

Feeding Value of Dried Fermented and Unfermented Vegetable Based Agro By-Products (VBAP)

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Abstract— Vegetable Based Agro By-Products (VBAP) can be used as an alternative feed ingredient amidst rising commercial feedstuff costs. VBAPs contains nutritional amounts needed by animal for growth and reproduction. The proximate analysis and mineral content of a number of vegetable based agro byproducts which includes; cabbage (*Brassica oleracea* var. *capitata* L) trimmings, carrot (*Daucus carota* L) tubers, chayote (*Sechium edule*) fruits, lettuce (*Lactuca sativa* L.) leaves, broccoli (*Brassica oleracea* L. var. *Italica* Plenck) trimmings, tomato (*Solanum lycopersicum* L.) fruits, Chinese cabbage/wombok (*Brassica rapa* subsp. *pekinensis*) trimmings and potato (*Solanum tuberosum*) tubers are presented in this research. Drying the VBAP and fermentation has been studied in these researches which are methods in prolonging the shelf life and easier integration to animal feeds. The study revealed that dried unfermented VBAP have lower moisture and NFE contents, while higher in DM, ash, CP, crude protein, crude fat content compared to dried fermented VBAP (*p*-values of less than 0.01). Mineral content such as calcium has lower amount in dried unfermented VBAP but has higher amount in phosphorus compared with fermented dried VBAP (*p*-values of less than 0.01). Therefore, dried unfermented VBAP has greater potential than dried fermented VBAP as animal feed. Though, complete potential of these alternative feeds and feed resources can be appreciated by intensive study.

Keywords— Feeds, Fermentation, mineral content, proximate analysis, VBAP.

I. INTRODUCTION

Vegetable based agro by-products are unwanted to some farmers in cultivated areas and vegetable markets which considered as wastes, though, these by products can be considered as alternative sources of feed for animal production. Recycling of by-product as feedstuffs for animal production is an important factor in waste reduction. The by-product residues can be classified as fruit and vegetable by-products, oil industry by-products and grain- and legume-milling industry by-products. Use of by-products from agro-industry could lessen animal production cost and can resolve waste disposal and environmental pollution problem. Furthermore, production of feedstuffs can be supported with the use of fruit and vegetable by-products as feeds and feed sources (Yang et al., 2021).

Utilization of these byproducts give the needs to identify the nutritional content for feed formulation. Feed quality or nutritional value is an idea that involves many indicators like energy and protein content, chemical composition, consumption and digestibility (Kirilov et al., 2017). Vegetable wastes and by-products such as sugar beet leaves, potato vines, bottle gourd pulp, radish leaves, cabbage leaves, pumpkin oil meal, snow peas among others are good source of energy and crude protein (CP) particularly for ruminant animals which contains more than 20% CP. Other vegetable wastes hold 19% to 10% CP contents. On the other hand, vegetable waste such as sweetcorn husk, and cob, waste of jackfruit and carrot pulp contains a CP with less than 10% (Bakshi et al., 2015). Furthermore, fruit seed cakes of passion fruit, soursop and custard apple could be use as feed

for animals after industrial process. They contain high amount of dry matter with low moisture content which can become a better alternative for ruminant feedstuff that may lessen the expenses in animal production (Pinto et al., 2020).

Though, agricultural by products required preservation for longer shelf life and needs to improve the nutritional value. Fermentation plays important part in food preservation via development organic acid such as formic acid, lactic acid, propionic acid and acetic acid. It includes also the production of reutrin, ethanol, carbon dioxide, bacteriocins and diacetyl. Fermentation could improve food safety, remove toxic compounds, improve the food quality and nutritional value (Ray and Joshi, 2015). Acetic acid produced by LAB strains prevents spoilage and contributes to the aroma. The LAB producing thermostable amylases have potential fermentations of tubers, cereal, and root. The LAB acidifies foods that frequently exert proteolytic and lipolytic activities and produce amino acids upon further bioconversion that contributes to the aroma and flavor of fermented products. LAB could increase nutraceuticals content in fermented foods and increase the quantities of low-calorie polyols in order to lessen amount of sugar. Furthermore, LAB stains may prevent galactose accumulation and lactose intolerance by eliminating the lactose and galactose from fermented milks. Moreover, content of soy that results to intestinal cramps and flatulence can be removed through fermentation (Ray and Joshi, 2015).

Great challenge in feed security is preservation because agricultural by products are highly perishable. To preserve these products, drying is an important technique used. Drying of food by products is appropriate way for extending shelf life and storage. Moreover, drying favors easy and economical packaging and transport, reduction of greenhouse gas, smaller space for storage and lesser environmental weight (Noori et al., 2022). Drying are used for the long-term storage to preserve raw materials where in, some grains need atleast 9% moisture content depending on the grain and climate (Lyda and Kyosung, 2018). Methods of drying raw materials includes convection/air drying, this is characterized by a method simultaneous movement of mass and heat. Other method is freeze-drying which is the most conventional technique of drying fruits, vegetables and LAB, since the resulting product is of good quality, less effect on nutritional value, aroma, texture and color (Janiszewska-Turak et al., 2021). Other drying methods used for agricultural products, meat products and medicinal plants includes solar drying, ultrasound drying, microwave drying, spray drying, fluidized bed drying and vacuum drying (Noori et al., 2022).

Recent researches disclosed that drying agricultural by products is important for preservation and significant result of fermentation improved the nutritional value of agricultural byproducts, though published data for the nutritive value of VBAP is limited.

This study aims to determine the chemical composition and mineral content of locally available VBAP and comparing the value of dried unfermented and fermented VBAP.

II. MATERIALS AND METHODS

2.1 VBAP Collection:

Collection of VBAP were conducted at vegetable farms around Benguet province and La Trinidad Vegetable Trading Post which includes; cabbage (*Brassica oleracea* var. *capitata* L) trimmings, carrot (*Daucus carota* L) tubers, chayote (*Sechium edule*), lettuce (*Lactuca sativa* L.), broccoli (*Brassica oleracea* L. var. *Italica Plenck*), tomato (*Solanum lycopersicum* L.) fruits, Chinese cabbage/wombok (*Brassica rapa* subsp. *pekinensis*) and potato (*Solanum tuberosum*) tubers.

2.2 Fermentation procedure of VBAP:

VBAP samples were chopped at approximately 3 cm in size and weighed. Molasses was mixed at the chopped VBAP at 15% rate based from the weight of the VBAP. Mixture of VBAP and molasses were filled-in and compacted firmly in the empty high-density polyethylene plastic jar that were installed with airlock fermenter. After filling, containers were tightly sealed using waterproof aluminum foil tape to avoid oxygen from entering inside the container. Containers filled with VBAP were stored within 20 days in a cool dark area. After fermentation, Samples were subjected to oven drying at 70 degrees Celsius within 48 hours.

2.3 Proximate analysis:

Oven dried Unfermented and fermented VBAP undergo proximate and mineral analysis. Nutrient contents such as crude protein (CP), crude fat, crude fiber (CF), moisture, Dry Matter (DM), Nitrogen Free Extract (NFE) and ash following the AOAC International guidelines (2005) content and mineral contents such as calcium and potassium were analyzed at Lipa Quality Control Center Inc. (LQCCI) North, Gov F Halili Ave, Barangay Turo, Bocaue, Bulacan.

2.4 Experimental Design and Statistical Analysis:

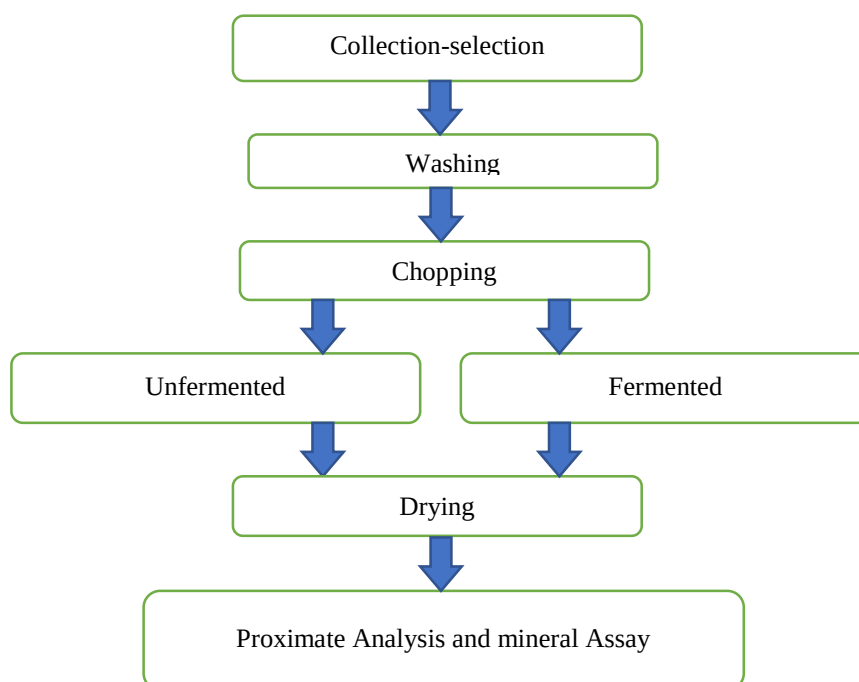


FIGURE 1: Research diagram of Study 2

This study was conducted in an 8x2 factorial in CRD replicated 3 times with different unfermented VBAP as Factor A namely: cabbage trimmings, carrot tubers, sayote, lettuce, broccoli, tomato fruits, Chinese cabbage/woombok and potato tubers and fermented VBAP as Factor B (with 15% molasses). Data was analyzed using SPSS ver 21. Analysis of variance (ANOVA) and statistically significant parameters will be compared using Least Significant Difference (LSD).

III. RESULTS AND DISCUSSION

3.1 Proximate Analysis Content of Dried Unfermented and Fermented VBAP:

Table 1 presents the results on the proximate analysis content of dried VPAB with computed p-values of less than 0.01. Result indicates that broccoli has higher moisture, ash and CP content after fermentation but has lower amount of DM, crude fiber, crude fat and NFE after fermentation compared with unfermented broccoli. Unfermented cabbage has lower moisture, ash, crude fiber and NFE content but higher DM, CP and crude fat and NFE compared with fermented cabbage. In carrot, unfermented one contains greater amount of moisture, crude fiber and crude fat content while lesser amount on DM, ash, CP, and NFE compared with the fermented one. Unfermented chayote has higher amount of moisture, CP, crude fiber and crude fat content while lower amount on DM, ash and NFE compared with fermented. Unfermented Chinese cabbage has lower moisture, crude fat and NFE content and while higher DM, ash, CP and crude fiber than fermented Chinese cabbage. Meanwhile, unfermented lettuce has lower moisture and NFE content but higher DM, ash, CP, crude fiber and crude fat content than fermented. In addition, unfermented potato has higher DM, ash, CP and NFE content but lower moisture, crude fiber and crude fat content compared with fermented potato. Lastly, unfermented tomato has higher moisture, CP, crude fiber, and crude fat content while lower content on DM, ash and NFE compared with fermented tomato.

On the other hand, unfermented tomato, fermented Chinese cabbage and fermented cabbage contained the highest amount of moisture while unfermented potato and unfermented lettuce has the lowest moisture content. VBAP with highest dry matter content are unfermented lettuce, unfermented potato and unfermented broccoli while lowest in unfermented tomato and fermented carrot. Unfermented lettuce followed by unfermented Chinese cabbage and fermented Chinese cabbage contains the highest amount of ash while unfermented and fermented potato has the lowest ash content. In CP content, unfermented Chinese cabbage, unfermented cabbage and unfermented lettuce contains the highest amount while lowest amount of CP in fermented chayote and unfermented carrot. Furthermore, unfermented broccoli, unfermented lettuce and fermented broccoli contained the highest amount of crude fiber while unfermented potato and fermented chayote have the lowest crude fiber content. VBAP with highest crude fat content are unfermented lettuce, unfermented tomato and unfermented broccoli while fermented potato

and unfermented potato has the lowest crude fat content. Lastly, VBAP with highest NFE content are unfermented potato, fermented potato and fermented chayote while lowest NFE content are unfermented Chinese cabbage and unfermented lettuce.

Unfermented carrot contains 14.31% amount of moisture higher than 8.78% moisture content of carrot powder stated by Gazzali et al. (2013). Unfermented chayote has 10.71% moisture content which is little higher than the result of the study of Islam, et, al., (2018) with 10.18% amount of moisture of oven dried chayote. Ashraf, (2015) stated that unfermented carrot peels contain 7.46%, while fermented carrot peels has 26.7%.

Result from the study of Gazzali et al. (2013) presented lower content on ash (5.05%), protein (6.16%) and crude fat (2.43%) while higher amount on crude fiber (24.66%) of carrot powder. Meanwhile, Islam et al. (2018) reported lower amount on ash (0.21%), crude protein (0.48%), crude fiber (0.32%) and crude fat (0.06%) of chayote compared with the result of this study.

Findings of Sun et al. (2017) showed lower content on ash (4.0%), crude protein (8.65%) but higher crude fat (11.31%) of dried unfermented potato. On the other hand, Ashraf (2015) discussed higher content on ash (11.2%) and crude fiber (17%) crude fat (3.84%) of unfermented carrot peels while lower content on CP (4.47%) and lower content on ash (7.8%), CP (7.81%) and crude fat (1.54%) though higher crude fiber (12.75%) of fermented carrot peels compared with the findings in this study.

TABLE 1
PROXIMATE ANALYSIS CONTENT (%) OF DRIED UNFERMENTED AND FERMENTED VBAP

		Broccoli	Cabbage	Carrot	Chayote	Chinese Cabbage	Lettuce	Potato	Tomato
Moisture	un	5.52	10.51	14.31	10.71	6.66	4.6	4.8	14.66
	f	9.82	10.77	10.71	9.61	11.67	9.86	6.85	8.4
DM	un	94.48	89.49	85.69	89.29	93.34	95.4	95.2	85.34
	f	90.18	89.23	89.29	90.39	88.31	90.14	93.15	91.6
Ash	un	11.83	10.51	10.88	7.74	16.63	24.57	6.03	9.91
	f	11.92	12.01	11.44	9.65	13.91	12.88	5.96	10.28
CP	un	13.73	20.73	10.15	10.83	28.27	18.98	11.84	18.3
	f	17.95	18.74	11.42	10.24	16.23	17.39	10.67	12.04
Crude Fiber	un	14.33	10.39	8.82	8.72	12.52	14.06	2.63	11.38
	f	13.21	10.72	7.11	2.38	7.09	8.78	6.97	7.95
Crude Fat	un	4.76	3.48	2.63	3.07	3.03	5.88	1.26	4.82
	f	3.82	2.96	2.08	2.48	3.87	3.73	1.28	3.85
NFE	un	49.84	44.38	53.21	58.93	32.89	31.92	73.45	40.94
	f	43.29	44.8	57.25	65.64	47.21	47.35	68.26	57.48

**Note- un - unfermented; f - fermented*

3.2 Calcium (Ca) and phosphorus (P) Content of Dried Unfermented and Fermented VBAP:

Table 2 shows the result of calcium and phosphorus content of dried unfermented and fermented VBAP with computed p-values of less than 0.01. Unfermented broccoli, unfermented Chinese cabbage and unfermented lettuce have higher calcium contents while unfermented cabbage, unfermented carrot, unfermented chayote, unfermented potato and unfermented tomato have lower calcium content than fermented ones. Moreover, unfermented broccoli, unfermented chayote and unfermented potato have lower phosphorus content while higher content on unfermented cabbage, unfermented carrot, unfermented Chinese cabbage, unfermented lettuce and unfermented tomato compared to fermented counterparts.

Meanwhile, unfermented broccoli had the highest calcium content followed by unfermented Chinese cabbage and unfermented lettuce respectively. On the other hand, unfermented chayote and unfermented tomato had the lowest calcium contents with values of 0.42% and 0.41%, respectively. Furthermore, unfermented Chinese cabbage had the highest phosphorus content with a value of 0.91%. This was followed by unfermented cabbage and unfermented lettuce with values of 0.56% and 0.49%, respectively. On the other hand, unfermented chayote and unfermented potato had the lowest phosphorus contents with values of 0.27% and 0.23%, respectively.

Sun, et, al. (2017) reported lower phosphorus (0.098) content of unfermented potato and fermented potato with 0.056% phosphorus compared with the finding in this study.

TABLE 2
CALCIUM AND PHOSPHORUS CONTENT OF DRIED UNFERMENTED AND FERMENTED VBAP

VBAP	Ca		p	
	un	f	un	f
Broccoli	1.66	0.86	0.33	0.39
Cabbage	0.72	1	0.56	0.51
Carrot	0.45	0.83	0.48	0.43
Chayote	0.42	0.84	0.27	0.28
Chinese Cabbage	1.25	1.11	0.91	0.42
Lettuce	1.14	1.14	0.49	0.39
Potato	0.24	0.49	0.23	0.29
Tomato	0.41	0.73	0.45	0.31

IV. CONCLUSION

In conclusion, VBAP contains nutrient needed by the animals as revealed in the gathered data results and can be used as alternative feeds for animal production. Likewise, dried unfermented VBAP appears to have higher potential as animal feed compared with dried fermented VBAP as exposed in the result of proximate analysis which includes moisture content, dry matter, ash, crude protein, crude fiber, crude fat, nitrogen free extract and analysis of mineral content such as calcium and phosphorus. Nevertheless, problems of insufficient records of published study on VBAP were observed. Further exploration of VBAP on fermentation, practical application and nutrient analysis of VBAP is hereby recommended.

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