dregs, added at a daily rate of 20 kg per cow, feeding levels recommended by Leclerc & Moynet (2012), in order to avoid acidosis and limit these risks. A 10-day adaptation and transition period is allowed for breeding. The cows used in our experiment are subject to rigorous veterinary control. Blood samples are taken to monitor normal blood counts.

Milk collection

All of our milk samples are taken during the morning milking collection (5:00 am to 6:30 am). The milk is collected in sterile bottles, on which is mentioned the identification number of each cow in order to ensure traceability of the samples. Two samples are taken each week during three months (24 samples in total). Milking takes place in optimal hygienic conditions (cleaning of the udders equipment and the milking parlor). The milk samples are placed in a cooler at 4 °C and transferred directly (7:30 a.m.) for physicochemical analyzes in order to avoid any lactic acid fermentation. The milk volumes of each milking are recorded to calculate milk quantities.

Blood count formula

With the aim of demonstrating the harmlessness of the ingestion of tomato spent grain by cows, and for a better valuation of this by-product, we carried out blood analyzes of five randomly chosen cows from both groups. Blood samples were taken in EDTA tubes, at a frequency of one sample per month for the duration of the experiment. Analyzes of blood components are carried out under the same experimental conditions using the same apparatus and by the same methods (Figure 1).

2.2 Chemical composition of tomato dregs

Determining the water content (moisture)

The moisture content is determined by a food specific moisture meter (ISO 6496:1999) (International Organization

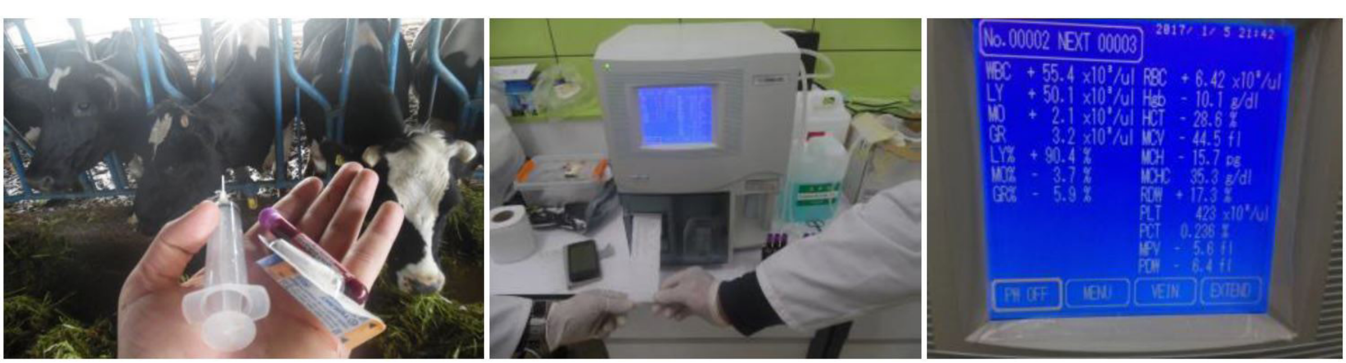

Figure 1. Samples for blood count analysis.

for Standardization, 1999b). The moisture content is determined on a 1 g sample crushed and spread on a porcelain capsule, then placed in the moisture meter for 2 min.

Determining the dry matter content (dry extract)

This is the product resulting from the dehydration (removal of water) of a solid or liquid compound. The dry matter can be calculated by the following formula: Dry matter(%) = 100-humidity.

Determining the mineral content

The mineral matter is determined according to ISO 5984:2002 standard (International Organization for Standardization, 2002). It is expressed as a percentage of the total dry matter.

Determining the total protein level

The identification of the protein level via total nitrogen is carried out according to the Kjeldahl method (ISO 5983-1:2005) (International Organization for Standardization, 2005). The nitrogen content obtained is multiplied by the factor 6.25.

Determining the calcium level

Calcium determination is carried out according to ISO 6490-1:1985 (International Organization for Standardization, 1985). It is indicated as a percentage of the total dry matter according to the following formula (Equation 1):

$$calcium(\%) = \frac{40 \times Vt \times D \times F\ EDTA \times 100}{m} \quad (1)$$

Vt is the titration volume in milliliters.

F is the EDTA factor equal to 0.01.

D is the dilution of the solution.

m is the mass, in grams, of the test sample (5 g).

Determining the level of phosphorus

The determination of phosphorus is carried out according to ISO 6491:1998 standard (International Organization for Standardization, 1998). The phosphorus content is outlined as a percentage according to the following formula (Equation 2):

$$phosphorus(\%) = \frac{X \times F}{20 \times m} \quad (2)$$

X is the phosphorus content in micrograms per milliliter read on the calibration curve.

F is the reciprocal of the dilution factor of the aliquot.

m is the mass, in grams, of the test sample (5 g).

Determining the fat content

Fat is identified according to standard (ISO 6492:1999) (International Organization for Standardization, 1999a).

It is expressed according to the following formula (Equation 3):

$$Fat\ content(\%) = \frac{m2 - m1}{m0} \times 100 \quad (3)$$

m0 stands for the mass, in grams, of the test sample (3 g).

m1 stands for the mass, in grams, of the flask containing the granules of glass bubbles.

m2 stands for the mass, in grams, of the flask containing the glass bubble granules and the dried extract residue.

Determination of vitamin A level

Vitamin A dosage is found out by spectrophotometry after saponification.

Reading the optical density (OD) is achieved at 325 nm. The values are expressed in IU/g of retinol (Equation 4).

$$VitaminA(\mathrm{UI/g}) = \frac{do325 \times V}{100 \times P} \times 1830 \quad (4)$$

P: Test portion in grams.

V: Total volume.

Determining the level of vitamin E (α -tocopherol)

The vitamin E level is determined after saponification of the sample and extraction through hexane by Emmerie-Engel colorimetry. The values are expressed as a percentage of α-tocopherol. According to the following formula (Equation 5):

$$VitaminE = \frac{DO520 \times dil}{100 \times P} \quad (5)$$

2.3 Physicochemical composition of milk

pH determination

The pH is determined according to ISO 11289:1993 standard (International Organization for Standardization, 1993).

Determining acidity

The acidity of milk is identified according to standard NF-V04-206 (Association Française de Normalisation, 1969). It is conventionally expressed in grams of lactic acid per liter of milk according to the following formula (Equation 6):

$$Acidity(g/l) = V \times 0.9 \quad (6)$$

V is the volume in milliliters of the 0.1N sodium hydroxide solution

Determining density

The density is determined by lacto-densimeter according to NF V04-204 August 2004 standard (Association Française de Normalisation, 2004).

Determining fat

Also called acid-butyrometric method, according to the Gerber method ISO 2446:2008 (International Organization for Standardization, 2008) the fat content is expressed in grams per liter.

Determining dry matter (total dry extract)

The dry matter content is determined according to ISO 6731:2010 standard (International Organization for Standardization, 2010). The dry matter is expressed in grams per liter according to the following formula (Equation 7):

$$Dry\,matter = \frac{M1 - M0}{M2 - M0} \times 100 \quad (7)$$

M0: Mass in g of the empty capsule.

M1: Mass in g of capsule and of the residue after drying and cooling.

M2: Mass in g of capsule and of the test sample residue.

Determining defatted dry matter

The defatted dry matter is expressed in grams per liter, calculated according to the following formula: Defatted matter = total dry matter-fat.

2.4 Statistical analyzes

All measurements were repeated three times. The values are expressed as the average of the three measurements ± the standard deviation. ANOVA analysis of variance was applied to the results obtained. A principal component analysis is carried out under the R environment.

3 Results and discussion

3.1 Physicochemical characterization of tomato spent grain

The results of the physicochemical assays and measurements of the various parameters are shown in Table 1.

Determining the water content (moisture)

From the above results, the moisture content of tomato grains varies between 9.8 and 10.28%, and on average 10 ± 0.24%. Our results are slightly superior to those of Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (2018) who are around 7.3%, those of Gasa et al. (1988) and Fondevila et al. (1994) with a value of 7.80%, as well as by Shevchuck et al. (1985) which are of the order of 5%. This could be explained by the different technological processes from one factory to another, and more especially compared to the cylindrical sieve centrifuge that follows the tomato crushing phase.

Determining the dry matter

The dry matter content varies depending on any drying applied to the tomato by-products before use. From the above results, the dry matter content of tomato spent grain varies between 89.72 and 90.2%, with an average of 89.99 ± 0.24%. Our results are close to those of Amokrane (2010) with 88.77%; Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (2018) with 92.7%; Gasa et al. (1988) and Fondevila et al. (1994) with 92.20% values. These values are significantly lower than those recorded by Shevchuck et al. (1985) with 95%. These high values of dry matter represent a good guarantee of supplementation of the food bolus (of the cows, since each cow will receive 20 kg of tomato spent grain containing approximately 18 kg of dry matter.

Determining mineral matter

The mineral content is on average 4.41 ± 0.11%. This value is consistent with the work of Chapoutot & Savant (1986) with 3.40 to 4.5%; Institut Technique de L'élevage Bovin (1988) with 4.10%; d'Arleux (1990) with 5% and Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (2018) with 4.4%. Our values differ from the work of Ibrahem & Alwash (1983) who obtained very high rates of around 12.80%. Volpato et al. (1989) also obtained a rate of 9.80%. For Amokrane (2010), the values of the mineral matter reached 11.77%.

Determining fat

The fat content found in our samples varies between 5.23 and 6.06% with an average of 5.63 ± 0.41%. It is relatively low if we compare it with those of Chapoutot & Savant (1986) and Institut Technique de L'élevage Bovin (1988) with 10.80%, d'Arleux (1990) and Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (2018) with 15% of the dry matter. These values are higher than the results of Amokrane (2010) where the fat content is 1.66%. The fat content found was similar to that reported in previous studies by Bartocci et al. (1980) 7.40% and Ibrahem & Alwash (1983) at 7.20%. González et al. (2011) and Elbadrawy & Sello (2016) found in a dried skin a crude fat content of respectively 6.0% and 4.04% While Knoblich et al. (2005) as well as Nour et al. (2018) reported a crude fat content of 3.22% and 2.19% respectively, which is also lower than our results. This discrepancy between

Table 1. Physicochemical characterization of tomato spent grain (n = 3).

	Water content %	Dry matter %	Mineral matter %	Fat %	Protein content %	Calcium content g/kg DM	Phosphorus content g/kg DM	Vit A UI/g	Vit E mg/kg
Mean	10.00	89.99	04.41	05.63	18.09	7.46	1.76	17.38	15.00
SD	0.24	0.24	0.11	0.41	1.40	0.23	0.56	0.91	2.00

researches could be caused by tomato by-product components (mainly seeds) that differ from region to region, but mostly from one variety of tomato to another. As the product is very heterogeneous, the cultivated varieties, the soil, the climate and the ripeness of the fruits can influence the quality of tomato spent grain (Boumendjel et al., 2013).

Determining total protein content

The protein content obtained is 18.09 ± 1.4%. It is close to the level of crude protein (18.92%) found by Salajegheh et al. (2012). Similar yet lower rates were found by Nour et al. (2018) (17.62%) as well as those of Amokrane (2010) where the protein content was 12.06%. These differences could be owing to the contribution of seeds, given that in a previous study the crude protein of the seed by-product (20.23%) was found to be approximately twice as that of the skin by-product (10.08%) (Knoblich et al., 2005) while Persia et al. (2003) reported a crude protein content of the seed by-product of 25%. González et al. (2011) and Elbadrawy & Sello (2016) found that dried tomato peels are made up of respectively 13.3 and 10.5% protein. This wide range of variation is explained by the proportion of nitrogen linked to the different carbohydrate fractions, which itself depends on technological processes (Cotte, 2000). Ui Proteins have an amino acid composition close to that of soybean meal; this places tomato pulps among foods with an interesting protein value for ruminants (Aghajanzadeh-Golshani et al., 2010).

Determining calcium level

The calcium content is 7.6 ± 0.23 g/kg MS. This value is higher than that of the work of Proto et al. (1988) with 2.6 g/kg DM, Institut Technique de L'élevage Bovin (1988) with 3 g/kg DM, d'Arleux (1990) with 4 g/kg DM, and Shevchuck et al. (1985) with 4.3 g/kg DM. It is noted that in other studies, calcium content is between 1.8 and 4.2 g/kg DM according to Hacala et al. (1990). These calcium contents greatly depend on the edaphic conditions of tomato cultivation, and more precisely on the salinity of the soils on which the tomato is cultivated (Cotte, 2000).

Determining phosphorus level

The phosphorus content is 1.76 ± 0.56 g/kg DM. This result is more similar to that of Ecole Nationale Vétérinaire de Lyon (1984) with 2.3 g/kg DM, then than Shevchuck et al. (1985) with 0.9 g/kg DM. This value is not consistent with the work of Institut Technique de L'élevage Bovin (1988) with 3 g/kg DM, Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement (2018) with 4.8 g/kg DM, or even d'Arleux (1990) with 5.53 g/kg DM. These enormous differences are explained by various phenomena such as insufficient washing steps; soil contamination; quality of used transport (metal waste from the skips); type of cultivated land and importance of mineral fertilizers (Cotte, 2000).

Determining vitamin A

Identifying vitamins A, either, Retinol or Tocopherol, is carried out twice in repetitions and they are expressed in international units per gram IU/g. Table 1 shows the results obtained for the vitamin A content in the spent grain. Based on the above results, we notice that the precursor content of vitamin A is 17.38 ± 0.91 UL/g, this value is close to the results of Surendar et al. (2018) which reaches 18.58 IU/g, this reflects that tomato pulp is thus a reasonable source of vitamin A (Aghajanzadeh-Golshani et al., 2010).

Vitamin E (tocopherol)

According to the results obtained, the α-Tocopherol content is on average 15 mg/kg ± 2. This value is lower than that reported in the results of Rezaeipour et al. (2012) with 39 mg/kg. This may be due to the industrial processing of tomatoes where heat can affect vitamin E content. As tomato spent grain is rich in vitamin E, it takes part in the food bolus with its antioxidant role.

3.2 Blood count formula

The results of main blood component are presented in the Table 2.

According to obtained results, the variations in the values of white blood cells, lymphocytes and monocytes, although showing significant standard deviations, were constantly increasing during the two experimental groups. This denotes the absence of a relationship with the studied variable. However, the presence of a subclinical infection could possibly be due to the diet generally supplied.

3.3 Physicochemical parameters of milk

Variation of physicochemical parameters of milk

Below are the results of the physicochemical analyzes of the milk (Figure 2) obtained from the two monitored batches: with tomato spent grain and without tomato spent grain. The evolution of the various parameters has enabled us to pinpoint the qualitative and quantitative characteristics after introducing tomato spent grain. The objective is to assess the benefit of introducing tomato spent grain in bovine feed by detecting significant thresholds of variation in physicochemical parameters. According to the results of Figure 1, we notice that the pH values are normal varying very little between the two batches (6.69 ± 0.13 for the batch supplemented with spent grain and 6.67 ± 0.14 for the batch without spent grain). The density of the tested milk increased from (1023) value at the start of the practical training up to (1032) value at the end of the practicum. This increase influences particularly the biochemical quality of the milk, which is used not only by the farmer himself, but also by the dairy industries (the high rate of the dry matter and the defatted matter will be involved in the production of

Table 2. Main blood components (x10^3/μL).

Parameter/Mean + SD	White blood cell	Lymphocytes	Monocytes
First month without	29.8 ± 9.91	19.8 ± 8.76	2.2 ± 0.46
Second month without	34.34 ± 15.97	26.4 ± 15.25	1.98 ± 0.33
First month with	49.56 ± 10.46	39.5 ± 10.83	2.58 ± 1.05
Second month with	54.62 ± 11.11	45.34 ± 10.09	3.04 ± 0.76

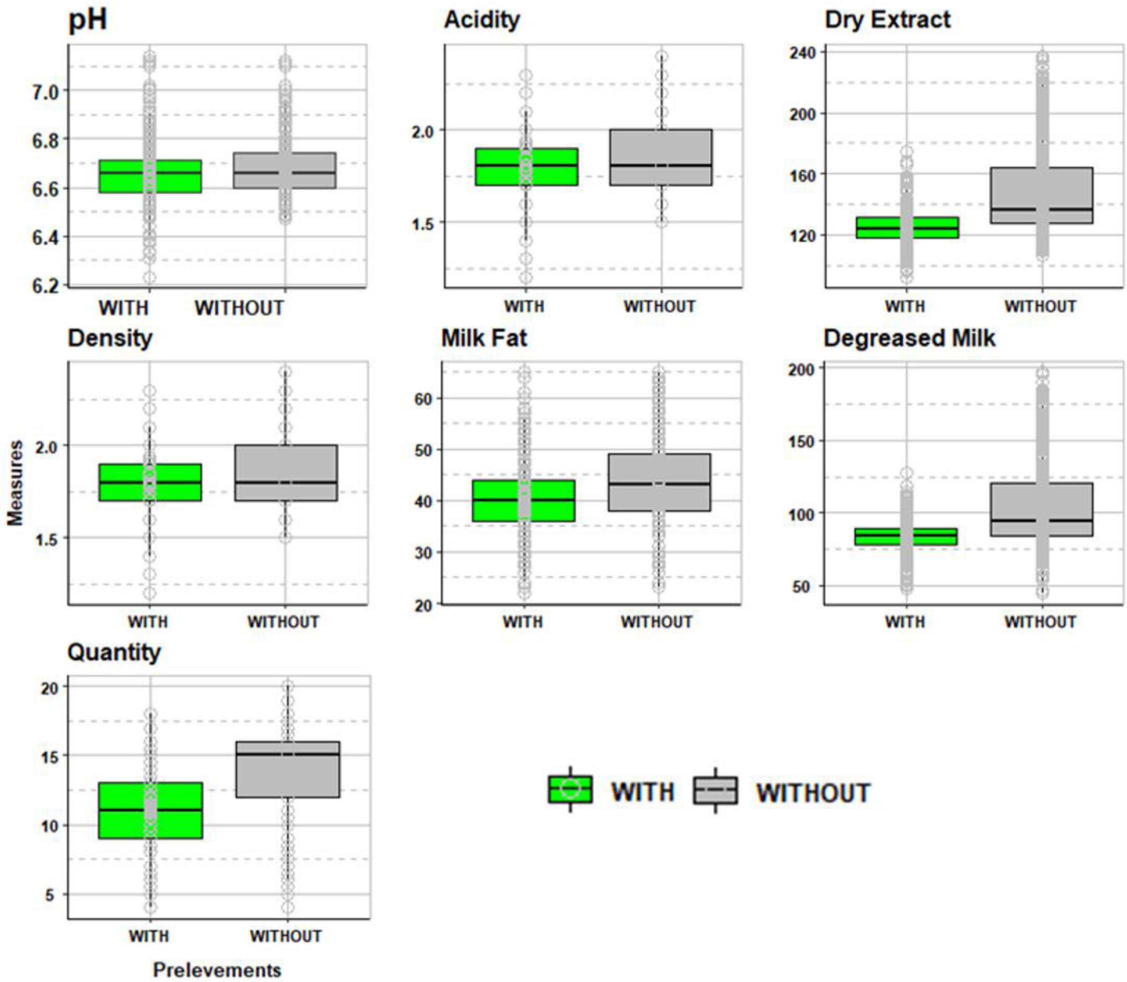

Figure 2. Characterization of the milk from the two lots with and without tomato spent grain.

milk powder). Without overlooking the evolution of the milk fat incorporated with spent grain which is a very important criterion in the butter industry.

Analysis of variations in physicochemical parameters

The average counts of the 24 samples obtained for the various parameters which are taken from two batches containing 40 dairy cows in total are summarized in Table 3.

Milk volumes

The milk quantities recorded in the batch of dairy cows not supplemented with tomato spent grain are 11.12 ± 3.00. On the other hand, the intake of the volumes of milk in the tested batch reveals a very highly significant increase ($p < 0.001$) with a mean value of 13.73 ± 3.47. Statistical analysis does not demonstrate an effect of time on improving milk volumes ($p > 0.05$).

pH

pH of our sample, whether without grain or with tomato spent grain, is successively 6.69 ± 0.13 and 6.67 ± 0.14, this is the range of Luquet's research (1985), Wattiaux (1997) and Vignola (2002), Aïssi & Soumanou (2016) (6.6 and 6.8). Indeed, pH of the different milks studied varies between 6.5 ± 0.000 and 6.8 ± 0.057 according to Dossou et al. (2016) and is in accordance with the values obtained by Kora (2005) and Cazet (2007) where pH of the milk varies between 6.5 and 6.7. pH values obtained within the framework of this study could be due to the preservation of the freshness of the milks during their transfer. Because according to Cazet (2007), during a lack of freshness, lactic acid bacteria convert lactose into lactic acid which lowers the pH of the milk by increasing the concentration of hydronium ions ($H3O$ +). Two-way ANOVA analysis showed no significant difference ($P > 0.05$). Moreover, statistical analysis does not demonstrate an effect of time on improving the pH of milk ($p > 0.05$).

Density

The cow milk to be experimented with a density varies between (1026 ± 1.97) concerning the food ration without tomato spent grain and (1028 ± 2.14) with the spent grain, these results are similar to that of Sboui et al. (2009) (1028) and Gaddour et al. (2013) varied between 1028 and 1030. The density at 20 °C of these different milks varies between 1.028 ± 0.002 and 1.032 ±

Table 3. Analysis of variance of physicochemical parameters.

	Average counts ± SD (Min-Max)		Anova Two Factors			
	n = 24	n = 24	*Samples*		*Time*	
	Samples with dregs	Samples without dregs	*F*	*P*	*F*	*P*
Quantity	13.73 ± 3.47 (4-20)	11.12 ± 3.00 (4-18)	72.70	0.000***	0.46	0.99
pH	6.69 ± 0.13 (6.47-7.12)	6.67 ± 0.14 (6.23-7.14)	0.82	0.36	1.30	0.08
Density	1028 ± 2.14 (1023-1033)	1026 ± 1.97 (1020-1031)	41.97	0.000***	2.60	0.000***
Acidity	1.87 ± 0.18 (1.5-2.4)	1.82 ± 0.16 (1.2-2.3)	4.10	0.04*	1.51	0.01*
Milk Fat	43.94 ± 8.45 (23-65)	40.74 ± 7.07 (22-65)	8.34	0.003**	1.02	0.43
Dry Extract	148.7 ± 29.88 (106.7-237.1)	124.56 ± 11.31 (91.98-174.52)	61.08	0.000***	4.74	0.000***
Degreased Milk	104.83 ± 30.65 (44.82-197.1)	83.86 ± 10.40 (48.28-127.52)	37.78	0.000***	4.32	0.000***

*p < 0.05. **p < 0.01. ***p < 0.001.

0.002 (Dossou et al., 2016). The analysis of variance showed that there was a very highly significant difference for this parameter between the different cultivars (P ≤ 0.001). Statistical analysis also demonstrates an effect of time on improving milk density (p ≤ 0.001). The longer the cows receive tomato spent grain, the more the density will continue to increase.

Acidity

Acidity is subject to NF-V04-206 standard of January 1969 (Association Française de Normalisation, 1969). It must be between 15 and 18° Dornic referred to in our study (18 °D). It is superior to the work of Dossou et al. (2016) which varies between 15 and 16 °D. This value takes into account the natural acidity of fresh milk, which relates to the richness in dry matter. An analysis of variance showed that there was a major difference for this parameter between the different cultivars (P < 0.05). Statistical analysis also reveals an effect of time on improving the acidity of milk (p ≤ 0.01), this explains the effect of tomato spent grain on the physicochemical quality of milk.

Fat

The fat of the milk examined ranges from 43.94 ± 8.45 and 40.74 ± 7.07. These values are confirmed by the work of Pougheon (1974) with 42 g/L, and they differ from the results of Lebeuf et al. (2002) with 33 g/L, and Mathieu (1998) 38 g/L. We detected a highly significant difference between samples from two lots (p < 0.01). This suggests that the livestock system in Algeria is not the same. This variation can be explained by the level of food on the farms in this region. Statistical analysis does not show an effect of time on improving milk volume (p > 0.05).

Total dry extract and degreased matter

The total dry milk extract has values between 148.7 ± 29.88 for the incorporated sample of the spent grain and a value of 124.56 ± 11.31 for the second batch. Our results are superior to those of the work on the dry matter content of cow's milk of the breeds studied by Sboui et al. (2009) where the dry extract is 104.88 g/L, as well as that of Veinoglou et al. (1982) where the dry extract was 120.2 g/L. This reveals a positive effect of the addition of tomato spent grain in beef feed. Statistical analysis for this parameter disclosed that there was a very highly significant difference (p ≤ 0.001) between the two studied batches. This is also the case for degreased material. On the other hand, our experience shows that tomato spent grain improves the dry matter content over time and also the defatted matter.

Principal component analysis of variations in milk quality depending on the diet with or without tomato grain

According to the results obtained by the principal component analysis of the variations (Figure 3) we note that the main parameters varying along the first axis (Dim1 33.2%) are gradually; fat, milk volume, density, the defatted matter and finally the dry matter which varies mostly according to the supplementation of tomato spent grain. We notice that acidity and pH are the parameters that vary the least and depend the least on grain supplementation. A study carried out by Chapoutot & Savant (1986) showed that the chemical composition of tomatoes and their behavior in the rumen varied little, whatever the variety and precocity of the tomatoes used. According to the tests carried out by Cotte (2000), negative effects are sometimes observed when incorporating tomato spent grain on the pH of the milk. Tomato pulps are therefore favorable for milk production as long as they do not represent more than 20 to 30% of the DM of the ration. According to Hacala et al. (1990), the pulp is a relatively acidic product (pH between 3 and 4), which can cause a variation in the pH of the milk. Our results are confirmed by the work of Belisabakis (1990), which replaces part of the corn silage and cake with tomato pulp, and found no modification in feed intake and production, only the fat content of milk fell by 4%. The fat content varies from 3.45 to 21.93%, which gives tomato by-products an interesting energy value (Cotte, 2000). The use of tomato spent grain can increase the dry matter content (Institut Technique de L'élevage Bovin, 1988). These results are similar to ours, in the same way, the dry matter implies an increase in the rate of defatted matter. The dry matter content varies depending on whether the tomato by-products are dried before use. Belisabakis (1990) also finds a slight increase in milk production. This result is found in some cows in our experiment, inducing an increase in the overall average milk production.

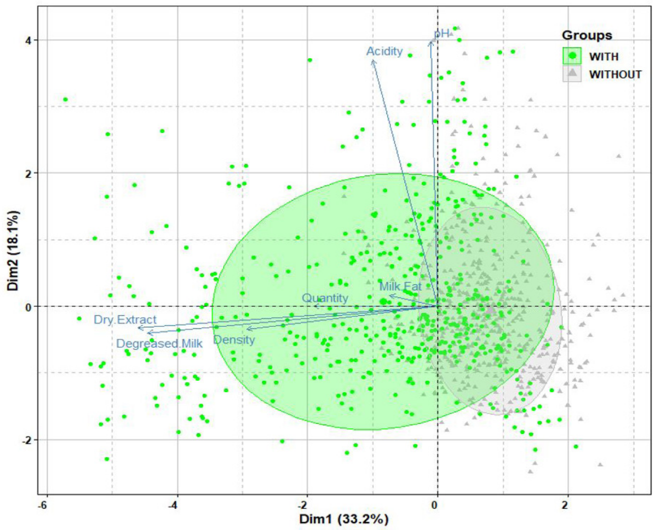

Figure 3. Principal component analysis of variations in milk quality depending on the diet with or without tomato spent grain.

4 Conclusion

Processed tomato by-products are potentially valuable supplemental feeds for cattle farms. They are rich in dry matter, minerals and vitamins A and E. The industrial tomato is widely used in beef feed during the summer period. Our present study focused on a metric and physicochemical characterization of cow milk from two batches fed with or without tomato spent grain. The results of the physicochemical investigations prove that there is an increase in quantitative milk production in the batch supplemented with tomato spent grain. There is also a significant improvement in the physicochemical parameters of the milk: dry matter content, defatted matter content, density, fat content, without considerably altering the pH of the milk or its acidity. Furthermore, maintaining tomato spent grain supplementation for three months also reveals a time effect on the variation in the quality of milk. So the use of these products in animal nutrition should be part of a sustainable partnership between industry and farmers and a framework to ensure product quality. It would be interesting to carry out fine assays of the lycopene level in cow's milk in order to flesh out the hereby study.

Conflict of interest

The authors report no conflict of interest. The authors alone are responsible for the content and writing of the article.

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