

Full Length Research Paper

Quality evaluation of canned cauliflower pickles prepared with different ingredients

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The aim of this research was to evaluate sensory quality of canned cauliflower pickles having different ingredients in their brines and the losses occurred in nutritive value especially in total phenolics and antioxidant activity due to processing. For this purpose, cauliflower florets were blanched in water containing NaCl (0.1%), Ca-ascorbate (0.25%), citric acid (0.1%), ascorbic acid (0.5%) and sodium metabisulphite (160 ppm) for inhibiting enzymatic browning. Six different brines consisting of, salt (4%), Ca-ascorbate (0.25%), acetic acid, (1%) lactic acid (1%), citric acid (1%) and their combinations with L-cysteine (0.25%) were used. The samples were pasteurized at 98°C for 30 min. Head space, net and drained weight, colour (L^* , a^* , b^*), total dry matter, total acidity, salt, SO_2 , total phenolics and antioxidant activity analysis were done. Blanching and pasteurization significantly reduced the total phenolic compounds levels by 7.12 - 14.78 %. The lowest and the highest reduction ratio of the antioxidant activity were determined in the sample including citric acid and the control sample as 2.90 and 72.79% respectively. Although L - cysteine affected visual appearance and colour positively, it affected taste and odour negatively. While acetic and citric acid containing samples were preferred for odour, acetic and lactic acid containing samples were preferred for taste criteria. Also lactic acid containing sample was preferred for hardness ($p < 0.05$).

Key words: Cauliflower, pickle, canning, sensory quality, total phenolics, antioxidant activity.

INTRODUCTION

Cauliflower (*Brassica oleracea botrytis*) is an important vegetable crop which belongs to the family *Brassicaceae* and is grown in many countries. A large proportion of its production is commercialised fresh and the remaining production is destined for processing as freezing or fermentation. Although in recent years there has been interest in an intermediate form of commercialised cauliflower as a minimally processed product (Sharma et al., 2005; Sanz et al., 2007). Cauliflower is generally used as cooked vegetable either singly or mixed with potato, carrot, and peas. In raw form, it is also mixed with green salad or its pieces are dipped into sauces. It is also used in the preparation of pickle or mixed pickle with other vegetables (Sharma et al., 2005).

Cauliflower is considered as a food of high nutritional value and low in calories, but is a good source of ascorbic acid and contains substantial amount of protein,

and nutrients like phosphorus, calcium, and iron. Some researchers state that its quality is related to stability of its fatty acids (Scalzo et al., 2007; Sharma et al., 2005).

Cauliflower is worthy of consideration as an important vegetable source of protein compounds including amino acids. Cauliflower florets contain about 27% protein in dry matter; a high amount of antioxidative compounds; and low amounts of nitrates and nitrites (Souci et al., 2000; Amr and Hadidi, 2001; Gebczynski and Kmiecik, 2007; Slupski et al., 2009). Cauliflower contains flavonoids and glucosinolates, the health-promoting potential of which has been the focus of intensive researches. Also, it has been determined that cruciferous vegetables, including cauliflower, exhibits antiproliferative effects on a wide variety of tumour cell lines (Hertog et al., 1995; Boivin et al., 2009; Paramithiotis et al., 2010). Although the exact mechanism is unclear, these anticarcinogenic effects have

been attributed to nitrogen and sulfur containing glucosides called glucosinolates (Hodges et al., 2006).

Cauliflower has a relatively high respiration rate and therefore it is highly perishable. Post-harvest senescence of cauliflower is correlated with lipid peroxidation. Some oxygen catabolites, commonly called as reactive oxygen species, cause lipid peroxidation, whose degradation products contribute to the decrease in overall quality of a vegetable during senescence, especially with respect to nutritive value and flavour. The storage-life is approximately 7 to 10 days at 5°C. Storage for more than 3 weeks or at temperatures higher than 0°C results in poor visual and sensory quality (Hardenburg et al., 1986; Suslow and Cantwell, 1998; DeEll et al., 2003; Scalzo et al., 2007). Quality loss in fresh cauliflower includes undesirable odors, yellowing of the curd sharp increase in bitter taste, curd softening, and leaf wilting (Fjeldsenden et al., 1981; Forbes and Chapman, 1989; Berrang et al., 1990; Schonhof et al., 2004; Hodges et al., 2006).

Cauliflower florets are used to prepare various dishes and pickles or canning industry. It gives a special taste to different kind of foods and it has a very high digestibility (Apahidean et al. 2010). Despite the fact that cauliflower is most often consumed after heat treatment such as boiling, steam boiling or frying, they can also be subjected to different alternative methods of preparation, such as fermentation or pickling (Sosinska and Obiedzinski, 2011). Uylaşer and Şahin (2002) reported that cauliflower does not have wide range of utilization in Turkish food industry. They studied suitability of cauliflowers for canned type pickle production. In order to reduce pink discoloration of the product, addition of ascorbic acid (0.2%) to brine was recommended.

The aim of this research was to determine sensory quality of canned cauliflower pickles having different ingredients in their brines and the losses occurred in nutritive value especially in total phenolics and antioxidant activity due to the processing. Because cauliflower was not utilized widespread in food industry, it is required to determine possibility of the production of canned cauliflower pickle as a value added product.

MATERIALS AND METHODS

Materials and canned cauliflower pickle production method

Mature cauliflowers without any damage obtained from the local market of Bursa province were used. After manual removal of outer leaves and stem, the cauliflowers were washed with cold tap water and cut into their florets using stainless steel knife. In order to inhibit enzymatic browning, they were blanched in water containing NaCl (0.1%), Ca-ascorbate (0.25%), citric acid (0.1%), ascorbic acid (0.5%) and sodium metabisulphite (160 ppm) at 98°C for 5 min then cooled in tap water to avoid over cooking and discolouration. Glass jars (720 ml) were filled with approximately 300 g cauliflower florets and 420 ml brine was added. Composition of the brines of the samples was given in Table 1. The brine of the control sample was only water. The samples were pasteurized at 98°C for 30 min, then cooled with water and stored at room temperature.

Physicochemical analysis

All of the analysis applied after material balance occurred between the liquid and the solid part of the canned cauliflower pickle (CCP). The physical analyses (head space, net and drained weight) of CCP samples were determined according to (Cemeroğlu, 2007). Colour related parameters: L^* (lightness), a^* (redness and greenness) and b^* (yellowness and blueness) were determined by D 25A-PC2Δ model Hunter colorimeter. The content of dry matter was determined according to procedures described by the AOAC (1990). Total acidity of the brines of the samples was measured by titration with 0.1N NaOH. Results were given as citric acid (AOAC, 1990). Salt content of the brines of the samples was measured by the Mohr method (AOAC, 1980). SO₂ analyses were done in the solid part of the samples according to modified Monier-Williams Method (AOAC, 2000). The method employed for the total phenolics was based on Folin-Ciocalteu's phenol reagent (Spanos and Wrolstad, 1990). The spectrophotometric measurements for total phenolics were carried out at 452 nm using a Shimadzu UV 1208 model spectrophotometer and the results were calculated as the gallic acid equivalent. The antioxidant activity of the CCP was identified by using the 2,2-diphenylpicrylhydrazyl (DPPH) radical spectrophotometrically. The inhibition percentage of the DPPH free radical at 517 nm was calculated (Zhang and Hamauzu, 2004). Both total phenolics and antioxidant activity analysis applied for solid part of the CCP. All determinations were carried out in three replications for each experiment. The results of this investigation were means ± SD of three measurements.

Sensory analysis

The samples were evaluated using a ranking test (Kramer, 1963) for the overall quality with comments on visual appearance, odour, taste and texture and the results were analysed using the expanded tables developed by Kahan et al. (1973) from which, based on the number of panellists and the number of samples, a range of values for no significant difference at 5% level was obtained. According to the above procedure, test samples with ranksum scores below the range were significantly superior and those with scores above the range were significantly inferior while the ones with ranksum scores within the range were not significantly different.

Statistical analysis

The experiment was conducted in a completely randomized design with three replications. The results were statistically evaluated by one-way analysis of variance (ANOVA) using the JMP software package version 6.0 (SAS Institute Inc. NC, 27513). The significance of the treatments was determined at the 0.05 probability levels by the F-test.

RESULTS AND DISCUSSION

The preparation of the cauliflowers resulted in a 23.84% wastage and the fruit flesh/peel ratio was 3.2/1. The average width and the height of the vegetable were 17.03 and 11.33 cm, respectively. Physicochemical properties of the raw material were given in Table 2. The results obtained in the determinations performed were discussed in more detail later.

The content of the analysed parameters of raw cauliflower was comparable to that given by numerous authors

Table 1. Composition of the brines of the samples.

Sample	NaCl (4%)	Ca-ascorbate (0.25%)	Acetic acid (1%)	Lactic acid (1%)	Citric acid (1%)	L - cysteine (0.25%)
A	x	x	x	-	-	-
B	x	x	-	X	-	-
C	x	x	-	-	x	-
D	x	x	x	-	-	x
E	x	x	-	X	-	x
F	x	X	-	-	x	x

Table 2. Results of the analysis of raw cauliflower (mean \pm S.D).

Total dry-matter (g / 100 g)	8.55 \pm 0.17
Total acidity* (g / 100 g)	0.16 \pm 0.00
Total phenolics** (mg GAE / 100 g)	768.60 \pm 6.3
Antioxidant activity (%)	60.36 \pm 1.10

S.D: standard deviation; *citric acid, ** gallic acid equivalent.

(Uylaşer and Şahin, 2002; Bahorun et al., 2004; Wu et al., 2004; Scalzo et al., 2007; Volden et al., 2009 a, b; Paramithiotis et al., 2010). Result of the total dry matter was compatible with the result of Scalzo et al. (2007) (8.8 to 12.6 %) and USDA (2008) data (8.09 g / 100 g).

Scalzo et al. (2007) determined titratable acidity as between 2.96 to 5.09 (mEq% NaOH). Paramithiotis et al. (2010) reported titratable acidity (lactic acid) as 0.11%. There have been only a few studies that evaluated the content of polyphenols in *Brassica* vegetables (Podsdek, 2007). Bahorun et al. (2004) and Wu et al. (2004) determined phenol content of cauliflower as 27.8 \pm 1.5 and 274 mg of gallic acid/100 g edible portion respectively. Volden et al. (2009 a) determined total phenols of two white varieties as between 63.5 \pm 0.6 to 66.6 \pm 3.1 mg GAE/100 g. These results were distinctly lower than that given in this research. However, Scalzo et al. (2007) measured the total polyphenols index of the cauliflower samples as 4041.4 to 6492.6 mg/kg. The content of polyphenols in vegetables could be affected by various factors such as varieties, climatic conditions and cultural practices, maturity at harvest, and storage conditions (Podsdek, 2007).

Köksal and Gülçin (2008) reported the strong antioxidative effect of cauliflowers. The antioxidative components such as ascorbic acid, carotenoids and phenolics were also found to be positively correlated with this parameter. Velioglu et al. (1998) emphasized this positive correlation in research on some fruits, vegetables and cereals. Gebczynski and Kmiecik (2007) determined antioxidative activity of cauliflower as 32.5 \pm 0.9%. Scalzo et al. (2007) reported antioxidant properties, measured by enzymatic (soybean lipoxygenase) linoleic acid degradation of cauliflower as between 30.7 to 66.8%. Variation in the antioxidant contents of *Brassica* vegetables is caused

by many factors: variety, maturity at harvest, growing condition, soil state, and condition of post-harvest storage (Podsdek, 2007).

Vegetable industrial processing such as blanching, canning, sterilization and freezing, as well as domestic cooking, is expected to affect the content, composition, antioxidant activity and bioavailability of antioxidants. In addition, operations such as cutting and slicing may induce a rapid enzymatic depletion of several naturally occurring antioxidants as a result of cellular disruption which allows contacts of substrates and enzymes. Generally, the antioxidant concentrations and activities in processed vegetables were lower than those of the corresponding raw samples. This was caused by their degradation, but also by absorption of water during boiling, which diluted the compounds and decreased their content per weight unit (Podsdek, 2007). Results of the physical analysis of the CCP samples were given in Figure 1.

Because of cauliflower florets were put on the glass jar manually, head space changed between 1.00 to 2.46 cm. Mean \pm standard deviation of net and drained weight of CCP were 688.28 \pm 13.07 g and 331.57 \pm 6.50 g, respectively. While the lowest L^* (brightness) value of the CCP was determined in the sample B containing lactic acid, the highest L^* value was determined in the sample D containing acetic acid and L - cysteine (Table 3). Cysteine has been reported to have a combined inhibitory effect, hence reducing o-quinones, acting directly on the enzymatic complex and forming a colourless cysteine-quinone compound (Soliva-Fortuny and Martin-Belloso, 2003). Richard-Forget et al. (1992) reported that, cysteine was responsible for the appearance of pinkish-red coloured compounds at low pH. While the samples containing L - cysteine (D, E, F) had negative a^* values presenting

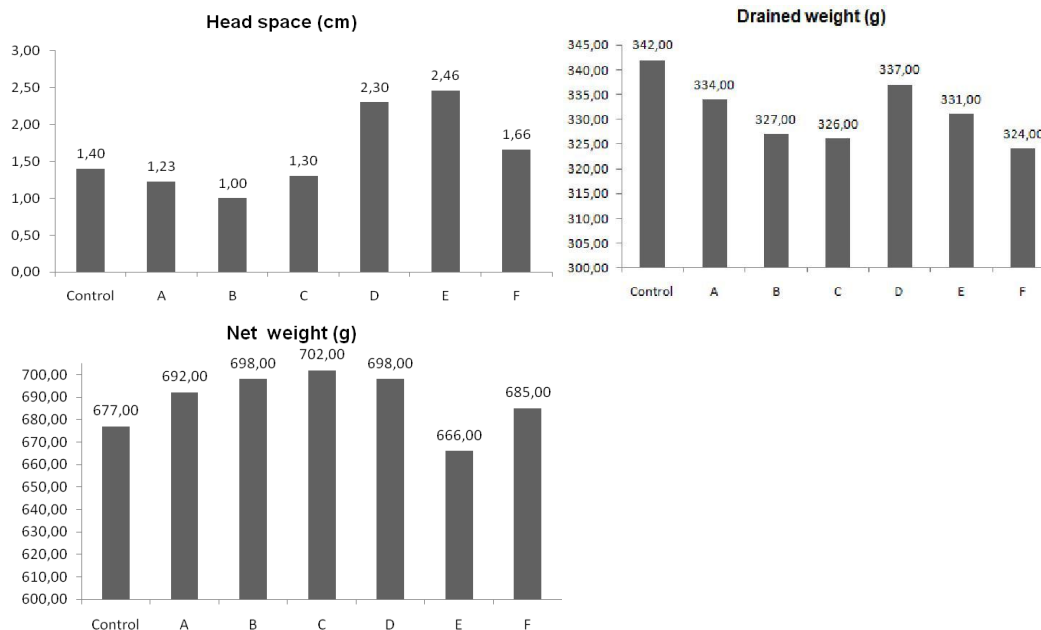


Figure 1. Physical properties of canned cauliflower pickles.

Table 3. Colour values of canned cauliflower pickles (mean \pm standard deviation).

Sample	L^*	a^*	b^*
Control	69.70 \pm 0.1 d	1.77 \pm 0.15 a	19.93 \pm 0.06 a
A	68.53 \pm 0.63 e	0.50 \pm 0.00 c	17.90 \pm 0.35 d
B	65.77 \pm 0.06 f	1.00 \pm 0.10 b	17.00 \pm 0.00 e
C	66.30 \pm 0.00 f	0.60 \pm 0.10 c	16.60 \pm 0.00 f
D	75.37 \pm 0.11 a	-1.87 \pm 0.15 e	18.37 \pm 0.11 c
E	71.97 \pm 0.06 c	-1.17 \pm 0.06 d	19.60 \pm 0.00 a
F	74.03 \pm 0.49 b	-2.43 \pm 0.25 f	18.83 \pm 0.21 b
LSD (5%)	0.24	0.27	0.54

Means within a row sharing a common letter were not significantly different ($p < 0.05$).

greenish colour, their b^* values were higher than the others.

It was significant that total dry matter content of the control sample was the lowest (5.10 ± 0.19 g / 100 g) since the brine used was just water (Table 4). Total acidity (as citric acid) of the brines of the samples changed between 0.39 ± 0.00 to 0.58 ± 0.01 (%) (Table 4). Salt content of all of the brines was adjusted as 4% at the beginning. Due to the material balance, salt contents of the samples were decreased between 2.15 ± 0.04 to 2.34 ± 0.06 %.

Cauliflowers were blanched in a solution containing sodium metabisulphite (160 ppm) for prevention of enzymatic browning. Dakin and Scholey (1970) reported that sulphur dioxide has a marked beneficial effect on the colour of cauliflower both before and after making into pickle. The presence of sulphur dioxide in brined

cauliflower is, apart from the advantage of colour protection, a hindrance to processing because it will either have to be removed or reduced to an acceptable level during freshening so that the finished pickle does not contain more than the amount permitted by the regulations. The level of sulphur dioxide to be added during the brining of cauliflower should thus be the minimum consistent with the maintenance of a good white colour. According to the Turkish Food Codex maximum SO_2 level of brined vegetables is 100 ppm (Anonymous, 2010). Blanching at atmospheric condition with high temperature, washing with water for cooling and then pasteurization caused important decrease of the sodium metabisulphite content of the products (Table 4).

Total phenolics of CCP were determined between 644.90 ± 4.90 to 713.89 ± 2.9 mg GAE / 100 g (Table 4). While the control sample had the lowest value, the sample

Table 4. Physicochemical properties of canned cauliflower pickles.

Sample	Total dry matter (g/100 g)	Titrateable acidity (g/100 ml)	Salt (g/100 ml)	pH	Antioxidant activity (%)	Total phenolics (mg GAE/ 100 g)
Control	4.99±0.19 ^d	0.10±0.01 ^d	0.15±0.07 ^d	5.01±0.01 ^a	16.42±0.29 ^d	654.94±15.44 ^b
A	6.62±0.07 ^c	0.57±0.01 ^a	2.18±0.03 ^{bc}	3.85±0.01 ^b	37.25±1.58 ^b	652.54±4.94 ^b
B	8.14±0.10 ^a	0.41±0.00 ^c	2.15±0.04 ^c	3.37±0.01 ^e	39.21±3.97 ^b	708.51±1.96 ^a
C	7.83±0.08 ^b	0.45±0.01 ^b	2.19±0.00 ^{bc}	3.44±0.01 ^d	58.61±2.62 ^a	713.89±2.95 ^a
D	7.66±0.07 ^b	0.58±0.01 ^a	2.34±0.06 ^a	3.86±0.00 ^b	20.57±5.35 ^{cd}	676.81±31.39 ^b
E	8.09±0.08 ^a	0.39±0.01 ^c	2.25±0.07 ^{ab}	3.45±0.01 ^c	24.45±4.68 ^c	663.13±6.30 ^b
F	7.85±0.16 ^b	0.47±0.02 ^b	2.24±0.06 ^b	3.38±0.01 ^e	17.52±2.57 ^d	658.09±12.09 ^b
LSD (5%)	0.21	0.03	0.09	0	5.97	25.04

Means within a row sharing a common letter were not significantly different ($P < 0.05$).

C had the highest. Blanching and pasteurization significantly reduced the total phenolic compounds levels by 7.12 to 14.78% for all samples. Conventional canning operations have the tendency to induce permanent changes to the nutritional and sensory attributes of foods (Awuah et al., 2007). Volden et al. (2009 b) found that blanching and boiling reduced the contents of the phenolics in cauliflower in the range 10 to 21% and 13 to 37%, respectively. In contrast, Gliszczynska-Swiglo et al. (2006) determined a 52% increase in the total phenolics in 10 min steamed broccoli, explaining this by enhanced extractability due to disruption of the polyphenol-protein complexes. Treatment of vegetables for consumption exposes the phytochemicals present to destructive factors that may lead to changes in concentrations and nutritive quality. Wet-thermal treatment causes denaturation of enzymes that can catalyse breakdown of nutrients and phytochemicals. On the other hand, processing can result in reduction of constituents by leaching or due to thermal destruction (Volden et al., 2009 b). Antioxidant activity of the CCP was in the range of 16.42 ± 0.29 to $58.61 \pm 2.62\%$ (Table 4). The lowest and the highest reduction ratio of the antioxidant activity were determined in the sample C including citric acid and the control sample as 2.90 and 72.79% respectively. The sample B and C having higher amount of total phenolics showed the higher antioxidant activity (Table 4). Wen et al. (2010) stated that the total phenolic content was positively correlated with the antioxidant activity of the vegetables like four-angled bean, French bean, long bean, snow pea and snap pea to some extent.

Generally, the antioxidant potential of vegetables is affected by thermal processing. Puupponen-Pimia et al. (2003) reported that blanching reduced the antioxidant capacity by 23% for cauliflower. Canned vegetables exhibited lower activity than their fresh counterparts (Murcia et al., 2009). However, Dewanto et al. (2002) stated that antioxidant activity was lower during the canning process, which were not significant for artichoke, Brussels sprout, cauliflower, carrot or maize, probably due to the increased release of bound phenolic compounds despite the loss of vitamin C.

According to ranking test for visual appearance and colour of CCP, the samples D, E and F, all of them containing L - cysteine, were preferred for their brightness and homogeneous colours. For odour criteria, acetic and citric acid containing samples which were coded as A and C respectively were preferred. According to taste criteria the samples A and B, acetic and lactic acid including samples respectively, were preferred. For hardness criteria, the samples were evaluated for softening of the cauliflowers. The sample B containing lactic acid was preferred ($p < 0.05$). Panellists reported that although L-cystein affected visual appearance and colour positively, it caused off flavour. The control sample was rejected by the panellists at the 95% probability level for all sensory criteria.

Conclusion

It could be concluded from the results of this research that blanching and pasteurization applied for processing of canned cauliflower pickles significantly reduced the total phenolic compounds levels by 7.12 to 14.78%. To ascertain the influence of processing on antioxidant activity of canned cauliflower pickles, results were compared with raw the vegetable. The lowest and the highest reduction ratio of the antioxidant activity were determined in the sample including citric acid and the control sample as 2.90 and 72.79% respectively. Although visual appearance and colour were positively affected by L-cystein, taste and odour were affected negatively. While acetic and citric acid containing samples were preferred for odour, acetic and lactic acid containing samples were preferred for taste criteria. Also lactic acid containing sample was preferred for hardness. Among all of the samples, the control sample was rejected by the panellists for all sensory criteria ($p < 0.05$).

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