

# Hydrolization of *Raphanus Sativus* L. White Hot Radish Starch to Receive Active Elements and Nutritional Components

Pham Huu Quynh Nhu, Nguyen Phuoc Minh, Dong Thi Anh Dao

Vietnam National Uni. HCMC University of Technology, Vietnam

## ABSTRACT

*Raphanus sativus* L. contains many active elements and nutritional components benefit for human health including essential amino acids, vitamins, mineral ingredients and especially flavonoids. In the scope of this research, the nutritional components of *Raphanus sativus* L. and parameters influencing to production process of *Raphanus sativus* L. powder have been conducted based on such key processes as blanching, enzyme treatment and drying to improve ratio of active elements and nutritional components. Result of experiments shows that first blanching raw material at 80°C for 2 minutes, next having them ground with adding enzyme of 0.2% w/w, keeping at 80°C for 120 minutes, filtering, condensing to the concentration of 9~10% of dry matter, adding maltodextrin to increase concentration of dry matter to 25%, and finally spray drying to get *Raphanus sativus* L. powder with 5.6% of moisture, there is not big change of protein and quercetine, decreasing of antioxidant quantity is 52% vs raw material, 3.5% of ash.

**Keywords:** *Raphanus sativus* L., blanching, enzyme treatment, drying, active element, nutritional component

## 1. INTRODUCTION

The radish (*Raphanus sativus*) is an edible root vegetable of the Brassicaceae family that was domesticated in Europe in pre-Romantimes. They are grown and consumed throughout the world. Radishes have numerous varieties, varying in size, color and duration of required cultivation time. There are some radishes that are grown for their seeds; oilseed radishes are grown, as the name implies, for oil production. Radishes are round to cylindrical with a color ranging from white to red. A longer root form, ideal for cooking, grows up to 15 cm (6 in) long, while the smaller, rounder form is typically eaten raw in salads. The flesh initially tastes sweet, but becomes bitter if the vegetable is left in the ground for too long. Leaves are arranged in a rosette, with sizes ranging from 10–15 cm (4–6 in) in small cultivars, to up to 45 cm (18 in) in large cultivars. They have a lyrate shape, meaning they are divided pinnately with an enlarged terminal lobe and smaller lateral lobes. The white flowers are borne on a racemose inflorescence.

### 1.1 Classification

Kingdom: *Plantae*

Division: *Angiosperms*

Order: *Brassicales*

Family: *Brassicaceae*

Genus: *Raphanus*

Species: *R. sativus*



Figure 1. White hot radish

### 1.2 Nutrient components in white hot radish

Main nutrient components in white hot radish includes (per 100 gram): Moisture 92g, calorie 21 Kcal, protein 1.5g, glucid 3.7g, fiber 1.5g, ash 1.2g, Ca 40mg, Fe 1.1mg, phospho 41mg, vitamin PP 0.5mg, vitamin B1 0.1mg, vitamin B2 0.1mg, vitamin C 30mg, beta-caroten 15microgram, other 15%.

### 1.3 Several studies regarding to white hot radish

Most of studies in Vietnam and all over the world have focused on anti-oxidant activities, nutrient components but not mention to processing application from white hot radish.

### 1.3.1 Extract from white hot radish

Hiroataka Katsuzaki et al., (2004) carried out the comparison of antioxidative activity between the hot water extract and ambient water extract of Japanese radish (daikon). The activity of the hot water extract was higher than that of the ambient water extract. One of the antioxidants was isolated as L-tryptophan that should no change in its amount that was determined between the hot water extract and ambient water extract. Moreover, tryptophan changed to 5-hydroxy tryptophan in the rat liver microsome model. This phenomenon may show that tryptophan is changed to another antioxidant in the body [2].

Tran Thi Hong et al. (2007) studied the enzyme *Perosidase* supplementation from white hot radish to determine mercury content in sewage. *Results showed that protein content was 0.1269 mg/g, POD activity activated at pH=6.5, ion Hg<sup>2+</sup> affected to POD activity, and enzyme inactivated at 5mg/ml Hg<sup>2+</sup>* [13].

Jalila Ben Salah-Abbès et al. (2008) assessed the biological activity of radish extract and to evaluate the protective role of radish extract against the toxicity of zen in female Balb/c mice. Animals were divided into seven groups and treated orally for 10 days as follows: a control, an olive oil group, groups treated with radish extract alone (5, 10 and 15 mg kg(-1) b.w.), a group treated with zen (40 mg kg(-1) b.w.) and a group treated with zen plus the lowest dose of radish extract. The results indicate that radish extract improved the antioxidant status and had no significant effects on hematological and biochemical parameters tested or histology of the liver and kidney. Treatment with zen results in a significant increase in ALT, AST, ALP, BILT, BILD, CRE accompanied with significant changes in most of hematological parameters and the antioxidant enzyme activities, co-treatment of zen and the radish extract results in a significant reestablishment of hematological, serum biochemical parameters, and the histology of the liver and kidney. These findings suggest that radish extract is safe and can be overcome or, at least, significantly diminish zen effects [4].

Rattanamanee Jakmatakul et al. (2009) evaluated antityrosinase and antioxidant activities for two types of extracts (freeze-dried juice and methanolic extract) from the root of Thai radish (*Raphanus sativus* L.) to determine their potential as a skin-whitening and anti-aging agent in cosmetic applications. The contents of total phenolics, total flavonoids and L-ascorbic acid (as per 1 mg of the dried extract) were found to be 10.09, 0.51 and 24.11 µg for the freeze-dried juice and 6.59, 0.33 and 8.28 µg for the methanolic extract, respectively. The freeze-dried juice showed higher potency of tyrosinase inhibition (IC 50 = 3.09 mg/ml) than the methanolic extract (IC 50 = 9.62 mg/ml). Also, the scavenging effects of the freeze-dried juice on DPPH radical, superoxide anion radical and singlet oxygen were greater than the methanolic extract, with the respective IC 50 values of 0.64, 4.20 and 1.42 mg/ml for the freeze-dried juice and 1.25, 6.28 and 2.40 mg/ml for the methanolic extract. The higher contents of phenolic compounds and L-ascorbic acid in the freeze-dried juice appeared to be responsible for its greater antityrosinase and antioxidant activities. However, the activities of both extracts were much less than that of the reference antityrosinase agent (purified licorice extract) and the pure antioxidants (L-ascorbic acid and Trolox) used as positive controls. Measurements of LDH leakage from fibroblast cells indicated that both extracts exhibited only mild cytotoxicity. Thus, provided that a more refined extraction process is developed with further evaluation, the extract of *R. sativus* root appeared to be a good candidate for application as a natural skin whitening/skin anti-aging agent due to its abilities to inhibit tyrosinase and scavenge several types of reactive oxygen species [11].

Syed Sultan Beevi et al., (2010) evaluated the protective effect of different parts of *R. sativus* such as root, stem and leaf obtained with a variety of extraction solvents against cell death and oxidative DNA damage induced by hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) in normal human lymphocytes. *R. sativus* extracts as such showed no cytotoxicity and genotoxicity to the lymphocytes at the tested concentrations. Of the different extracts, hexane extract of root and methanolic extract of stem and leaf showed significant protective effect against oxidative damage induced by 200 µM H<sub>2</sub>O<sub>2</sub> in a dose dependent manner, as compared to cells exposed only to H<sub>2</sub>O<sub>2</sub>. Our results suggest that the protective effect afforded by *R. sativus* extract could be related to the presence of isothiocyanates and polyphenolics, as they possess significant capacity to remove reactive species by virtue of their ability to scavenge free radicals and induce antioxidant enzyme system in the cells [12].

### 1.3.2 Extract from white hot radish germ

Jessica Barillari et al. (2006) evaluated the antioxidant properties of radish (*Raphanus sativus* L.) sprouts (Kaiware Daikon) extract (KDE), in which the glucosinolate glucoraphasatin (GRH), showing some antioxidant activity, presented at 10.5% w/w. The contribution of GRH to KDE's antioxidant activity was considered in two chemical assays (Trolox equivalent antioxidant capacity and Briggs-Rauscher methods). The total phenol assay by Folin-Ciocalteu reagent was performed to quantify the reducing capacity of KDE. Finally, on the basis of the

putative choleric properties of antioxidant plant extracts, the effect on the bile flow of KDE administration was investigated in an animal experimental model. The findings showed that KDE had antioxidant properties and significantly induced bile flow in rats administered 1.5 g/kg of body weight for 4 consecutive days [5].

Rakesh Mohan Kestwal et al. (2011) demonstrated the cruciferous sprouts, including cabbage (*Brassicaoleracea*), broccoli (*Brassicacapitata*) and radish (*Raphanussativus*) cultivated with supplementation of sulphur salts. With supplementation of sulphur at 60 kg/ha, a 2–5-fold increases in total glucosinolates contents in the sprouts were observed. The individual glucosinolates whose concentration increased most significantly, included progoitrin, glucoerucin, glucobrassicin, glucohirsutin and 4-methoxybrassicin. The antioxidant properties of these sulphur supplemented sprouts were also higher than that of the normal sprouts due to the increases of phenolic compounds. Consequently, the glucosinolates fortified sprouts had higher anti-proliferative activity against HepG2 human hepatocarcinoma cells than the normal sprouts, as the cell viability decreased by 22–35%. Also in CT26 mouse colorectal cancer cells, the cell viability decrease by 34–59% [10].

#### 1.4 Several researches regarding to spray drying

Spray drying is a crucial step in this research. With medicinal elements in white hot radish, spray drying should be paid more attention. In spray drying, maltodextrin plays a key role as carrier to enhance dry content, as bead formation during micro encapsulation. Kenyon et al. (1995) proved that maltodextrin could protect carrier out of oxidation but not able to emulsify during micro encapsulation [7]. Yoshii et al. (2001) showed the microencapsulation of emulsified ethyl butyrate by spray drying and its release from the spray-dried powder. Retention of emulsified ethyl butyrate during spray was dependent on the concentration of maltodextrin and the type of emulsifier. The rate of release of the encapsulated ethyl butyrate during storage was not only dependent on the relative humidity of storage, but also on the type of the emulsifier. The rate of release of ethyl butyrate was analyzed using Avrami's equation. The addition of 1% gelatin in the feed liquid had a pronounced influence in increasing the retention of ethyl butyrate during spray drying, and also in controlling the release rate of the encapsulated ethyl butyrate [14]. Raja et al. (1989) analysed the addition to the Dextrose Equivalent value (DE) in the samples for their cold water solubility and clarity, percent age of cold water solubles, and total hydrolyzable carbohydrates. Samples were also analyzed for their hygroscopicity at different relative humidities varying from 40 to 95%. The carbohydrate profile was studied using HPLC and X-ray diffraction pattern were taken and compared. When samples were tried for flavour encapsulation it could be noticed that samples considerably differed in their encapsulation behaviour [9]. Kanakdande et al. (2007) studied the microencapsulations of cumin oleoresin by spray drying using gum arabic, maltodextrin, and modified starch (HiCap® 100) and their ternary blends as wall materials for its encapsulation efficiency and stability under storage. The microcapsules were evaluated for the content and stability of volatiles, and total cuminaldehyde,  $\gamma$ -terpinene and *p*-cymene content for six weeks. Gum arabic offered greater protection than maltodextrin and modified starch, in general, although the order of protection offered was volatiles > cuminaldehyde > *p*-cymene >  $\gamma$ -terpinene. A 4/6:1/6:1/6 blend of gum arabic/maltodextrin/modified starch offered a protection, better than gum arabic as seen from the  $t_{1/2}$ , i.e. time required for a constituent to reduce to 50% of its initial value. However protective effect of ternary blend was not similar for the all the constituents, and followed an order of volatiles > *p*-cymene > cuminaldehyde >  $\gamma$ -terpinene [6].

In health care, people concern to bad effects of oxidants, oxidised reactions so they emphasize on anti-oxidant to protect human health. Free radicals are always produced inside human body, accumulate to high level owing to pollution, ultraviolet light, tobacco smoke, inflammation, food and medicine. In order to eliminate free radicals, we should take anti-oxidants from out side such as beta-caroten, selen, flavonoid, polyphenol, vitamin C... Over several decades, most of researches concentrated on vegetables as medicine. Radish (*Raphanus sativus L.*), apart from root having the most valuable elements, its trunk and leaf also have been consumed as edible vegetables. Radish's extract has various anti-oxidant compounds such as polyphenol, kempferol, cyanidin, myricetin and quercetin to cure stomach disorder, liver, inflammation and bronchitis. Other researches demonstrated radish's extract has biological activity as glucosinolate and isothiocyanates. Apart from anti-oxidants, white hot radish also contains minerals, acid amin Histidin, Tryptophan, Methionie..., vitamin C, B1, B2 [1, 3, 8].

There are not many researches mentioning to production from this cheap and available source. In order to develop products from this useful source as well as improve its commercial value, we decide to study processing protocol for radish powder.

## 2. MATERIAL AND METHODS

### 2.1 Raw material

#### 2.1.1 White hot radish

Raw material white hot radish originated from Da Lat city, Lam Dong province, Vietnam is directly purchased in local Thu Duc market, crossbred F1, weight 150~200g.

#### 2.1.2 Enzyme Amylase

Enzyme Termamyl 120L is produced from *Bacillus licheniformis*. Enzyme is stable at  $\text{Ca}^{2+}$  50 – 70 ppm, starch 30%. KNU (Kilo Novo alpha – amylase Unit): enzyme destruction 5.26 g starch/hour (following Novozyme protocol to determine alpha – amylase)

#### 2.1.3 Maltodextrin

Maltodextrin has been supplied from Path Company., LTD , Tan Binh District, HCM City, manufactured from Qinhuangdao Lihua Starch Co., LTD.

### 2.2 Researching method

#### 2.2.1 Raw material inspection:

- Moisture: Drying 105°C to basic weight
- Crude protein: Kjeldahl
- Reduced sugar: Ferrycyanure
- Ash: Burning at 500°C to basic weight
- Anti-oxidant activity: DPPH
- Acid amin: HPLC
- Vitamin C: Iod titration

#### 2.2.2 Effect of blanching

- a) **Experiment No 1 - Determine blanching temperature:** Blanching strongly affects to soluble elements in raw material owing to dry content loss. Moreover, blanching at high temperature will accelerate oxidation reaction, destroy antioxidant in raw material. In this experiment, we choose blanching duration 2 minutes, blanching temperature 60, 70, 80, 90°C. Then grind raw material, treat with amylase at fixed parameter: 0.1% (v/w), temperature 80°C in 90 minutes, pH 5÷5.2.
- b) **Experiment No 2 - Determine blanching duration:** After finding blanching temperature, we investigate blanching duration at 1, 2, 3, 4 minutes. Then grind raw material, treat with amylase at fixed parameter: 0.1% (v/w), temperature 80°C in 90 minutes, pH 5÷5.2.

#### 2.2.3 Effect of hydrolization by amylase

We conduct three kinds of enzymes pectinase, cellulase and amylase on grinded radish. We recognize that dry content recovery accelerate dramatically while using amylase but not with two others. So we focus on the effect of amylase to treatment of grinded radish mixture.

- a) **Experiment No 3 - Determine enzyme concentration:** Fixed parameters: pH 5÷5.2, hydrolyzing duration 90 minutes, temperature 80°C. Experimental parameters: Enzyme concentration: 0.1; 0.2; 0.3; 0.4; 0.5 (v/w)
- b) **Experiment No 4 - Determine hydrolyzing duration:** Fixed parameters: optimized enzyme concentration in above experiments, pH 5÷5.2; temperature 80°C. Experimental parameters: Hydrolyzing duration 30; 60; 90; 120; 150 minutes
- c) **Experiment No 5 - Determine hydrolyzing temperature:** Fixed parameters: optimized enzyme concentration and hydrolyzing duration in above experiments, pH 5÷5.2. Experimental parameters: Hydrolyzing temperature 70; 75; 80; 85; 90°C.
- d) **Experiment No 6 - Determine pH of hydrolyzing solution:** Fixed parameters: optimized enzyme concentration, hydrolyzing duration and hydrolyzing temperature in above experiments. Experimental parameters: pH of hydrolyzing solution 4.0; 4.5; 5.0; 5.5; 6.0

### 2.3 Analytical method

- Moisture: Drying 105°C to basic weight
- Crude protein: Kjeldahl
- Reduced sugar: Ferrycyanure
- Acid amin: HPLC

- Mineral: ICP-MS
- Dry matter: QTTN/KT3 036:2005
- Ash: Burning at 500°C to basic weight
- Flavonoid: HPLC
- Anti-oxidant activity: DPPH
- Microorganism (TPC/*salmonella*/*Ecoli*): ISO 4833/ ISO 16649-2/ ISO 6579

## 2.4 Statistical analysis

All data are handled by Statgraphic 9.0 with triplicate at least. All numbers are expressed upon average  $\pm$  error (reliability 0.05).

## 3. RESULTS AND DISCUSSION

### 3.1 Raw material quality of white hot radish

Raw material quality of white hot radish contains moisture: 93.6%, reduced sugar 2.12 g/kg, vitamin C 186.3 mg/kg, DPPH 0975.75  $\mu$ mol Trolox/g, quercetin 0.842 mg/kg, ash 0.75%, crude protein 7.5 g/kg, glycine 224 mg/kg, alanin 188 mg/kg, serin 171 mg/kg, proline 137 mg/kg, valine 210 mg/kg, threonine 187 mg/kg, trans-4 hydroxy-L-prolin 130 mg/kg, leucine\_iso leucine 434 mg/kg, phenylalanine 133 mg/kg, arginine 270 mg/kg, aspartic acid 424 mg/kg, glutamic acid 442 mg/kg, lysine 350 mg/kg, histidine 140 mg/kg, tyrosine 126 mg/kg.

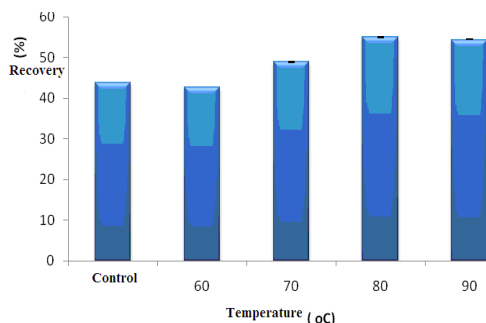
White hot radish has high moisture content so it's highly contaminated. Although crude protein is quite low, it contains non-replaceable acid amins. Notably there are abundant anti-oxidants such as flavonoid, polyphenol, vitamin C, and these components highly contribute raw material value so they should be maintained and improved during processing.

### 3.2 Effect of blanching temperature

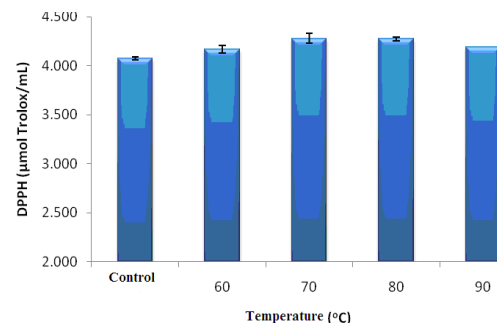
Blanching will tender radish's pulp and support for grinding. Under temperature, peroxidase has been inactivated to prevent browning. Moreover, protein denaturation will also lessen its viscosity and glutinosity so enzymatic treatment can proceed efficiently. However if blanching at high temperature, it will also loose specific flavor and aroma, reduced sugar and other anti-oxidants in raw material.

#### 3.2.1 Dry matter recovery

On figure 2, we see that when blanching temperature increases, dry matter recovery also increases. Blanching at 60°C is not significantly different to control 42.71<sup>a</sup> $\pm$ 0.90%, and increase to 48.91<sup>b</sup> $\pm$ 0.41% while temperature at 70°C and maximum 55.52<sup>c</sup> $\pm$ 0.56% at 80 °C. Blanching at high temperature, soft radish tissue will be ground more easily and hydrolized effectively; dry matter receiving is more and more. However if increasing to 90°C, soluble elements diffuse from raw material to blanching solution apparently and reduce dry matter recovery slightly.



**Figure 2.** Relationship between blanching temperature and dry matter recovery



**Figure 3.** Relationship between blanching temperature and anti-oxidant activity

#### 3.2.2 Anti-oxidant activity

From figure 3 we obviously see anti-oxidant activity increases from 4168.18<sup>b</sup> $\pm$ 12.34 $\mu$ mol Trolox/mL to 4278.36<sup>c</sup> $\pm$ 40.06 $\mu$ mol Trolox/mL when temperature increases from 50°C to 65°C, and drop down dramatically to

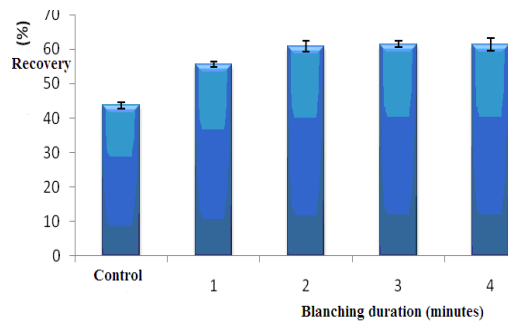


4272.64<sup>c</sup>±49.53 μmol Trolox/mL at 80°C and more reduction at 95°C (4193.22<sup>b</sup>±19.89 μmol Trolox/mL). This phenomenon is explained that at the first stage, tissue become softer and softer, antioxidants follow filtrate. However at higher temperature, anti-oxidants change their structures and lose anti-oxidative activity, some free from blanching solution. So blanching at 80°C is chosen for further experiments.

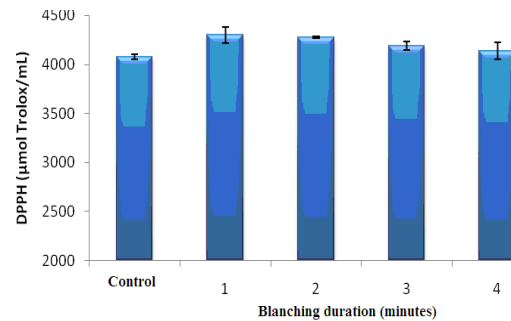
### 3.3 Effect of blanching duration

#### 3.3.1 Dry matter recovery

When blanching at 1, 2, 3 and 4 minutes at 80°C, we see that dry matter content increases at 1-2 minutes with 55.47<sup>b</sup>±0.78%, 59.37<sup>c</sup>±1.56% respectively and decreases at 3 - 4 minutes with 55.73<sup>b</sup>±0.90%, 53.91<sup>b</sup>±0.78% respectively (Figure 4). This can be explained when blanching at 1 minute radish tissue is not soft enough and if increasing temperature its tissue will get loose so dry matter recovery also accelerate. Prolong blanching duration is not significantly increased dry matter recovery.



**Figure 4.** Relationship between blanching duration and dry matter recovery



**Figure 5.** Relationship between blanching duration and antioxidant activity

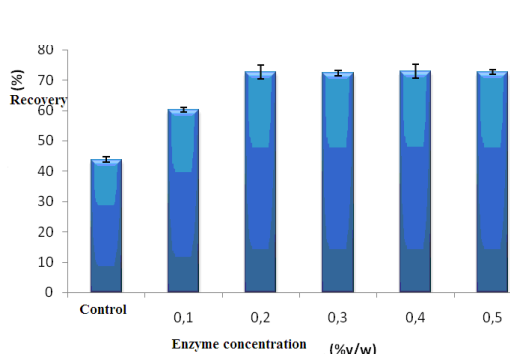
#### 3.3.2 Antioxidant activity

Meanwhile, effect of blanching duration to antioxidant activity is completely different (Figure 5). The more blanching duration, the less antioxidant activity is. Antioxidant activity at 1, 2, 3, 4 minutes is 4298.33<sup>d</sup>±80.36 μmol Trolox/mL, 4275.07<sup>cd</sup>±10.89 μmol Trolox/mL, 4191.07<sup>bc</sup>±45.38 μmol Trolox/mL, 4135.79<sup>ab</sup>±84.16 μmol Trolox/mL, respectively. At . There are two reasons, long blanching duration will change structures of antioxidants and lose in blanching solution. We choose temperature 80°C and duration 2 minutes for blanching.

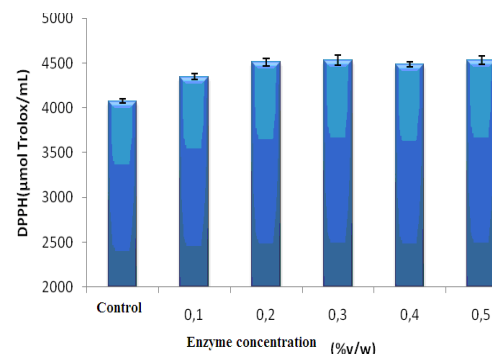
### 3.4 Effect enzyme concentration

#### 3.4.1 Dry matter recovery

Raw material after being blanched is fine grinded ready for hydrolization. Our results show that dry matter recovery in samples fortified with enzyme is higher than control ones. When increasing enzyme concentration from 0.1 to 0.5% v/w dry matter recovery increases 60.16<sup>b</sup>±0.78~72.92<sup>c</sup>±2.39%. Amylase divides starch segment at linkage α-1,4-glucozid to form dextrin short train, enhance dry matter recovery at filtration step. However at enzyme concentration 0.2% dry matter is nearly stable.



**Figure 6.** Relationship between enzyme concentration and dry matter recovery



**Figure 7.** Relationship between enzyme concentration and antioxidant activity

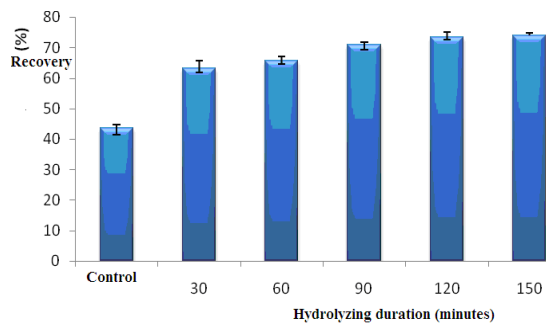
### 3.4.2 Antioxidant activity

From figure 7 we clearly see that antioxidant activity in sample fortified enzyme at 0.1 to 0.5% is higher than control  $4345.39^b \pm 32.49 \sim 4531.74^c \pm 43.77 \mu\text{mol Trolox/mL}$ . If increasing enzyme concentration, starch segment in raw material will be hydrolyzed thoroughly, antioxidant covered by starch will be released into filtrate. Parallel with this process, vitamin C is destroyed by heating or oxidation. However, at enzyme concentration 0.2%, antioxidant activity is nearly stable. We decide to choose enzyme supplementation at 0.2% v/w for further experiments.

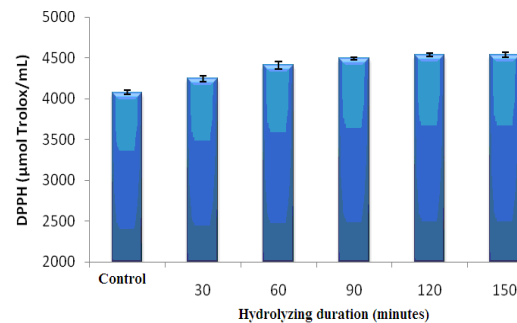
## 3.5 Hydrolyzation

### 3.5.1 Dry matter recovery

From figure 8, we see that hydrolyzing duration increases 30÷150 minutes, dry matter is higher than control. At 120 minutes, dry matter recovery  $73.44^d \pm 1.56\%$ . This proves that the more hydrolyzing duration, starch division will be completely. At 150 minutes, dry matter recovery is not significantly different.



**Figure 8.** Relationship between hydrolyzing duration and dry matter recovery



**Figure 9.** Relationship between hydrolyzing duration and antioxidant activity

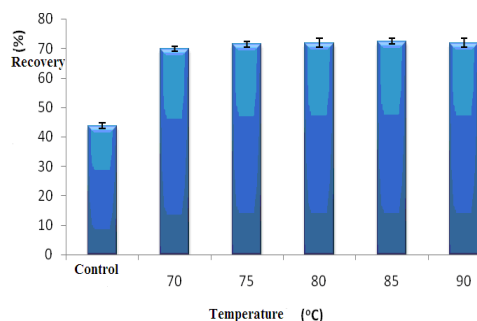
### 3.5.2 Antioxidant activity.

We acknowledge that antioxidant activity in hydrolyzed samples is higher than control one in range of 30÷150 minutes. This is demonstrated phenolic substance freely extracted. In this process, vitamin C doesn't play vital role in antioxidation. At hydrolyzing duration 120 minutes, antioxidant activity is  $4536.63^e \pm 16.88 \mu\text{mol Trolox/mL}$ . If continue increasing to 150 minutes, antioxidant activity is stable at  $4539.24^e \pm 31.27 \mu\text{mol Trolox/mL}$ .

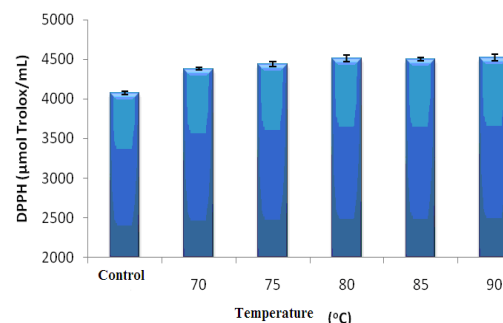
After two experiments regarding to effect of enzyme concentration and hydrolyzing duration, we choose ratio of enzyme supplementation 0.2% v/w in 120 minutes. By that, dry matter recovery increases 69.88% and antioxidant activity accelerates 11.3%.

## 3.6 Effect of hydrolyzing temperature

### 3.6.1 Dry matter recovery



**Figure 10.** Relationship between hydrolyzing temperature and dry matter recovery



**Figure 11.** Relationship between hydrolyzing temperature and antioxidant activity

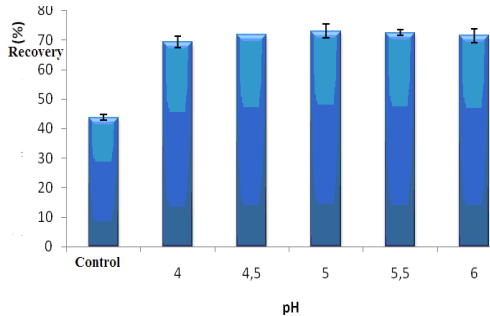
### 3.6.2 Antioxidant activity

From figure 10 and 11, we see that hydrolyzing temperature strongly affect to dry matter recovery and antioxidant activity. When temperature increases from 70°C to 80°C, dry matter recovery goes up  $69.79^b \pm 0.90$  to

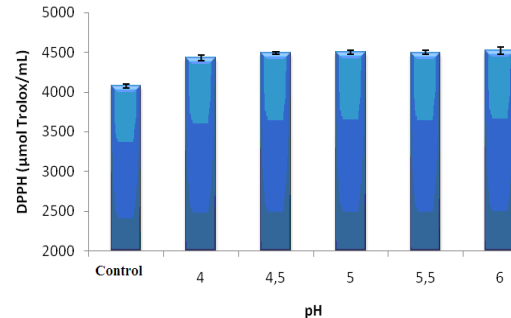
72.65<sup>c</sup>±0.78 % and antioxidant activity from 4379.75<sup>b</sup>±13.77 to 4514.26<sup>d</sup>±45.04 μmol Trolox/mL. If increasing temperature to 85, 90°C dry matter recovery and antioxidant activity all slightly decreased. So 80°C is suitable for further experiments.

### 3.7 Effect of pH in hydrolyzing solution

#### 3.7.1 Dry matter recovery



**Figure 12.** Relationship between hydrolyzing pH and dry matter recovery



**Figure 13.** Relationship between hydrolyzing pH and antioxidant activity

#### 3.7.2 Antioxidant recovery

From figure 12 and 13, we also notice pH has a strongly effect to dry matter recovery and antioxidant activity. At pH 5, dry matter recovery is 72.92<sup>c</sup>±2.39% and antioxidant activity is 4501.63<sup>c</sup>±21.88μmol Trolox/mL. Continue increasing the hydrolyzing pH to 5.5; 6 the dry matter recovery and antioxidant activity is not significantly different. So pH 5 is appropriated for enzyme hydrolyzation.

### 3.8 Quality of radish powder

Nutrients in radish powder are as follows moisture 5.6%, reduced sugar 84.95g/kg, DPPH 22490.94 μmol Trolox/g, quercetin 9.195 mg/kg, crude protein 38.13%, ash 3.5%. Mineral in radish powder are as follow Cr 290.7 ppb, Mn 7743.8 ppb, Fe 6124.1 ppb, Co 547.2 ppb, Ni 600.7 ppb, Cu 4369 ppb, Zn 9999.1 ppb, Se 38.2 ppb, Sr 2738.9 ppb, Sn 98.4 ppb, Ba 2709.5 ppb. Microorganisms in radish powder are as follows TPC 9x10<sup>2</sup> CFU/g, *E. Coli* < 10 CFU/g, *Salmonella* not detected. Acid amin in radish powder are as follows glycine 117 mg/kg, alanine 199 mg/kg, serine 300 mg/kg, proline 117 mg/kg, valine 281 mg/kg, threonine 482 mg/kg, Trans-4 hydroxy-L-prolin 172 mg/kg, leucine\_isoleucine 392 mg/kg, methionine 84 mg/kg, arginine 658 mg/kg, phenylalanine 190 mg/kg, aspartic acid 1036 mg/kg, glutamic acid 594 mg/kg, tryptophan 52 mg/kg, cysteine 6 mg/kg, lysine 400 mg/kg, histidine 161 mg/kg, tyrosine 117 mg/kg, cystine 11 mg/kg

## 4. CONCLUSION

In this research, we conclude some major technical parameters for radish powder production as follows: Raw material: Dry matter 6.4%, weight 150÷200g. Blanching: temperature 80°C within 2 minutes. Enzym hydrolyzation: Amylase 0.2% v/w, pH 5÷5.2, at temperature 80°C in 120 minutes. Spray drying: Maltodextrin supplementation to initial dry matter 25%. Then drying at temperature 160°C, pressure 3.5 bar, input speed 26.92 g/minute. Radish powder : Moisture 5.6%; ash 3.5%; reduced sugar 84.95 g/kg; protein 38.125g/kg; antioxidant activity DPPH 22490.94 (μmol Trolox/g dry matter) and other minerals. In conclusion, from white radish material we can process into different products having high content of acid amin, reduced sugar, phenolics useful for human health.

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