ASSESSMENT OF PESTICIDE RESIDUES IN CAULIFLOWER THROUGH GAS CHROMATOGRAPHY-µECD AND HIGH PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC) ANALYSIS

AASIA AKBAR PANHWAR & SAGHIR AHMED SHEIKH
Institute of Food Sciences and Technology, SAU, Tandojam, Sindh, Pakistan

ABSTRACT

The study was carried out to analyze the effect of traditional food processing on the reduction of pesticide residues in cauliflower through GC-µECD and HPLC. The results revealed that the residual level of pesticides in unwashed unprocessed cauliflower samples are beyond their recommended MRLs i.e Bifenthrin, endosulfan, profenofos, emamectin benzoate, imidacloprid and diafenthiuron and the respective values were 0.151, 0.671, 0.172, 1.04, 1.011 and 0.052ppm, respectively which is far above their respective MRLS set by FAO i.e. 0.05, 0.5, 0.05, 0.5, 0.4 and 0.02ppm. The results of the present study showed that, the plain washing and detergent washing reduced the fat soluble pesticides in the average of 28% and 48%, respectively whereas average of water soluble pesticides was found 40% and 55%, respectively. Plain washing followed by frying reduced the fat soluble residues more (up to 98%) as compared to water soluble pesticides (91%). sun drying (up to 93% for fat soluble and 96% for water soluble pesticide), dehydration (up to 84% for fat soluble and 87% for water soluble pesticide) and blanching (up to 72% for fat soluble and 79% for water soluble pesticide). It was concluded from this study that traditional processing methods play a significant role in reduction of pesticide residues in cauliflower vegetable.

KEYWORDS: Fat Soluble Pesticides, Water Soluble Pesticides, G-µecd, HPLC and Traditional Processing

INTRODUCTION

Vegetables are important sources of food and are highly beneficial for health. They are major constituent of daily diet all over the world. In Pakistan, among the vegetables, cauliflower, is the most commonly grown as it gives better return over investment to the farmers (Kumari et al., 2002, 2003 and 2008).

Cauliflower is low in fat and carbohydrates but high in dietary fiber, folate, water, and vitamin C, thus possessing a high nutritional value. Cauliflower contains several photochemicals which are also found in the cabbage family that may be beneficial to the human health. Cauliflower (Brassica Oleracea) is a great food that can help lose weight because of its versatile usage. Pakistan ranks 8th in cauliflower production and produced 212.22 thousand tons in which Sindh province contributes about 13.314 thousand tones (GOP, 2005 a& b).

Vegetables are short duration crops and are prone to pest attack; therefore it is necessary to spray a pesticide on crop plants repeatedly during the entire period of growth. Jeyanthi and Kombairaju, (2005) reported that pesticides are repeatedly sprayed on cauliflower up to 17 times on an average and 15 times during growing period. So it is need of the time to monitor the usage globally to assess the environmental load of the residues from pesticides, as these residues find their way into the human body through food, therefore, assessment of pesticide residues in food and their removal by traditional processing have become essential requirement (Torres et al., 2004).

The techniques used in this study focused on commercial or home processing of fruits and vegetables, which included washing, blanching, cooking and frying. The effects of food processing on pesticide residues have been
extensively reviewed by several researchers (Kumari, 2008; Kaushik et al., 2009). The removal of pesticide residues by washing has also been reported to depend on the age of the chemical (Guardia-Rubio et al., 2007). However, there is a scarcity of published data for the dissipation of bifenthrin and profenofos insecticides on field-grown cauliflower and in the processed products. Therefore, the present research was designed to study the persistence of bifenthrin, profenofos, endosulfan, imidacloprid, emamectin benzoate and difenthiuron in cauliflower. Emphasis on the safety periods for this insecticide in the tested vegetables was considered. This study is also aimed to throw light on the influence of different washing solutions and some kitchen processing on the removal of such residues from field-treated vegetables.

MATERIALS AND METHODS

Pesticide Spray on Cauliflower

Cauliflower was grown on farmer field (area of about half acre) through organic farming without pesticide spray to serve as control. Six separate plots of Cauliflower (area about half acre each) were sprayed with each pesticides i.e. bifenthrin, profenofos, endosulfan, emamectin benzoate and difenthiuron at recommended doses (Table 1). The sprayed cauliflower was harvested next day to determine the effect of traditional processing techniques, such as normal washing, detergent washing, blanching, and drying either under sun or thermal dehydration, cooking/frying at the extent of removal/reduction of pesticide residue contents. After harvesting, the samples were packed in polyethylene bags with appropriate labeling and brought to the laboratory of the Institute of Food Sciences and Technology for traditional processing.

<table>
<thead>
<tr>
<th>Pesticides</th>
<th>Formulation</th>
<th>Active Ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bifenthrin</td>
<td>250 ml/acre</td>
<td>25 ml/acre</td>
</tr>
<tr>
<td>Profenofos</td>
<td>800 ml/acre</td>
<td>400ml/acre</td>
</tr>
<tr>
<td>Endosulfan</td>
<td>600 ml/acre</td>
<td>210 ml/acre</td>
</tr>
<tr>
<td>Emamectin benzoate</td>
<td>200 ml/acre</td>
<td>38 ml/acre</td>
</tr>
<tr>
<td>Imidacloprid</td>
<td>80 ml/acre</td>
<td>16ml/acre</td>
</tr>
<tr>
<td>Diafenthiuron</td>
<td>300 ml/acre</td>
<td>150 ml /acre</td>
</tr>
</tbody>
</table>

Determination of Weight

For weight determination, the cauliflower was placed in a pre-weighed pan and then to the digital balance for measuring accurate weight. The weighing was done perfectly through digital top loading balance and the readings were noted carefully.

Traditional Processing of Cauliflower Samples

The cauliflower samples were subjected to different traditional processing techniques such as unwashed unprocessed, plain washed unprocessed, plain washed sun-dried, plain washed dehydrated, plain washed fried and detergent washed unprocessed. Samples were prepared for extraction of pesticides residues through traditional processing. The fresh cultivated cauliflower was cut into small pieces/or slices and divided into three main groups i.e. unwashed, plain washed and detergent washed. 1st group was unwashed and cauliflower samples were considered as unprocessed and were packed in polyethylene bags. The 2nd group was the plain water washed. The sliced cauliflower samples were washed with plain or tap water properly for 5-10 minutes in order to clean the pesticides. Some samples were packed in polyethylene bags as unprocessed and some kept for further processing. The 3rd group was named as
detergent washed. Cauliflower were soaked in the solution for few minutes and washed through tap water in order to remove detergent and samples were packed in polyethylene bags.

The plain washed samples were distributed into four groups each for applying blanching, sun drying, dehydration and frying.

1. **Blanching:** Required volume of water was taken in a pan and heated at 80 to 100°C. Florets of cauliflower were heated in water for 5 min followed by dipping in cold water for equal duration of time. The cauliflower samples were then surface dried with muslin cloth and then packed in transparent polyethylene bags and stored in deep freezer at -20°C till further processing.

2. **Sun drying:** The samples of the cauliflower were kept in the flat dishes and exposed to shining sun for three days for sun drying in order to remove moisture. Dried cauliflower samples were then transferred into transparent polyethylene bags and labeled till further analysis.

3. **Cabinet dehydration:** Similarly, cauliflower samples were placed in the trays of dehydration chamber at 70°C for 12h. After the removal of moisture, the samples were packed and labeled in the transparent polyethylene bags for further analysis.

4. **Frying:** Sliced cauliflower was fried in vegetable oil and were cooled at room temperature and packed in polyethylene bags with appropriate labeling and stored in deep freezer at -20°C till further processing.

**EXTRACTION OF PESTICIDE RESIDUES**

**Extraction of Endosulfan and Profenofos Residues**

Thirty ml ethyl acetate and 10g of sodium sulfate added in 25g of samples and homogenized in blender for 10 minutes. The homogenate was filtered twice with Whatman No.1 filter paper. The filtrate was dried in Rotary evaporator. The solvent n-hexane was added in dried filtrate and then further processed for cleanup. In case of fried samples, they were dissolved in n-hexane and partitioned with 50ml of acetonitrile in separating funnel. Oil was removed with n-hexane and the lower layer containing acetonitrile was saved. Acetonitrile portion was partitioned with 60ml n-hexane in separating funnel followed by addition of 10ml of 10% NaCl solution. The lower layer was discarded and the upper layer of n-hexane was saved and further processed for cleanup.

**Extraction of Bifenthrin Residues**

Thirty ml of n-hexane and 10g of sodium sulfate added in 25g of samples and homogenized in blender for 10 min. The homogenate was filtered twice with Whatman No.1 filter paper and the filtrate was further processed for cleanup. The fried samples were dissolved in n-hexane and partitioned with 50ml of acetonitrile in separating funnel. Oil was removed with n-hexane and the lower layer containing acetonitrile was saved. Acetonitrile portion was partitioned with 60ml n-hexane in separating funnel then 10ml of 10% NaCl solution was added. The lower layer was discarded and the upper layer of n-hexane was saved and then further processed for cleanup.

**Extraction of Emamectin Benzoate and Imidacloprid Residues**

Thirty ml of acetonitrile and 10g of sodium sulfate was added in 25g of samples and homogenized in blender for 10 min. The homogenate was filtered twice with Whatman No.1 filter paper and the filtrate was further processed for cleanup. In case of fried samples, the filtrate was partitioned with 50ml n-hexane in separating funnel. The upper layer of
n-Hexane containing oil was discarded, whereas lower layer containing acetonitrile and pesticide residues was saved and then further subjected to cleanup.

**Extraction of Diafenthion Residues**

Thirty ml acetone and 10g of sodium sulfate added in 25g of samples and homogenized in blender for 10 minutes. The homogenate was filtered twice with Whatman No.1 filter paper. The filtrate was dried in Rotary evaporator. The solvent acetonitrile was added in dried filtrate and then further processed for cleanup.

In case of fried samples, the filtrate was partitioned with 50ml n-hexane in separating funnel. The upper layer of n-hexane containing oil was discarded, whereas lower layer containing acetonitrile and pesticide residues was saved and then further subjected to cleanup.

**CLEANUP OF PESTICIDE RESIDUES**

**Cleanup of Endosulfan, Profenofos and Bifenthrin Residues**

Pesticide residues were cleaned up through Florisil column using n-hexane for elusion. The cleaned up residues were analyzed through Gas Chromatograph coupled with micro-ECD.

**Cleanup of Imidacloprid, Emamectin Benzoate and Diafenthiuron Residues**

Extracts containing residues were cleaned up from interfering materials through activated charcoal. Charcoal was activated by heating in oven for about 3 hours at the temperature of 115°C. One g of activated charcoal was then added to each extract and the mixture was shaken for 20 min and then was vacuum filtered. The filtrate containing cleaned up residues were analyzed through HPLC.

**Recovery Percentage of Bifenthrin, Profenofos, Endosulfan, Emamectin Benzoate, Diafenthiuron and Imidacloprid Residues**

In order to ensure quality assurance information, before taking up analysis of test samples, the analytical method was standardized by processing spiked samples. Vegetable samples were taken from control plots where no insecticide had been sprayed. Samples were cut into small pieces of about 1–1.5 cm which were thoroughly mixed by tumbling.

After quartering, 200–250g pieces were homogenized in a waring blender. Homogenized matrix (20g), in three replicates was spiked with emamectin benzoate, diafenthiuron, imidacloprid, endosulfan, profenofos and bifenthrin separately. Control samples were processed along with spiked ones.

The processes of extraction, cleanup of pesticide residues were same as described above. Average percent recoveries were 88.92–91 for emamectin benzoate, 87.01-96.24 for diafenthiuron, 76-80.1 for imidacloprid, 78.5-84.36 for endosulfan, 66.67-78.00 for profenofos and for bifenthrin were 77-89.35.

Recoveries were considered satisfactory for all above insecticides in tomato with the proposed methods. Retention times and peak areas of the studied pesticides in samples were comparable with the relative standards.

**Stability of Standard and Working Solution**

Standard stock solutions and working solutions were kept in freezer at -20°C and were found to be stable for 6–8 months. Repeatability/reproducibility was also found to be satisfactory.
DETERMINATION OF PESTICIDE RESIDUE

GC-µECD Determination of Endosulfan, Profenofos and Bifenthrin Residues

For the determination of endosulfan, profenofos and bifenthrin GC-µECD were used which contained Agilent 7890A gas chromatograph, Injector auto-sampler 7683-B, Capillary column HP-5MS (30 m × 0.320 mm × 0.25µm), Detector µ-ECD. Following protocol was used for the analysis.

Table 2: Gas Chromatography Coupled with Micro ECD (GC-µECD) Parameters for Determination of GC Amenable Pesticides (Bifenthrin, Endosulfan and Profenofos Residues)

<table>
<thead>
<tr>
<th></th>
<th>Endosulfan</th>
<th>Bifenthrin</th>
<th>Profenofos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oven:</td>
<td>250°C</td>
<td>250°C</td>
<td>220°C</td>
</tr>
<tr>
<td>Injection port:</td>
<td>280°C</td>
<td>280°C</td>
<td>270°C</td>
</tr>
<tr>
<td>Detector:</td>
<td>320°C</td>
<td>310°C</td>
<td>280°C</td>
</tr>
<tr>
<td>Injection volume:</td>
<td>2µl</td>
<td>2µl</td>
<td>2µl</td>
</tr>
</tbody>
</table>

HPLC Determination of Imidacloprid, Emamectin Benzoate and Diafenthiuron Residues

Separation was carried out on a Supelco LC-18 column (250mm× 4.6mm ID, 5µm) (Supelco Park, Bellefonte, USA). The mobile phase was acetonitrile and de-ionized water with UV (Ultraviolet) detector. Details of HPLC operation is given in Table 3.

Table 3: HPLC Parameters for Determination of HPLC Amenable Pesticides (Emamectin Benzoate, Diafenthiuron and Imidacloprid Residues)

<table>
<thead>
<tr>
<th></th>
<th>Imidacloprid</th>
<th>Emamectin Benzoate</th>
<th>Diafenthiuron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow rate=</td>
<td>1.2ml/min</td>
<td>1.2ml/min</td>
<td>0.7ml/min</td>
</tr>
<tr>
<td>Wavelength=</td>
<td>270nm</td>
<td>246nm</td>
<td>250nm</td>
</tr>
<tr>
<td>Injection volume=</td>
<td>20µl</td>
<td>30 µl</td>
<td>20µl</td>
</tr>
</tbody>
</table>

RESULTS

During the processing of cauliflower samples such as the frying, sun drying and thermal dehydration, weight loss had occurred. During frying, the weight of cauliflower was reduced to 17.9g due to the loss of water. The sun-drying and thermal dehydration reduced the weight of cauliflower by 9.0g and 7.4g, respectively (Table 4).

Table 4: Reduction in Cauliflower Weight by Various Traditional Preservation Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Weight (g)</th>
<th>% of Control</th>
<th>% of Weight Loss</th>
<th>Concentration Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before treatment</td>
<td>50g</td>
<td>100%</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Sun dried</td>
<td>9.0±0.18g</td>
<td>18.8</td>
<td>83.2</td>
<td>5.6</td>
</tr>
<tr>
<td>Dehydration</td>
<td>7.4±0.22g</td>
<td>13.4</td>
<td>88.6</td>
<td>8.1</td>
</tr>
<tr>
<td>Fried</td>
<td>17.9±0.71g</td>
<td>35.8</td>
<td>64.2</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Pesticide Residues (ppm) in Cauliflower

Effect of traditional processing on pesticide residues in cauliflower is shown in Table 5. The results revealed that the residual level of pesticides in unwashed unprocessed cauliflower samples are far above their recommended MRLs i.e Bifenthrin, endosulfan, profenofos, emamectin benzoate, imidacloprid and diafenthiuron and the respective values were
0.151, 0.671, 0.172, 1.04, 1.011 and 0.052 ppm, respectively which is far above their respective MRLS set by FAO i.e. 0.05, 0.5, 0.05, 0.5, 0.4 and 0.02 ppm.

Different traditional methods applied on cauliflower were found effective in reduction of pesticide residues. The most significant reduction was found in plain washed sun-dried samples which brought the pesticide residues of all six pesticides tested, that is, bifenthrin, profenofos, endosulfan, imidacloprid, emamectin benzoate and diafenthiuron within MRLs i.e. up to 0.031, 0.043, 0.089, 0.094, 0.013 and 0.256 ppm, respectively. Similarly, plain washed fried also showed reduction of five pesticides within MRLs namely bifenthrin (0.007 ppm), profenofos (0.006 ppm), endosulfan (0.049 ppm), diafenthiuron (0.016 ppm) and emamectin benzoate (0.434 ppm). On the other hand plain washed blanched samples brought three pesticide residues within MRLs i.e. of bifenthrin (0.042 ppm), endosulfan (0.221 ppm) and imidacloprid (0.211 ppm). Dehydration also played dynamic role in reduction of endosulfan residues (0.292 ppm) within MRLs set by FAO.

Table 5: Effect of Traditional Processing on Pesticide Residues (Ppm) in Cauliflower

<table>
<thead>
<tr>
<th>Traditional Processing Treatments</th>
<th>Bifenthrin (0.05 ppm)</th>
<th>Endosulfan (0.5 ppm)</th>
<th>Profenofos (0.05 ppm)</th>
<th>Imidacloprid (0.4 ppm)</th>
<th>Diafenthiuron (0.02 ppm)</th>
<th>Emamectin Benzoate (0.5 ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unwashed Unprocessed</td>
<td>0.151</td>
<td>1.050</td>
<td>0.172</td>
<td>1.010</td>
<td>0.052</td>
<td>1.040</td>
</tr>
<tr>
<td>Plain Washed Unprocessed</td>
<td>0.092</td>
<td>0.822</td>
<td>0.102</td>
<td>0.727</td>
<td>0.039</td>
<td>0.891</td>
</tr>
<tr>
<td>Detergent Washed Unprocessed</td>
<td>0.082</td>
<td>0.515</td>
<td>0.093</td>
<td>0.525</td>
<td>0.034</td>
<td>0.667</td>
</tr>
<tr>
<td>Plain Washed Blanched</td>
<td><strong>0.042</strong></td>
<td><strong>0.221</strong></td>
<td>0.051</td>
<td><strong>0.211</strong></td>
<td>0.022</td>
<td>0.583</td>
</tr>
<tr>
<td>Plain Washed Sun-dried</td>
<td><strong>0.031</strong></td>
<td><strong>0.089</strong></td>
<td><strong>0.043</strong></td>
<td><strong>0.094</strong></td>
<td><strong>0.013</strong></td>
<td><strong>0.256</strong></td>
</tr>
<tr>
<td>Plain Washed Dehydrated</td>
<td>0.091</td>
<td><strong>0.292</strong></td>
<td>0.086</td>
<td>0.725</td>
<td>0.032</td>
<td>0.822</td>
</tr>
<tr>
<td>Plain Washed Fried</td>
<td><strong>0.007</strong></td>
<td><strong>0.049</strong></td>
<td><strong>0.006</strong></td>
<td>0.449</td>
<td><strong>0.016</strong></td>
<td><strong>0.434</strong></td>
</tr>
<tr>
<td>Leaves</td>
<td>0.120</td>
<td>1.020</td>
<td>0.152</td>
<td>0.900</td>
<td>0.049</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Values marked in bold are within MRLS

Reduction of Pesticide in Cauliflower through Traditional Processing

Bifenthrin, endosulfan and profenofos are fat soluble pesticides which when subjected to plain washing reduced up to 25.0, 28.1 and 14.32%, respectively. Subsequent frying of plain washed cauliflower reduced the residues up to 98.71, 94.32 and 96.75% for bifenthrin, endosulfan and profenofos respectively and the values were within MRLs. Detergent washing contributed 34.61, 48.02 and 35.86% reduction of bifenthrin, endosulfan and profenofos. Blanching, Sun-drying and dehydration have also played dynamic role in reducing bifenthrin (72.18, 93.69 and 84.74%, respectively), endosulfan (58.95, 89.98 and 82.19%, respectively) and profenofos (67.34, 91.1 and 80.39%, respectively) residues. Plain washing followed by frying lowered the residues within MRLs level and made the produce fit for human consumption (Figure 1).
The effects of various traditional processing methods on the water soluble residues are illustrated in Figure 2. The data explained that plain water washing effectively removed the residues up to the level of 40.69, 39.07 and 21.71% for emamectin benzoate, diafenthiuron and imidacloprid. Washing by detergent solution further removed the residues of emamectin benzoate, diafenthiuron and imidacloprid up to 45.93, 55.69 and 50.95%, respectively. The plain washing followed by sun drying, dehydration and frying were also found effective in dislodging the residues of emamectin benzoate (91.23, 87.6 and 88.06%, respectively), imidacloprid (96.68, 83.1 and 84.08%, respectively) and diafenthiuron (93.1, 85.05 and 92.98%, respectively) residues. Blanching treatment was also found effective traditional method by which residues of emamectin benzoate, diafenthiuron and imidacloprid were reduced up to 55.94, 68.69 and 79.11%, respectively. Hence, traditional processing played important role in reduction of the residues below MRLs in cauliflower.

![Figure 2: Effect of Traditional Processing on the Reduction of Water Soluble Pesticide Residues in Cauliflower](image)

**DISCUSSIONS**

Current trend of increased use of pesticides in the world as means of pest control is reflected in ever increasing demand for pyrethroids, organochlorines (OC), organophosphates (OP), nicotinoids and evermectins. Vegetables are short duration crops and in sub tropical climate are prone to insect pest infestations at both growth and maturity stages. To save the crops from economic losses, it is necessary to spray pesticides on crop plants repeatedly during the entire period of growth and development (Jeyanthi and Kombairaju, 2005).

It has also been reported that pesticides are repeatedly being sprayed on cauliflower up to 17 times on an average and 15 times during growing period, so it is the need of the time to monitor the usage globally to assess the environmental load of pesticide residues and find their way into the human body through food, therefore, analysis of pesticide residues in food and their removal by traditional processing have become essential requirement (Toress et al., 2004).

It has been reported that the farmers repeatedly spray different pesticides on cauliflower crop to protect their crop from various pests without any awareness about their hazardous effect on health. It is also routine practice of farmers to send their produce to market only a day after spraying with contamination of residues beyond MRLs.

Fat soluble pesticides as their name suggests are non-polar in nature with low water solubility (25% for bifenthrin, 28.02% for endosulfan and 14.32% for profenofos) resulted in less reduction as compared with detergent washing (34.61% for bifenthrin, 48.02% for endosulfan and 35.86% for profenofos). This is because of fat soluble pesticides are more amenable to detergent solution. Similarly, water soluble pesticides i.e. emamectin benzoate, diafenthiuron and imidacloprid were reduced most efficiently by detergent washing with reduction up to 45.93, 55.69 and
50.95%, respectively and by simple washing the residues decreased by 40.69, 39.07 and 21.71%, respectively. The cauliflower samples were washed thoroughly with tap water in order to remove dirt and debris which reduced the water soluble pesticides also followed by washing with detergent solution and finally washing by running tap water to remove detergent which further reduced the loosely bound surface residues of pesticides.

This is because all pesticides showed more reduction in detergent solution washing as compared to plain water washing. As reported by Kumari et al. (2005) that washing with various chemical solutions for domestic and commercial use are necessary to decrease the intake of pesticide residues. The acidic detergent solutions are more effective in the elimination of organochlorines than alkaline and neutral solutions.

They further reported that common and simple processing techniques acquire significance for reducing the harmful pesticide residues in food. It was further observed that washing was found effective in dislodging the residues as it depends on a number of factors like location of residues, age of residues, water solubility, temperature and type of washing (Kumari et al., 2008). Similarly, Randhawa et al. (2007) and Chauhan and Kumari (2011) reported 15 to 30% reductions of endosulfan residues in brinjal by washing. Pala and Bilisli [14] also supported the above findings and reported that plain washing removed 30.62 percent residues of endosulfan from tomato. Thus present findings are in confirmation with the earlier reports.

Blanching affects both the water soluble pesticides and fat soluble pesticides, this is because the blanching involve the process in which vegetables are dipped in to hot water which is immediately followed by plunging in to cold water which affects both the water soluble and fat soluble pesticides and in our study results also showed that blanching reduced the fat soluble pesticides in the range of 55-72% whereas, water soluble residues reduced by 55-79%. These results are also in confirmation with the findings of Sheikh et al. (2012 a & b), Randhawa et al. (2007) and Bonnochere et al. (2012); they reported that blanching treatment has cumulative effect on reduction of pesticides residues.

Sun drying and dehydration further reduced these residues and brought them below their respective MRLs. Sun-drying and dehydration reduced the water soluble pesticides by 93-96% and 83-87%, respectively whereas, fat soluble pesticides reduced in sun-drying and dehydration up to 89-93% and 80-84%, respectively.

This might be because of ultra-violet (UV) rays that have tendency to cause photo-degradation and hydrolysis of compounds. This statement is in confirmation with the results of Sheikh et al. (2012 a & b), in which it is reported that the pesticides are hydrolyzed in sun due to the presence of UV rays.

Frying was observed to be more effective in reducing the fat soluble residues i.e. in the range of 94-98% as compared to water soluble pesticides which reduced the residues within the range of 84-92%.

The disappearance of pesticide residues by frying could be due to decomposition by the effect of heat, the stronger adsorption of pesticide onto plant tissues and or/the poor solubility of pesticides in water (Sheikh et al., 2012 a & b). The processes that normally occur during cooking are volatilization, hydrolysis and thermal breakdown (Stepan, 2005).

However, also reported that the rate of dislodging of residues due to cooking depends upon factors like temperature, duration of the process, the amount of water, food additives and type of system (open/ closed) [19]. Similar findings have also been reported by various researchers that boiling/ cooking were observed to be more effective in reducing the residues (Kumari, 2008; Chauhan and Kumari, 2011; Sheikh et al., 2012 a & b; Keikothlaie et al., 2010).
CONCLUSIONS

It is concluded that pesticides residues by using traditional processing treatments, can successfully be removed from cauliflower. It is suggested that vegetable consumers may apply sun-drying, dehydration and frying for removal of pesticides residues before consumption.

REFERENCES


