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Technolgical ,physical and biological Studies on Hemicelluloses and Carboxymethyl cellulose produced from Agro-industrial by-products and their application in Food technology

By

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6- English Summary

This work was designed to study the possibility of extracted hemicellulose and produced carboxymethyl cellulose from aGro-industrial by-products (rice hull, rice bran, wheat bran and sugar beet pulp) and their application as fat replacers in preparing low fat beef burger and edible coatings on fresh strawberry during cold storage for 14 days at 4±1C^{O} and 70-75% relative humidity (RH). Also, studying the possibility of using hemicellulose and carboxymethyl cellulose on the biological and effects in experimental rats which have hypercholesterolemic.

Therefore, this study aimed to:

1. Determination of chemical composition (%) of aGro-industrial by-products (rice hull, rice bran, wheat bran and sugar beet pulp).
2. Studying the Physicochemical characteristics of hemicellulose and carboxymethyl cellulose obtained from (rice hull ,rice bran,wheat bran and sugar beet pulp) compared with that of commercial CMC.
3. Studying the infrared spectra in hemicellulose and the confirm substitution reaction in carboxymethyl cellulose obtained from (rice hull, rice bran,wheat bran and sugar beet pulp) compared with that of commercial CMC.
4. Evaluating the effect of addition different concentrations of hemicellulose and carboxymethyl cellulose obtained from aGro-industrial by- products as fat replacers on physical, chemical and sensory properties of low fat beef burger.
5. Studying the effect of using hemicellulose and carboxymethyl cellulose obtained from aGro-industrial by- products as edible coating on physico–chemical, microbiological and sensory changes occurred in coated strawberry during cold storage for 14 days at 4±1C^{O} and 70-75% relative humidity (RH).
6. Studying the effect of feeding hemicellulose and carboxymethyl cellulose obtained from aGro-industrial by- products on hypercholesterolemic rats.

<u>The results of our investigation can be summarized in the following points:</u>

1. The Gross chemical composition of (rice hull, rice bran,wheat bran and sugar beet pulp) were as follow: Moisture was8.43% , 8.30%,8.12% and 8.75%, protein was 1.87%, 14.30%, 10.30% and 9.80%, ether extract was 18.00%, 1.02%, 6.90% and 6.83%, ash content was 16.21% ,8.90% , ,11.91% and7.95%, crude fiber was 32.11% , 14.13% , 10.41 % , 18.64

% , carbohydrates content was 48.79 %, 44.67 %, 60.48 % and 56.78 %, Cellulose content was 45.88% ,23.45% , 14.45% and34.34 %, Hemicellulose content was 14.29 %,28.11 %,49.85 %and 29.76, Lignin content was10.32%, 5.60%,5.85% and8.52%,silica content was 10.20%, 0.96% , 0.18% and1.09 respectively.

2. The percentage of hemicellulose extracted from wheat bran was high with a percentage of HC of 13.18% followed by HC extracted from rice bran which was 13.00% , HC extracted from sugar beet pulp which was 12.85% and HC extracted from rice hull which was 11.25%.
3. Hemicellulose extracted from rice hull had a high moisture and ash content(3.72 and 9.35%) respectively, while HC extracted from wheat bran had the highest Water holding capacity and oil holding capacity (23.11g/g and6.14g/g) respectively, compared with other hemicellulose extracted from aGro-industrial by-products
4. carboxymethyl cellulose produced from sugar beet pulp, had the highest value of the degree of substitution(DS) 0.84and CMC (69.7%) followed by CMC produced from rice bran which had (0.78) DS and (65.8% CMC), Commercial CMC which had (0.76) DS and (59.75% CMC) , CMC produced from Wheat bran which had (0.75) DS and (59.1%) CMC and produced from rice hull which had (0.63) DS and (51.2% CMC).
5. Water holding capacity and oil holding capacity of carboxymethyl cellulose produced from (rice hull ,rice bran, wheat bran and sugar beet pulp) are significantly higher than that of commercial CMC.
6. Carboxymethyl cellulose produced from sugar beet pulp, was found to be the highest value for swelling capacity while carboxymethylcellulose produced from rice hull showed the least swelling capacity, which is directly proportional to their DS respectively. Also carboxymethyl cellulose produced from rice hull showed the lowest water solubility index, which significantly varied from other Carboxymethyl cellulose produced aGro-industrial by-products.
7. The FTIR spectra of hemicellulose extracted from (RB, RH, WB and SBP) within the region of 500 - 4000 cm^{-1} including region 850 - 1200 cm^{-1} which is typical region for hemicellulose .the band at around 1408 cm^{-1} is due to the −CH and −OH groups bending. The presence of xylans was found at 1034 to 1040 cm^{-1}. The band at 895 cm^{-1} is due to β-glucosidic linkage between monosaccharides.

8. From the representative spectrum of carboxymethyl cellulose produced from (rice hull ,rice bran, wheat bran and sugar beet pulp) compared to commercial CMC, the strongest absorbance were at 1608, 1419 and 1055 cm^{-1}. This result was indicated the presence of carboxymethyl substituent from CMC production at COO–, –CH_2 and –O– Group. This result corroborated that CMC could be produced from cellulose of aGro-industrial by-products (rice hull ,rice bran, wheat bran and sugar beet pulp)

9. **<u>Prepared beef burger contained HC and CMC obtained from aGro-industrial by-products.</u>**

<u>9.1. Chemical composition of uncooked and cooked beef burger.</u>

- Moisture content was increased as the replacement level increased.
- Fat content of control beef burger had the highest amount of fat with significant differences compared to that of other treatments
- Protein and Crude fiber contents of the fat-replaced uncooked and cooked beef burgers were increased as the replacement levels increased.
- Cooked beef burgers have percentages of moisture, ether extract and protein lower than uncooked beef burger.

<u>9.2. Physical properties and feder value of beef burger</u>

- WHC values of beef burger prepared with HC extracted from aGro-industrial by-products at different concentrations ranged from 58.17to 65.61% meanwhile, WHC values of beef burger prepared with CMC produced from aGro-industrial by-products at different concentrations ranged from 59.11to 66.52% compared to 56.47% for control beef burger,
- The values of protein water coefficient (PWC) , protein water fat coefficient (PWFC), which are considered as indices for tenderness of the prepared beef burger, increased Gradually with the increasing of CMC produced from aGro-industrial by-products with concentration (1.0,1.5 and 2.0 %) comparing to control sample.

<u>6.3. Cooking properties and pH value of beef burger</u>

- All treatments which prepared with HC and CMC as fat replacers had a reduction in diameter with the full-fat control shrinkage due to the high loss in fat and moisture during cooking.
- Cooking loss of beef burger enriched with different concentrations of HC and CMC decreased with increasing the addition concentrations

since beef burger enriched with HC and CMC had cooking loss values lower than that of control. the highest value of cooking loss was observed with beef burger control (24.96%) while, The lowest value observed with beef burger containing HC (17.95 %)in a sample containing 2.0% HC produced from wheat bran, while, The lowest value observed with low beef burger containing CMC was 16.67% in a sample containing 2.0% CMC produced from sugar beet pulp

- HC and CMC obtained from aGro-industrial by-products at different concentrations improved the shrinkage, diameter reduction and cooking loss of low fat beef burger in compare with those of high beef burger control.

9.4. Texture Profile Analysis (TPA) of beef burger:

Hardness, springiness, gumminess, and chewiness value of cooked beef burger decreased significantly at ($P>0.05$) with increasing fat replacer produced from aGro-industrial by-products.

9.5. Sensory evaluation of beef burger

- It could be noticed that there were no significant difference at ($P<0.05$) in all sensory properties between all beef burger formula except color which had a significant decrease at ($p\leq0.05$) with increasing concentrations HC and CMC obtained from aGro-industrial by-products.

10. Effect of HC and CMC edible coating on fresh strawberry during cold storage for 14 days at $4\pm1C^{O}$ and 70-75% relative humidity (RH).

- decay increased significantly ($p<0.05$) during storage of both coated and uncoated samples. Where, all types of coating samples significantly ($p<0.05$) reduced decay during cold storage compare to uncoated samples.
- Hemicellulose and carboxymethyl cellulose obtained from agro-industrial by-products at concentration 1.0% are the best in reducing decay in strawberries comparing with HC or CMC in concentration 0.5, 1.5 % .
- weight loss significantly ($p<0.05$) increased during cold storage of both coated and uncoated samples. Where, all types of coating samples significantly ($p<0.05$) reduced weight loss during cold storage compared to uncoated samples.

- Total titratable acidity significantly decreased during cold storage of both coated and uncoated samples. Where, all types of coating samples significantly reduced total titratable acidity during cold storage compare to uncoated samples.
- Changes in TSS of stored strawberries coated with different concentrations of hemicellulose and carboxymethyl cellulose obtained from agro-industrial by-products . Generally all coated and un-coated samples had TSS content within the range of 9.65 to 12.85. Significant ($p \leq 0.05$) increase was observed in the samples coated with HC and CMC compared with uncoated strawberry during storage.
- The firmness of uncoated and coated strawberry was Gradually decreased with increasing the storage period .However, coating of fruits showed a significant beneficial effect on firmness retention. Where, all types of coating samples significantly reduced firmness retention during cold storage compare to uncoated samples.
- Ascorbic acid content significantly ($p<0.05$) decreased during storage of both coated and uncoated samples. Where, all types of coating samples significantly ($p<0.05$) reduced the decrease of ascorbic acid content during storage compare to uncoated samples.
- Molds and yeast count decreased Gradually with the increasing of HC or CMC concentrations obtained from aGro-industrial by-products comparing to control sample. However, samples coating with HC or CMC concentrations obtained from aGro-industrial by-products at concentrations of 1.0% were the best among all coatings in reducing concentrations of molds and Yeasts at the end of storage period.
- Total bacteria count decreased Gradually with the increasing of HC or CMC concentrations obtained from aGro-industrial by-products comparing to control sample. However, samples coating with HC or CMC concentrations obtained from aGro-industrial by-products at concentrations of 1.0% were the best among all coatings in reducing concentrations of bacteria at the end of storage period.
- Sensory evaluation significantly ($p<0.05$) decreased during storage of both coated and uncoated samples. Where, Uncoated samples (control) showed significant loss of quality at 6th days of storage, and then became unaccepted and discarded that due to high

shrinkage, less color, low quality and fungal deterioration while coating sample were relatively maintained to 14 days of storage.

11.Effect of feeding on replacing hemicellulose and carboxymethyl cellulose extracted from Wb and Sbp of cellulose on hyper-C rats.

- Final body weight of hyper-C rat in Group2 (control +ve) was higher than the negative Group (Gr1). Body weight gain of the other Groups showed significant reduction in comparing those of hyper-C rats in Group 2 (control +ve)
- the weight of liver in group 2 (control +ve) had the highest weight being (6.59g) and relatively liver weight (2.53) among all examined groups. Meanwhile, the lowest value in liver weight of rats fed with replacement with HC.WB and CMC.SBP of cellulose in the diet after hyper-C were lower than those of (control +ve).
- Total cholesterol content at final experiment for Group 1 (control -ve) was 132.25 mg/dl, whilst a total cholesterol content of Group 2 (control +ve) was 254.33 mg/dl. Moreover, rat Groups Gr_3, Gr_4 and Gr_5 which fed on hyper-C diet substituted with HC.WB at concentrations 30,60 and 90% of cellulose showed values of 168.95, 157.28and 152.21 mg/dl respectively while, rat Groups Gr_6, Gr_7 and Gr_8 which fed on hyper-C diet substituted with CMC.SBP at concentrations 30,60and 90% of cellulose showed values of 165.47 ,157.00 and 150.20 mg/dl respectively.
- Total triglycerides (TG) for group 1 (control -ve) was 117.78 mg /dl after 12weeks and increased to 219.13 mg/dl in hyper-C rats which fed on hyper-C diet in (Gr_2) while, total triglycerides contents for Gr_3, Gr_4 and Gr_5 which fed on hyper-C diet in replacement with HC.Wb (30,60 and 90%) showed values of 136.7 , 134.23 and 131.45 mg/dl respectively. While, the total triglycerides contents for Gr_6, Gr_7 and Gr_8 fed on hyper-C diet replaced by CMC.SBP (30, 60 and 90%) showed values of 137.22, 133.36 and 130.94 mg/dl respectively.
- Replacement of feeding hyper-C diet with HC.Wb and CMC.Sbp led to enhancement HDL-C.In addition to, hyper-C diet with HC.Wb and CMC.Sbp replacement at 90%.
- LDL-C from $group_1$ (control -ve) was 43.88 mg/dl, whilst value of hyper-C $group_2$ (control +ve) was 165.39 mg/dl. Furthermore, LDL-C of rats fed on hyper-C diet replaced by HC.Wb at the level of 30,

60 and 90% (Gr_3, Gr_4 and Gr_5) become 82.40, 69.40and 62.29 mg/dl, respectively. Whilst, LDL-C of rats fed on hyper-C diet substitution with CMC.SBP at the ratio 30 ,60 and 90% (Gr_6, Gr_7 and Gr_8) was 76.03 ,65.51 and 57.63 mg/dl, respectively.

- V.LDL-C of (control -ve) recorded 23.61 mg/dl, whilst the value of Group 2 (control +ve) was 43.76 mg/dl. Meanwhile, v.LDLC of rats which fed on hyper-C diet substituted by HC.Wb 30, 60 and 90% groups(Gr_3, Gr_4 and Gr_5) were 27.33, 26.80 and 26.26 mg/dl, respectively. While, the v.LDL-C of rats fed on hyper-C diet replacing with CMC.Sbp 30 ,60 and 90% (Gr_6, Gr_7 and Gr_8) being 27.40, 26.63 and 26.16 mg/dl, respectively.
- Blood sugar concentrations of hyper-C Groups were significantly higher than those of Group 1 (control -ve), also different concentrations of HC.Wb and CMC.Sbp of cellulose.
- The concentration of AL.T of the hyper-C (control +ve) increased significantly compared with Group $_1$ (control -ve)which was 52.73 and 30.46 U/L respectively. Meanwhile, the feeding on hyper-C diets replaced by HC.Wb (Gr_3, Gr_4 and Gr_5) led to more decrease at level 30,60 and 90% which were 39.26, 36.88 and 35.73 U/L, respectively.
- High cholesterol diet caused significant increase of AS.T ($P<0.05$) control +ve which was 73.26 U/L compared to control -ve (52.37 U/L). Whilst, the feeding on hyper-C diets replaced by HC.Wb of cellulose at 30,60 and 90% were 59.53, 58.35 and 55.39 U/L respectively for(Gr_3, Gr_4 and Gr_5) , Also, AS.T in rats on hyper-C diets replaced by CMC.SBP at 30,60and 90% were 58.50, 57.34 and 54.38 U/L respectively for (Gr_6 , Gr_7 and Gr_8).
- hyper-C rats which fed on HC.Wb and CMC.Sbp at levels 30,60and 90% had significant reduce concentrations in creatinine, uric acid and urea in blood compared with those of hyper-C group 2 (control +ve). ($P\leq0.05$). Whilst, group 1 (control -ve) Which fed on the basal diet had a significant reduce of urea, uric acid and creatinine.
- hyper-C rats significantly decreased the values of glutathione peroxidase (G.P.X), superoxide dismutase (SO.D) and catalase (CA.T) antioxidant enzymes activity in compared with negative groups (Gr_1) .